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A World Bank Group Flagship Report

world development report 2016

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1818 H Street NW, Washington DC 20433
Telephone: 202-473-1000; Internet: www.worldbank.org

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Cover photo: This 2013 World Press Photo of the Year shows migrants crowding the night shore of Djibouti City in an attempt to capture inexpensive cellphone signals from neighboring Somalia. © John Stanmeyer/National Geographic Creative. Used with the permission of John Stanmeyer/National Geographic Creative. Further permission required for reuse.

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Foreword

We find ourselves in the midst of the greatest information and communications revolution in human history. More than 40 percent of the world's population has access to the internet, with new users coming online every day. Among the poorest 20 percent of households, nearly 7 out of 10 have a mobile phone. The poorest households are more likely to have access to mobile phones than to toilets or clean water.

We must take advantage of this rapid technological change to make the world more prosperous and inclusive. This Report finds that traditional development challenges are preventing the digital revolution from fulfilling its transformative potential.

For many people, today's increase in access to digital technologies brings more choice and greater convenience. Through inclusion, efficiency, and innovation, access provides opportunities that were previously out of reach to the poor and disadvantaged.

In Kenya, for example, the cost of sending remittances dropped by up to 90 percent after the introduction of M-Pesa, a digital payment system. New technologies allow women to participate more easily in the labor market—as e-commerce entrepreneurs, in online work, or in business-process outsourcing. The world's 1 billion persons with disabilities—80 percent of whom live in developing countries—can lead more productive lives with the help of text, voice, and video communication. And digital ID systems can provide better access to public and private services for the 2.4 billion people who lack formal identification records, such as a birth certificate.

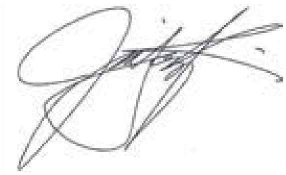
While this is great progress, many are still left out because they do not have access to digital technologies. Those in extreme poverty have the most to gain from better communication and access to information. Nearly 6 billion people do not have high-speed internet, making them unable to fully participate in the digital economy. To deliver universal digital access, we must invest in infrastructure and pursue reforms that bring greater competition to telecommunications markets, promote public-private partnerships, and yield effective regulation.

The Report concludes that the full benefits of the information and communications transformation will not be realized unless countries continue to improve their business climate, invest in people's education and health, and promote good governance.

In countries where these fundamentals are weak, digital technologies have not boosted productivity or reduced inequality. Countries that complement technology investments with broader economic reforms reap digital dividends in the form of faster growth, more jobs, and better services.

The World Bank Group stands ready to help countries pursue these priorities. We are already working with clients to promote competitive business environments, increase accountability, and upgrade education and skills-development systems to prepare people for the jobs of the future.

While people around the world make more than 4 billion Google searches every day, 4 billion people still lack access to the internet. The findings of this Report should be used by all who are working to end extreme poverty and boost shared prosperity. The greatest rise of information and communications in history will not be truly revolutionary until it benefits everyone in every part of the world.



Jim Yong Kim
President
The World Bank Group

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Abbreviations

2G	second-generation
3D	three-dimensional
3G	third-generation
4G	fourth-generation
5G	fifth-generation
ADB	Asian Development Bank
AfDB	African Development Bank
AI	artificial intelligence
APEC	Asia-Pacific Economic Cooperation
ATM	automated teller machine
AV	autonomous vehicles
B2B	business-to-business
BIA	Bridge International Academies
BISP	Benazir Income Support Programme (Pakistan)
BPO	business process outsourcing
C2C	consumer-to-consumer
CAL	computer-assisted learning
CDRs	call data records
CERT	computer emergency response team
CRM	customer relationship management
CSIRT	Computer Security Incident Response Team
CSO	civil society organization
DAI	Digital Adoption Index
DFID	Department for International Development (United Kingdom)
DRM	disaster risk management
DSL	digital subscriber line
EBRD	European Bank for Reconstruction and Development
EC	European Commission
ERP	economic resource planning; Electronic Road Pricing
EU	European Union
FCC	Federal Communications Commission (United States)
FDI	foreign direct investment
G-8	Group of Eight (Canada, France, Germany, Italy, Japan, the Russian Federation, the United Kingdom, and the United States)
G2B	government-to-business
G2C	government-to-citizen
G2G	government-to-government

GDP	gross domestic product
GIS	geographic information system
GNI	gross national income
GPS	global positioning system
GSMA	Groupe Speciale Mobile Association (aka Global System for Mobile communications Association)
GTAP	Global Trade Analysis Project
HEWs	Health Extension Workers
HMIS	Health Management Information System
HS	harmonized classification system
I2D2	International Income Distribution Database (World Bank)
IANA	Internet Assigned Numbers Authority
IATA	International Air Transport Association
ICANN	Internet Corporation for Assigned Names and Numbers
ICT	information and communication technology
ID	identification
IDRC	International Development Research Centre (Canada)
IETF	Internet Engineering Task Force
IFAD	International Fund for Agricultural Development
IFC	International Finance Corporation (of the World Bank Group)
IoT	internet of things
IP	intellectual property; internet protocol
IPRs	intellectual property rights
ISP	internet service provider
IT	information technology
ITRs	International Telecommunication Regulations
ITU	International Telecommunication Union
IXP	internet exchange point
KILM	Key Indicators of the Labour Market
LDCs	least developed countries
LLU	local loop unbundling
LPI	Logistics Performance Index
LTE	Long Term Evolution
M&E	monitoring and evaluation
MDGs	Millennium Development Goals (United Nations)
MFN	most favored nation
MLM	multilateral model
MOOC	massive open online course
MSM	multistakeholder model
NGO	nongovernmental organization
NTM	nontariff measure
OECD	Organisation for Economic Co-operation and Development
OLPC	One Laptop per Child
OSI	online service index
OTT	over-the-top
PC	personal computer
PFR	Program for Results (World Bank)
PIAAC	Programme for the International Assessment of Adult Competencies
PISA	Programme for International Student Assessment
$PM_{2.5}$	particulates with a diameter of less than 2.5 micrometers

PMR	Product Market Regulation
POP	point of presence
PPP	public-private partnership; purchasing power parity
PTT	public telephone and telegraph
R&D	research and development
RFID	radio frequency identification
RSS	Rich Site Summary
SCM	supply chain management
SDGs	Sustainable Development Goals (United Nations)
SIM	subscriber identification module
SMEs	small and medium enterprises
SMS	short message service
STEM	science, technology, engineering, and mathematics
STEP	Skills Towards Employability and Productivity (World Bank)
SYNOP	surface synoptic observations
TFP	total factor productivity
TRCs	Truth and Reconciliation Commissions
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
USAID	U.S. Agency for International Development
USF	Universal Service Fund
VAT	value added tax
W3C	World Wide Web Consortium
WDI	World Development Indicators (World Bank database)
WDR 2016 team	team for the 2016 *World Development Report*
WEF	World Economic Forum
WIPO	World Intellectual Property Organization
WITS	World Integrated Trade Solution (World Bank database)
WTO	World Trade Organization

Currencies

$A	Australian dollar
€	euro
K Sh	Kenyan shilling
₹	Indian rupee
US$	U.S. dollar
Y	Chinese yuan

Units of measurement

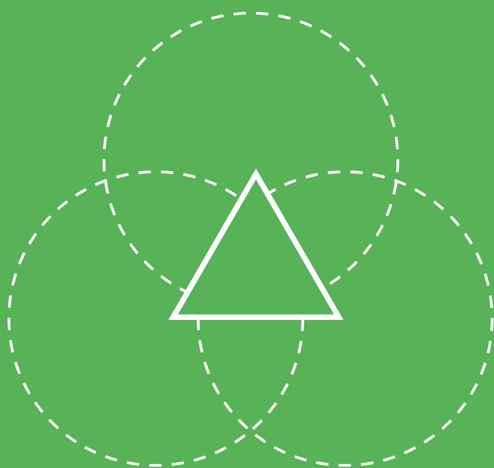
GB	gigabyte
Gbit/s	gigabits per second
GHz	gigahertz
kbps	kilobits per second
kWh	kilowatt-hour
Mbit/s	megabits per second
MHz	megahertz
Tbit/s	terabits per second

Country and economy codes

AFG	Afghanistan
AGO	Angola
ALB	Albania
ARE	United Arab Emirates
ARG	Argentina
ARM	Armenia
AUS	Australia
AUT	Austria
AZE	Azerbaijan
BDI	Burundi
BEL	Belgium
BEN	Benin

BFA	Burkina Faso
BGD	Bangladesh
BGR	Bulgaria
BHR	Bahrain
BIH	Bosnia and Herzegovina
BLR	Belarus
BLZ	Belize
BOL	Bolivia
BRA	Brazil
BRB	Barbados
BRN	Brunei Darussalam
BTN	Bhutan
BWA	Botswana
CAN	Canada
CHE	Switzerland
CHL	Chile
CHN	China
CIV	Côte d'Ivoire
CMR	Cameroon
COD	Congo, Dem. Rep.
COL	Colombia
CPV	Cabo Verde
CRI	Costa Rica
CYP	Cyprus
CZE	Czech Republic
DEU	Germany
DJI	Djibouti
DNK	Denmark
DOM	Dominican Republic
DZA	Algeria
ECU	Ecuador
EGY	Egypt, Arab Rep.
ESP	Spain
EST	Estonia
ETH	Ethiopia
FIN	Finland
FJI	Fiji
FRA	France
GAB	Gabon
GBR	United Kingdom
GEO	Georgia
GHA	Ghana
GIN	Guinea
GMB	Gambia, The
GRC	Greece
GRD	Grenada
GTM	Guatemala
GUY	Guyana
HND	Honduras
HRV	Croatia
HTI	Haiti
HUN	Hungary
IDN	Indonesia
IND	India
IRL	Ireland
IRN	Iran, Islamic Rep.
IRQ	Iraq
ISL	Iceland
ISR	Israel
ITA	Italy
JAM	Jamaica
JOR	Jordan
JPN	Japan
KAZ	Kazakhstan
KEN	Kenya
KGZ	Kyrgyz Republic
KHM	Cambodia
KOR	Korea, Rep.
KWT	Kuwait
LAO	Lao PDR
LBN	Lebanon
LBR	Liberia
LBY	Libya
LKA	Sri Lanka
LSO	Lesotho
LTU	Lithuania
LUX	Luxembourg
LVA	Latvia
MAR	Morocco
MDA	Moldova
MDG	Madagascar
MDV	Maldives
MEX	Mexico
MKD	Macedonia, FYR
MLI	Mali
MLT	Malta
MMR	Myanmar
MNE	Montenegro
MNG	Mongolia
MOZ	Mozambique
MRT	Mauritania
MUS	Mauritius
MWI	Malawi
MYS	Malaysia
NAM	Namibia
NER	Niger

NGA	Nigeria
NIC	Nicaragua
NLD	Netherlands
NOR	Norway
NPL	Nepal
NZL	New Zealand
OMN	Oman
PAK	Pakistan
PAN	Panama
PER	Peru
PHL	Philippines
PNG	Papua New Guinea
POL	Poland
PRT	Portugal
PRY	Paraguay
PSE	West Bank and Gaza
QAT	Qatar
ROU	Romania
RUS	Russian Federation
RWA	Rwanda
SAU	Saudi Arabia
SEN	Senegal
SGP	Singapore
SLB	Solomon Islands
SLE	Sierra Leone
SLV	El Salvador
SOM	Somalia
SRB	Serbia
STP	São Tomé and Príncipe
SVK	Slovak Republic
SVN	Slovenia
SWE	Sweden
SWZ	Swaziland
SYC	Seychelles
TCD	Chad
TGO	Togo
THA	Thailand
TJK	Tajikistan
TKM	Turkmenistan
TLS	Timor-Leste
TON	Tonga
TTO	Trinidad and Tobago
TUN	Tunisia
TUR	Turkey
TZA	Tanzania
UGA	Uganda
UKR	Ukraine
URY	Uruguay
USA	United States
UZB	Uzbekistan
VEN	Venezuela, RB
VNM	Vietnam
YEM	Yemen, Rep.
ZAF	South Africa
ZMB	Zambia
ZWE	Zimbabwe



Inclusion

Efficiency

Innovation

OVERVIEW

OVERVIEW

Strengthening the analog foundation of the digital revolution

Digital technologies have spread rapidly in much of the world. Digital dividends—the broader development benefits from using these technologies—have lagged behind. In many instances digital technologies have boosted growth, expanded opportunities, and improved service delivery. Yet their aggregate impact has fallen short and is unevenly distributed. For digital technologies to benefit everyone everywhere requires closing the remaining digital divide, especially in internet access. But greater digital adoption will not be enough. To get the most out of the digital revolution, countries also need to work on the "analog complements"—by strengthening regulations that ensure competition among businesses, by adapting workers' skills to the demands of the new economy, and by ensuring that institutions are accountable.

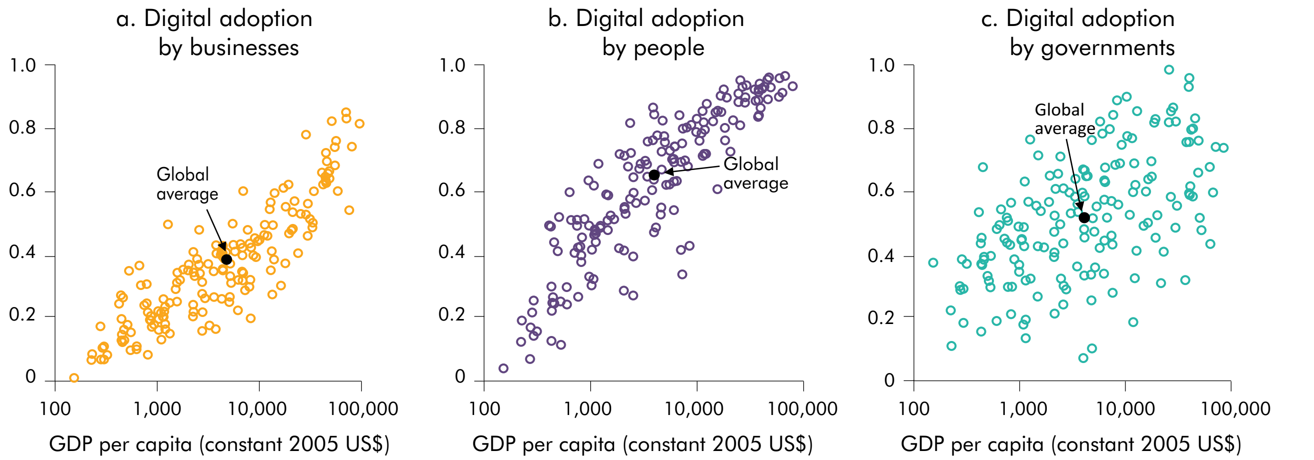
Digital technologies—the internet, mobile phones, and all the other tools to collect, store, analyze, and share information digitally—have spread quickly. More households in developing countries own a mobile phone than have access to electricity or clean water, and nearly 70 percent of the bottom fifth of the population in developing countries own a mobile phone. The number of internet users has more than tripled in a decade—from 1 billion in 2005 to an estimated 3.2 billion at the end of 2015.[1] This means that businesses, people, and governments are more connected than ever before (figure O.1). The digital revolution has brought immediate private benefits—easier communication and information, greater convenience, free digital products, and new forms of leisure. It has also created a profound sense of social connectedness and global community. But have massive investments in information and communication technologies (ICTs) generated faster growth, more jobs, and better services? Indeed, are countries reaping sizable digital dividends?

Technology can be transformational. A digital identification system such as India's Aadhaar, by overcoming complex information problems, helps willing governments to promote the *inclusion* of disadvantaged groups. Alibaba's business-to-business e-commerce site, by significantly reducing coordination costs, boosts *efficiency* in China's economy and arguably the world's. The M-Pesa digital payment platform, by exploiting scale economies from automation, generates significant financial sector *innovation,* with great benefits to Kenyans and others. Inclusion, efficiency, innovation—these are the main mechanisms for digital technologies to promote development.

Although there are many individual success stories, the effect of technology on global productivity, expansion of opportunity for the poor and the middle class, and the spread of accountable governance has so far been less than expected (figure O.2).[2] Firms are more connected than ever before, but global productivity growth has slowed. Digital technologies are changing the world of work, but labor markets have become more polarized and inequality is rising—particularly in the wealthier countries, but increasingly in developing countries. And while the number of democracies is growing, the share of free and fair elections is falling. These trends persist, not because of digital technologies, but in spite of them.

So, while digital technologies have been spreading, digital dividends have not. Why? For two reasons. First, nearly 60 percent of the world's people are still offline

Figure O.1 Digital technologies have spread rapidly in much of the world



Source: WDR 2016 team. Data at http://bit.do/WDR2016-FigO_1.

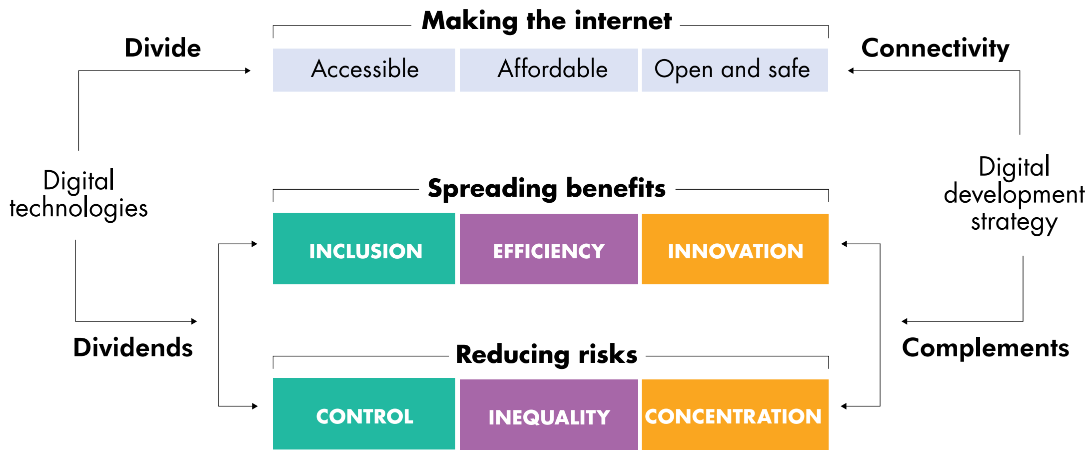
Note: The figures show the diffusion of digital technologies across countries as measured by the Digital Adoption Index compiled for this Report and described in detail in chapter 5 of the full Report. GDP = gross domestic product.

and can't participate in the digital economy in any meaningful way. Second, some of the perceived benefits of digital technologies are offset by emerging risks (figure O.3). Many advanced economies face increasingly polarized labor markets and rising inequality—in part because technology augments higher skills while replacing routine jobs, forcing many workers to compete for low-paying jobs. Public sector investments in digital technologies, in the absence of accountable institutions, amplify the voice of elites, which can result in policy capture and greater state control. And because the economics of the internet favor natural monopolies, the absence of a competitive business environment can result in more concentrated markets, benefiting incumbent firms. Not surprisingly, the better educated, well connected, and more capable have received most of the benefits—circumscribing the gains from the digital revolution.

Figure O.2 The pessimism concerning the global outlook is not because of digital technologies, but in spite of them

Sources: Panel a: Conference Board (various years); WDR 2016 team. Panel b: Lakner and Milanovic 2013. Panel c: Bishop and Hoeffler 2014. Data at http://bit.do/WDR2016-FigO_2.

Figure O.3 Why digital dividends are not spreading rapidly—and what can be done



Source: WDR 2016 team.

To maximize the digital dividends requires better understanding of how technology interacts with other factors that are important for development—what the Report calls "analog complements." Digital technologies can make routine, transaction-intensive tasks dramatically cheaper, faster, and more convenient. But most tasks also have an aspect that cannot be automated and that requires human judgment, intuition, and discretion. When technology is applied to automate tasks without matching improvements in the complements, it can fail to bring broad-based gains. The digital revolution can give rise to new business models that would benefit consumers, but not when incumbents control market entry. Technology can make workers more productive, but not when they lack the know-how to use it. Digital technologies can help monitor teacher attendance and improve learning outcomes, but not when the education system lacks accountability.[3]

What should countries do? Making the internet universally accessible and affordable should be a global priority. The internet, in a broad sense, has grown quickly, but it is by no means universal. For every person connected to high-speed broadband, five are not. Worldwide, some 4 billion people do not have any internet access, nearly 2 billion do not use a mobile phone, and almost half a billion live outside areas with a mobile signal. The unfinished task of connecting everyone to the internet—one of the targets in the recently approved Sustainable Development Goals (SDGs)—can be achieved through a judicious mix of market competition, public-private partnerships, and effective regulation of the internet and telecom sector.

Access to the internet is critical, but not sufficient. The digital economy also requires a strong analog foundation, consisting of *regulations* that create a vibrant business climate and let firms leverage digital technologies to compete and innovate; *skills* that allow workers, entrepreneurs, and public servants to seize opportunities in the digital world; and accountable *institutions* that use the internet to empower citizens. The long-term development impact is by no means definitive, being continuously shaped by the evolution of technology (connectivity) and the country's choice of economic, social, and governance arrangements (complements).[4] Countries that are able to swiftly adjust to this evolving digital economy will reap the greatest digital dividends, while the rest are likely to fall behind (figure O.3 and box O.1).

The triple complements—a favorable business climate, strong human capital, and good governance—will sound familiar—and they should because they are the foundation of economic development. But digital technologies add two important dimensions. First, they raise the opportunity cost of not undertaking the necessary reforms. They amplify the impact of good (and bad) policies, so any failure to reform means falling farther behind those who do reform. With digital technologies, the stakes have risen for developing countries, which have more to gain than high-income countries, but also more to lose. Second, while digital technologies are no shortcut to development, they can be an enabler and perhaps an accelerator by raising the quality of the complements. Online business registries ease market entry for new and innovative firms. Well-designed internet-based training helps workers upgrade their skills. New media platforms can increase citizen participation. And digital enablers—digital finance, digital identification, social media, and open data—spread

Box O.1 Frequently asked questions: The Report at a glance

What is the Report about?
It explores the impact of the internet, mobile phones, and related technologies on economic development. Part 1 shows that potential gains from digital technologies are high, but often remain unrealized. Part 2 proposes policies to expand connectivity, accelerate complementary reforms in sectors beyond information and communication technology (ICT), and address global coordination problems.

What are the digital dividends?
Growth, **jobs**, and **services** are the most important returns to digital investments. The first three chapters show how digital technologies help **businesses** become more productive; **people** find jobs and greater opportunities; and **governments** deliver better public services to all.

How do digital technologies promote development and generate digital dividends?
By reducing information costs, digital technologies greatly lower the cost of economic and social transactions for firms, individuals, and the public sector. They promote **innovation** when transaction costs fall to essentially zero. They boost **efficiency** as existing activities and services become cheaper, quicker, or more convenient. And they increase **inclusion** as people get access to services that previously were out of reach.

Why does the Report argue that digital dividends are not spreading rapidly enough?
For two reasons. First, nearly 60 percent of the world's people are still offline and can't fully participate in the digital economy. There also are persistent digital divides across gender, geography, age, and income dimensions within each country. Second, some of the perceived benefits of the internet are being neutralized by new risks. Vested business interests, regulatory uncertainty, and limited contestation across digital platforms could lead to harmful **concentration** in many sectors. Quickly expanding automation, even of mid-level office jobs, could contribute to a hollowing out of labor markets and to rising **inequality**. And the poor record of many e-government initiatives points to high failure of ICT projects and the risk that states and corporations could use digital technologies to **control** citizens, not to empower them.

What should countries do to mitigate these risks?
Connectivity is vital, but not enough to realize the full development benefits. Digital investments need the support of "*analog complements*": **regulations**, so that firms can leverage the internet to compete and innovate; improved **skills**, so that people can take full advantage of digital opportunities; and accountable **institutions**, so that governments respond to citizens' needs and demands. Digital technologies can, in turn, augment and strengthen these complements—accelerating the pace of development.

What needs to be done to connect the unconnected?
Market competition, public-private partnerships, and effective regulation of internet and mobile operators encourage private investment that can make access universal and affordable. Public investment will sometimes be necessary and justified by large social returns. A harder task will be to ensure that the internet remains open and safe as users face cybercrime, privacy violations, and online censorship.

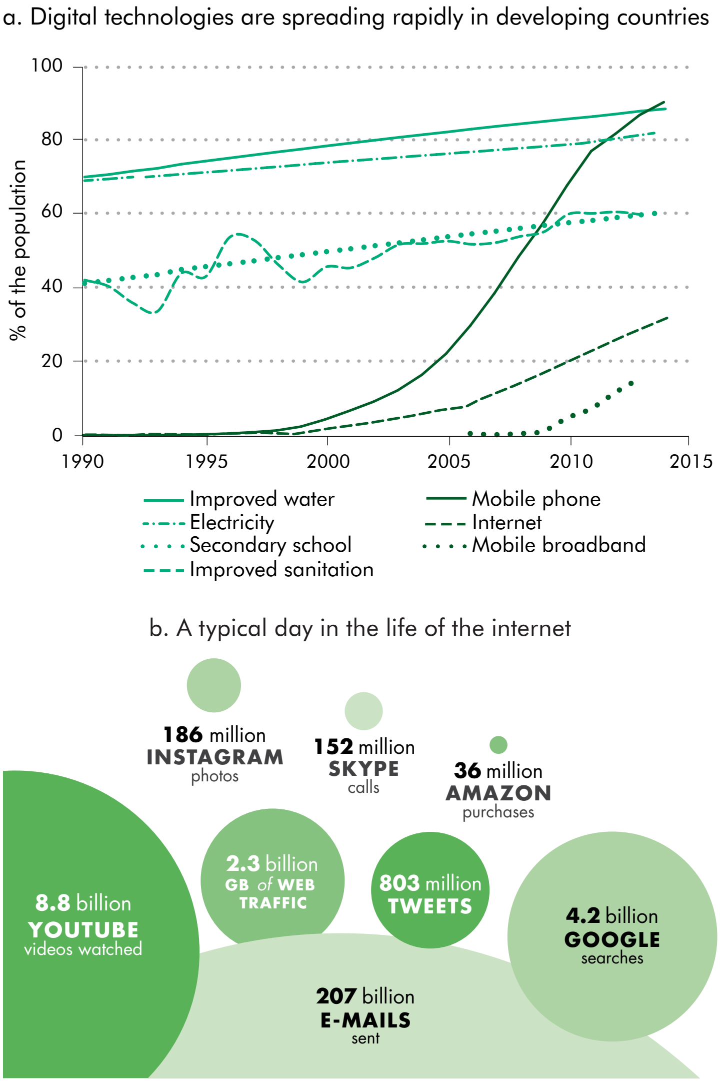
What is the main conclusion?
Digital development strategies need to be broader than ICT strategies. Connectivity for all remains an important goal and a tremendous challenge. But countries also need to create favorable conditions for technology to be effective. When the analog complements are absent, the development impact will be disappointing. But when countries build a strong analog foundation, they will reap ample digital dividends—in faster **growth**, more **jobs**, and better **services**.

benefits throughout the economy and society, further strengthening the interaction between technology and its complements.

Digital transformations—digital divides

The internet and related technologies have reached developing countries much faster than previous technological innovations. For Indonesia to reap the benefits of steamships took 160 years after their invention and for Kenya to have electricity, 60 years; but for Vietnam to introduce computers, only 15 years. Mobile phones and the internet took only a few years. More households in developing countries own a mobile phone than have access to electricity or improved sanitation (figure O.4, panel a). Greater internet access has led to an explosion in the production and consumption

Figure O.4 Digital transformation in action



Sources: World Development Indicators (World Bank, various years); WDR 2016 team; http://www.internetlivestats.com/one-second/ (as compiled on April 4, 2015). Data at http://bit.do/WDR2016-FigO_4.

Note: In panel a, for some years data for electricity are interpolated from available data. GB = gigabytes.

of information around the world (figure O.4, panel b). But while the internet has reached almost all countries quickly, the intensity of its use has been lower in poorer countries—in large part because it has not spread as widely within those countries. And despite many great examples of the uses of new technologies in developing countries, advanced economies have been using them even more effectively.[5]

Connected people

On average, 8 in 10 individuals in the developing world own a mobile phone, and the number is steadily rising. Even among the bottom fifth of the population, nearly 70 percent own a mobile phone. The lowest mobile penetration is in Sub-Saharan Africa (73 percent), against 98 percent in high-income countries. But internet adoption lags behind considerably: only 31 percent of the population in developing countries had access in 2014, against 80 percent in high-income countries. China has the largest number of internet users, followed by the United States, with India, Japan, and Brazil filling out the top five. The world viewed from the perspective of the number of internet users looks more equal than when scaled by income (map O.1)—reflecting the internet's rapid globalization.

Connected businesses

Internet adoption has increased across businesses in all country income groups. Nearly 9 of 10 businesses in high-income OECD (Organisation for Economic Co-operation and Development) countries had a broadband internet connection in 2010–14, compared with 7 for middle-income countries and 4 for low-income countries. But adoption rates for more sophisticated technologies such as secure servers, enterprise network, inventory management, and e-commerce are much lower in most developing countries.

Connected governments

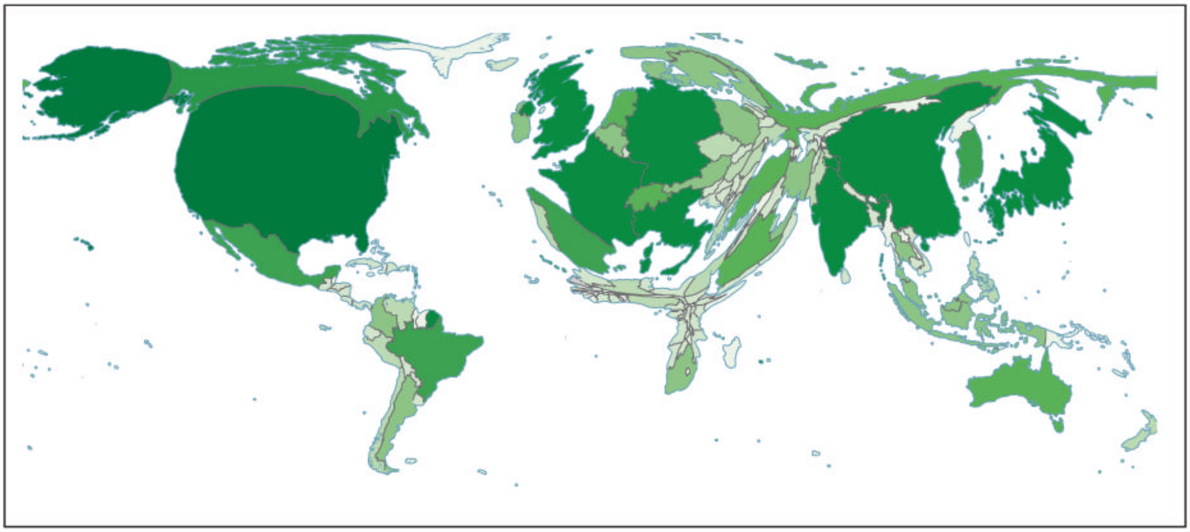
Governments are increasingly going digital, and a greater share of government jobs in developing countries is ICT-intensive than in the private sector. By 2014, all 193 member states of the United Nations (UN) had national websites: 101 enabled citizens to create personal online accounts, 73 to file income taxes, and 60 to register a business. For the most common core government administrative systems, 190 member states had automated financial management, 179 used such systems for customs processing, and 159 for tax management. And 148 of them had some form of digital identification, and 20 had multipurpose digital identification platforms. So far, developing countries have invested more in automating back-office functions than in services directed at citizens and businesses.

The divide in digital access and use persists

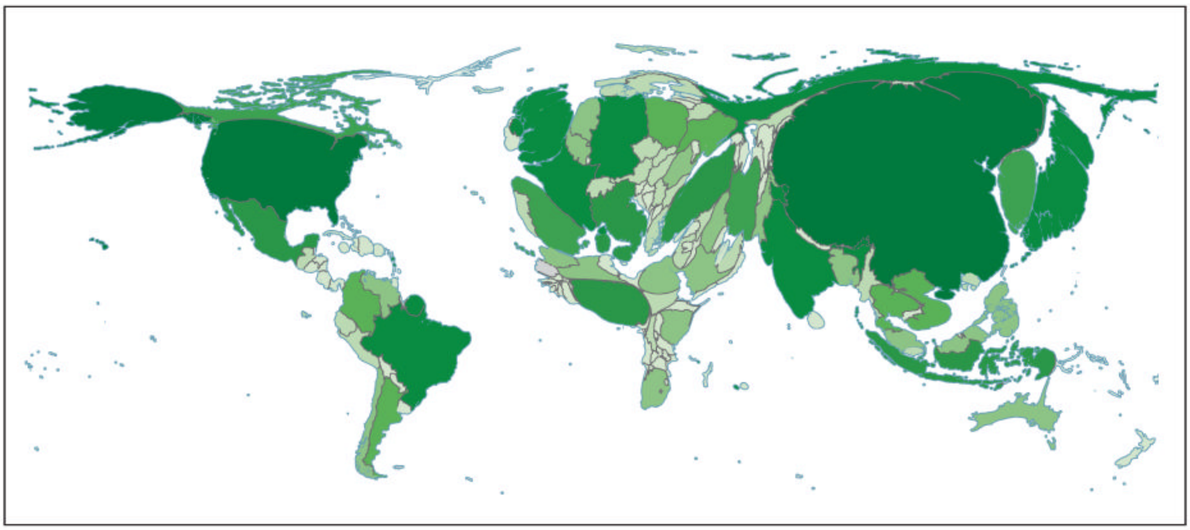
The lives of the majority of the world's people remain largely untouched by the digital revolution. Only around 15 percent can afford access to broadband internet. Mobile phones, reaching almost four-fifths of the world's people, provide the main form of internet access in developing countries. But even then, nearly 2 billion people do not own a mobile phone, and nearly 60 percent of the world's population has no access to the internet. The world's offline population is

Map O.1 **The internet is more evenly spread than income**

a. Based on national income, 2014



b. Based on internet population, 2014



IBRD 42010

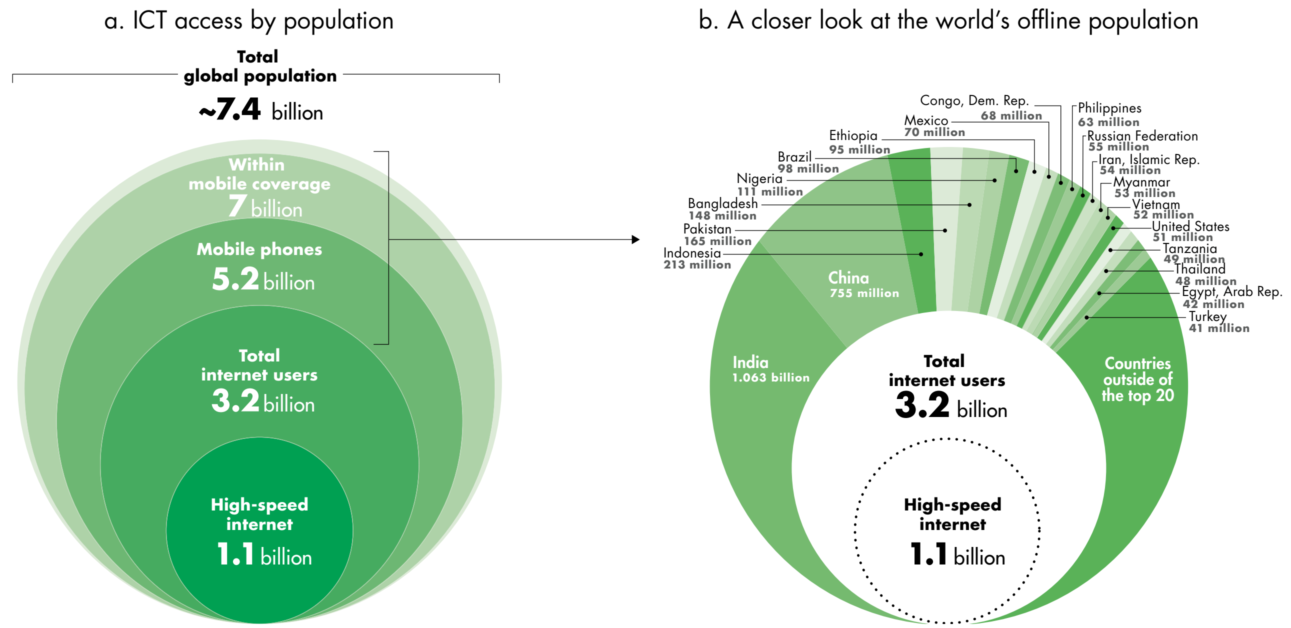
Source: World Bank. Data at http://bit.do/WDR2016-MapO_1.

Note: Countries' sizes are rescaled in proportion to national income and internet population. The darker the shade, the higher the national income (panel a; GDP at market exchange rates) and the higher the internet population (panel b).

mainly in India and China, but more than 120 million people are still offline in North America (figure O.5).

The digital divide within countries can be as high as that between countries. Worldwide, nearly 21 percent of households in the bottom 40 percent of their countries' income distribution don't have access to a mobile phone, and 71 percent don't have access to the internet. Adoption gaps between the bottom 40 percent and the top 60 percent and between rural and urban populations are falling for mobile phones but increasing for the internet. In Africa, the digital divide across demographic groups remains considerable (figure O.6, panel a). Women are less likely than men to use or own digital technologies. Gaps are even larger between youth (20 percent) and those more than 45 years old (8 percent).

Figure O.5 The internet remains unavailable, inaccessible, and unaffordable to a majority of the world's population



Sources: World Bank 2015; Meeker 2015; ITU 2015; GSMA, https://gsmaintelligence.com/; UN Population Division 2014. Data at http://bit.do/WDR2016-FigO_5.

Note: High-speed internet (broadband) includes the total number of fixed-line broadband subscriptions (such as DSL, cable modems, fiber optics), and the total number of 4G/LTE mobile subscriptions, minus a correcting factor to allow for those who have both types of access. 4G = fourth generation; DSL = digital subscriber line; ICT = information and communication technology; LTE = Long Term Evolution.

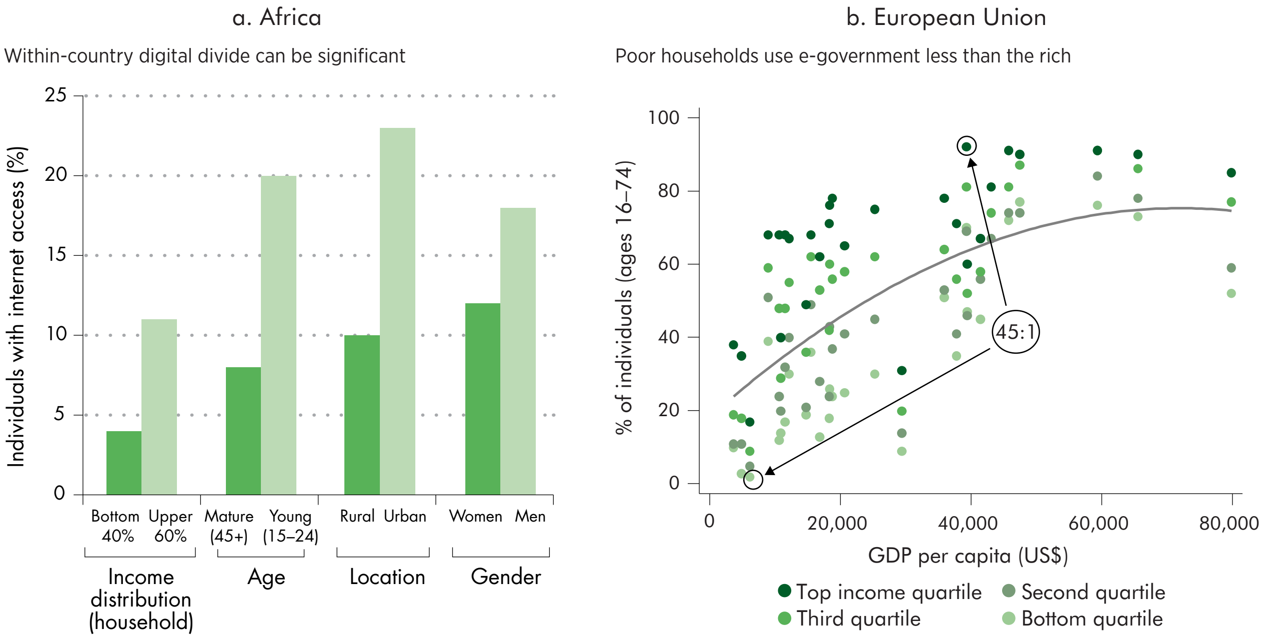
The increased connectivity has had limited effect in reducing information inequality. For example, there are more contributions to Wikipedia from Hong Kong SAR, China, than from all of Africa combined, despite the fact that Africa has 50 times more internet users.[6] The amount of information published on the web, and its origin, often corresponds to what one sees in the offline world as well. For instance, 85 percent of the user-generated content indexed by Google comes from the United States, Canada, and Europe, similar to the share of global scientific journals originating in these countries. In fact, the information produced and consumed in the digital economy has little bearing on the number of users of digital technologies. Given that nearly one-fifth of the world's population is illiterate, the spread of digital technologies alone is unlikely to spell the end of the global knowledge divide.

Countries that have bridged the digital-access divide often face a new divide in digital capabilities. In the European Union (EU), businesses are more likely than citizens to use the internet to interact with the government. Citizens use e-government mostly for getting information and not for transacting with government. And their use of e-government is highly uneven—citizens in the top 20 percent of income in the most connected EU country are 45 times more likely to use e-services than those in the bottom 20 percent of income in the least connected EU country (figure O.6, panel b). Within countries, greater e-government use by individuals is associated with education, employment, urban residence, being male, and broadband access.

How the internet promotes development

Digital technologies have dramatically expanded the information base, lowered information costs, and created information goods. This has facilitated searching, matching, and sharing of information and contributed to greater organization and collaboration among economic agents—influencing how firms operate, people seek opportunities, and citizens interact with their governments. The changes are not limited to economic transactions—they also influence the participation of women in the labor force, the

Figure O.6 The digital divide in access is high in Africa, and the divide in capability is high in the European Union



Sources: WDR 2016 team, based on data from Research ICT Africa (various years), ITU, and Eurostat (EC, various years). Data at http://bit.do/WDR2016-FigO_6.

Note: For more details see figure 2.4 in the full Report.

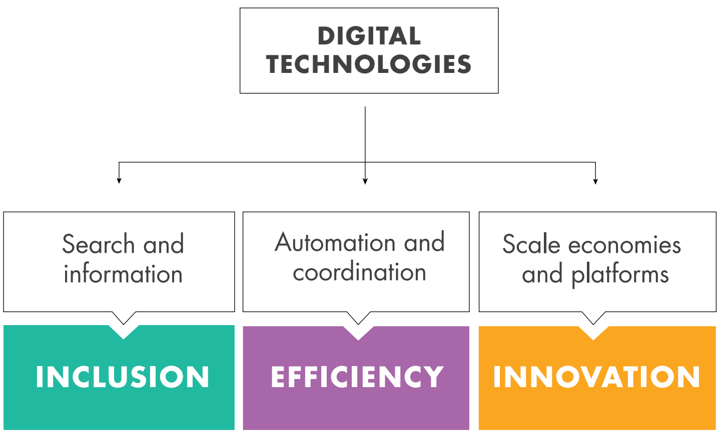
ease of communication for people with disabilities, and the way people spend their leisure. By overcoming information barriers, augmenting factors, and transforming products, digital technologies can make development more inclusive, efficient, and innovative (figure O.7 and box O.2). Spotlight 1 in the full Report explores the links between these three mechanisms in the broader economic literature.

The internet promotes inclusion

Before the internet arrived, some transactions were so expensive that a market for them did not exist. Two types of transactions fall into this category. First is when two parties to a potentially beneficial transaction simply didn't know about each other and faced exorbitantly high search and information costs. Second is when one party had a lot more information than the other. In the economics literature, such situations are known as information asymmetries between buyers and sellers, and in the absence of trust and transparency, many transactions do not take place.

By reducing the cost of acquiring information and making more information available transparently, digital technologies can make new transactions possible.[7] Consider a poor farmer who cannot access credit because the lender has no way to assess creditworthiness. Or a small firm that cannot connect with a potential buyer in another country and does not know whether to trust a new business partner. Or a freelancer willing to perform small tasks for a fee. Or a homeowner looking to rent her spare room to local visitors. Or remote or marginalized population groups who fall outside the reach of the services that governments provide. In all these cases, a fundamental

Figure O.7 The internet promotes development through three main mechanisms



Source: WDR 2016 team.

Box O.2 e-commerce with Chinese characteristics: Inclusion, efficiency, and innovation in Taobao villages

The dynamic growth and rapid spread of e-commerce in China is best illustrated by the Shaji phenomenon. The economy of Dongfeng village in Shaji town (Jiangsu Province) shifted from pig farming in the 1980s to plastic waste recycling in the 1990s. In 2006, a migrant from the village returned to open an online shop to sell simple furniture. His success encouraged other villagers to do likewise, and by the end of 2010, the village had 6 board processing factories, 2 metal parts factories, 15 logistics and shipping companies, and 7 computer stores serving 400 households engaged in online sales throughout China and even in neighboring countries. Shaji was one of the first "Taobao villages"—named after an online shopping platform run by the Alibaba Group—where at least 10 percent of households are engaged in online commerce.[a] The Taobao villages, and the rise of e-commerce in China more generally, illustrate how the internet promotes inclusion, efficiency, and innovation.

Inclusion. While the economies of China's coastal urban areas have grown rapidly over the last three decades, rural and western parts of the country have lagged behind. But China's large investments in rural connectivity are beginning to pay off. More than 90 percent of villages will have fixed broadband access by the end of 2015. Online commerce has allowed producers in towns and villages to participate in the national and even global economy. At the end of 2014, there were more than 70,000 merchants in 200 Taobao villages, and many more in other rural areas. Most of the stores are small, with an average of 2.5 employees. About one-third of owners are female, and one-fifth were previously unemployed. About 1 percent are persons with disabilities. One of Alibaba's top "netpreneurs," confined to a wheelchair after an accident, built a thriving online livestock business.

Efficiency. Besides the Taobao e-commerce site for consumers, Alibaba and other Chinese firms operate business-to-business platforms. They facilitate intra- and inter-industry trade in China's already efficient production sector, as well as exports. They also make it easier for foreign firms to sell in China. Consumers benefit from greater selection and convenience on online retail sites. Online trade has not only helped raise rural incomes but also made shopping more efficient. Purchasing power in rural areas is only about one-third that in cities, but the aggregate consumption of China's 650 million rural residents is vast, contributing to the national goal of moving from an export- and investment-driven economy to one that is more consumption based. And the boom in online trade has spawned numerous logistics companies that provide quick delivery—sometimes by bicycle in towns and villages.

Innovation. Taobao and other e-commerce platforms are examples of innovation generated by the economies of scale that emerge when transaction costs drop drastically. Since these platforms are highly automated, fees can be kept low, and operations are often financed by advertising alone. Some problems cannot easily be solved solely by automation, such as creating trust in the market and preventing fraud. Online ratings, escrow services, and conflict resolution mechanisms address them. One of the most valuable assets Alibaba and other e-commerce operators accumulate is data. Each transaction contributes to better knowledge about the economy and consumer behavior. This information supports new business lines, such as extending credit to small firms based on automated evaluations of creditworthiness. This can also advance financial inclusion. In early 2015, for instance, Alibaba's Ant Financial teamed up with the International Finance Corporation to expand credit to female entrepreneurs in China.

Sources: WDR 2016 team, based on information from the China State Information Center, China Association for Employment Promotion, and Alibaba company reports.

a. http://www.alizila.com/report-taobao-villages-rural-china-grow-tenfold-2014.

information problem makes it difficult to make a deal or a match. Mobile phone records, business-to-business e-commerce, the sharing economy, online reputation mechanisms, and digital identification systems all help to overcome these information barriers. While they make the market more efficient, the biggest benefit seems to be their market creation effects: expanding trade, creating jobs, and increasing access to public services—and thus promoting inclusion.[8]

The internet promotes efficiency

Perhaps the largest impact has been on transactions that existed before the arrival of the internet but are now quicker, cheaper, or more convenient to carry out.

This mechanism operates in two ways. First, the dramatic decline in the price of digital technologies has led businesses and governments to replace existing factors—labor and non-ICT capital—with ICT capital and to automate some of their activities. Airlines use online booking systems to fill planes. Supermarkets substitute cashiers with automated checkout counters. Manufacturers use real-time inventory and supply chain management systems. And governments invest in information management systems and offer online services for a wide range of tasks—from issuing drivers' licenses to filing taxes.

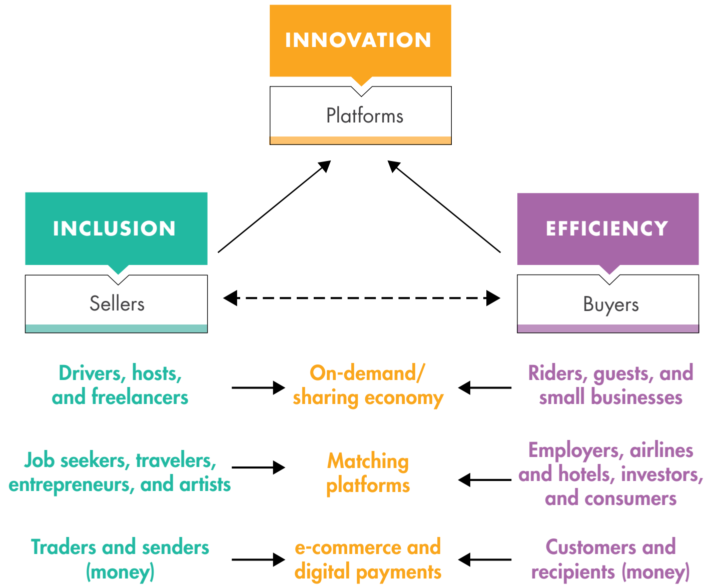
Second, digital technologies augment the factors not substituted and make them more productive. They help managers to better supervise their workers, politicians to monitor the service providers, and workers to use technology to become more productive, thus raising the returns to their human capital. By streamlining tasks and raising the productivity of existing factors, the internet can greatly increase economic efficiency across firms, workers, and governments.

The internet promotes innovation

The extreme case of efficiency is when transactions are executed automatically, without human input, and transaction costs fall to essentially zero. This is the realm of the "new economy," such as search or e-commerce platforms, digital payment systems, e-books, streaming music, and social media. The fixed cost of building the platform may be large, but the marginal cost of carrying out another transaction or adding another user is tiny. This gives rise to increasing returns to scale, which stimulate new business models and provide a major advantage to online firms competing with their offline counterparts. The zero marginal cost attracts new sellers and buyers to the firm's platform, creating virtuous network effects, where the benefit to a buyer increases as more sellers join in, and vice versa. An auction site attracts more bidders the more the sellers use it, and a search engine learns and becomes more useful the more searches are performed. Scale and zero marginal costs also explain why many of the social network sites have become the preferred vehicles for social mobilization and political protests. By enabling almost frictionless communication and collaboration, the internet can support new delivery models, encourage collective action, and accelerate innovation.

The 2016 WDR presents many examples of how the internet promotes inclusion, efficiency, and innovation. In the internet economy the three mechanisms often operate together. So the one-to-one mapping in figure O.7 simplifies a more complex reality.

Figure O.8 Many digital transactions involve all three mechanisms and a two-sided market



Source: WDR 2016 team.

Many internet businesses or services use a platform or "two-sided market" model. The platforms match buyers with sellers or a service user with a provider. In a ride sharing service, the platform automatically matches drivers and passengers (innovation), the driver takes advantage of a flexible income-earning activity not otherwise accessible (inclusion), and the passenger benefits from greater convenience and often lower prices (efficiency). Online crowdfunding, job matching, room sharing, and music sites operate similarly (figure O.8).

The dividends: Growth, jobs, and service delivery

The benefits of digital technologies filter throughout the economy (figure O.9). For businesses, the internet promotes inclusion of firms in the world economy by expanding trade, raises the productivity of capital, and intensifies competition in the marketplace, which in turn induces innovation. It brings opportunities to households by creating jobs, leverages human capital, and produces consumer surplus. It enables citizens to access public services, strengthens government capability, and serves as a platform for citizens to tackle collective action problems. These benefits are neither automatic nor assured, but in numerous instances digital technologies can bring significant gains.

Figure O.9 How the three mechanisms apply to businesses, people, and governments

DIGITAL TECHNOLOGIES

	INCLUSION	EFFICIENCY	INNOVATION
BUSINESSES	Trade	Capital utilization	Competition
PEOPLE	Job opportunities	Labor productivity	Consumer welfare
GOVERNMENTS	Participation	Public sector capability	Voice

Source: WDR 2016 team.

The internet can lead to more trade, better capital use, and greater competition

The ICT sector is a fairly modest part of the overall economy. Its share in GDP is around 6 percent in OECD member countries and considerably less in developing countries (figure O.10, panel a). In the United States, home to 8 of the world's 14 largest technology companies by revenue, the contribution of the ICT sector to GDP is around 7 percent. The corresponding number for Ireland is 12 percent—a country that does not boast its own Silicon Valley, but attracts many foreign firms through its competitive business environment and favorable tax rates. In Kenya, which hosts one of the largest ICT sectors in Africa, the value added share of ICT services in GDP was 3.8 percent in 2013.

The contribution of ICT capital to GDP growth has been fairly constant over the past two decades. In high-income countries, it has fallen from 0.7 percentage points in 1995–99 to 0.4 percentage points in 2010–14 (figure O.10, panel b). In developing countries, the contribution of ICT capital to GDP growth has been fairly modest—around 15 percent of growth—reflecting lower digital adoption. With rapid diffusion of digital technologies into developing countries, this number could rise in the future. In addition, the indirect contributions of ICT capital to economic growth, through improvements in total factor productivity (TFP), could be large as well, although rigorous evidence linking the two is still missing.

The rapid adoption of digital technologies in the economy has meant that its benefits are widely dispersed and its indirect growth impacts difficult to estimate. Like energy or transport, the internet has become an essential part of a country's infrastructure—and a factor of production in almost any activity in a modern economy. Isolating the impact of digital technologies is therefore difficult at an aggregate level. Firm-level analysis provides a more reliable picture.[9] The internet enables many small firms to participate in global trade, thus leading to more inclusion; it makes existing capital more productive, raising efficiency; and by stimulating competition, it encourages innovation.

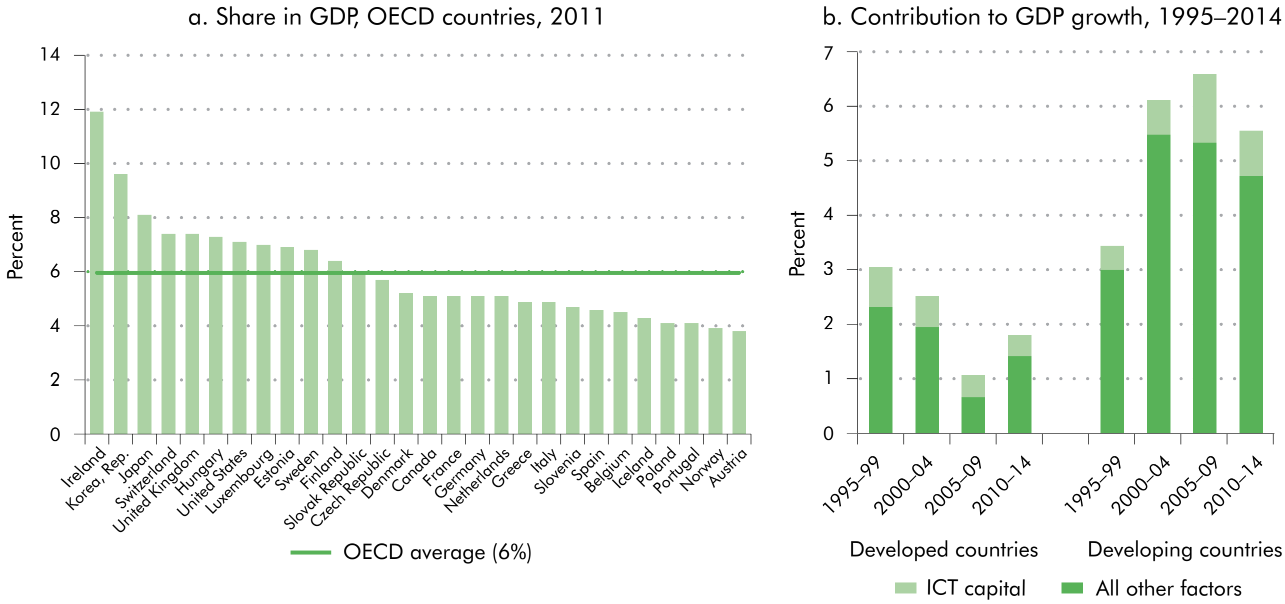
Expanding trade

The internet enables more products to be exported to more markets, often by newer and younger firms. A 10-percent increase in internet use in the exporting country is found to increase the number of products traded between two countries by 0.4 percent. A similar increase in internet use of a country pair increases the average bilateral trade value per product by 0.6 percent.[10] Firms selling on eBay in Chile, Jordan, Peru, and South Africa are younger than firms in the offline markets.[11] In Morocco, rural artisans, some of them illiterate, sell globally through the Anou crafts platform. At the other end of the spectrum, businesses trade on global e-commerce sites such as Alibaba's in an online market that could reach more than US$6 trillion over the next five years. Online platforms overcome trust and information problems through feedback and rating systems and by offering escrow and dispute resolution mechanisms. Easier trade of intermediate products encourages further "unbundling" of production processes, not just in the markets for goods but also for services.[12] Firms in India, Jamaica, and the Philippines have captured a share of these global markets for services that range from traditional back-office services to long-distance online tutoring.

Improving capital utilization

Perhaps the greatest contribution to growth comes from the internet's lowering of costs and thus from raising efficiency and labor productivity in practically all economic sectors. Better information helps companies make better use of existing capacity, optimizes inventory and supply chain management, cuts downtime of capital equipment, and reduces risk. In the airline industry, sophisticated reservation and pricing algorithms increased load factors by about one-third for U.S. domestic flights between 1993 and 2007. The parcel delivery company UPS famously uses intelligent routing algorithms to avoid left turns, saving time and about 4.5 million liters of petrol per year. Many retailers now integrate their suppliers in

Figure O.10 **The size of the ICT sector and its contribution to GDP growth is still relatively modest**



Sources: OECD 2014; Conference Board Total Economy Database, January 2014; WDR 2016 team. Data at http://bit.do/WDR2016-FigO_10.

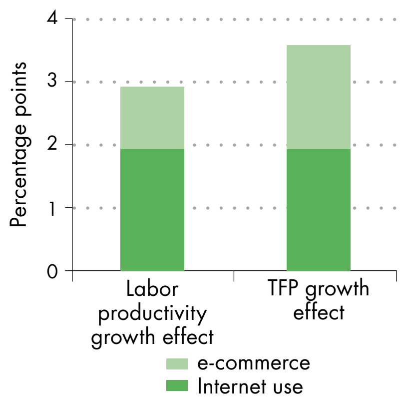
Note: GDP = gross domestic product; ICT = information and communication technology; OECD = Organisation for Economic Co-operation and Development.

real-time supply chain management to keep inventory costs low. Vietnamese firms using e-commerce had on average 3.6 percentage point higher TFP growth than firms that did not use it (figure O.11). Chinese car companies that are more sophisticated users of the internet turn over their inventory stocks five times faster than their less savvy competitors. And Botswana and Uruguay maintain unique ID and trace-back systems for livestock that fulfill requirements for beef exports to the EU, while making the production process more efficient.

Advancing competition

When fully automated internet-based services drive marginal transaction costs to zero, the consequences for market structure are somewhat ambiguous. Low marginal costs imply large economies of scale, which favor natural monopolies. In the offline world, such sectors—for example, electricity production—often require some form of regulation to protect consumer interests. But the characteristics of internet-based services could also encourage competition. Price-comparison websites, for example, should reduce prices for consumers, even though the evidence shows that price dispersion on the internet persists, in part because companies are getting better at price discrimination—offering different prices to different consumers based on search history, geographic location, or other information collected about buyers.

Figure O.11 **Vietnamese firms using e-commerce have higher TFP growth, 2007–12**



Source: Nguyen and Schiffbauer 2015 for the 2016 WDR. Data at http://bit.do/WDR2016-FigO_11.

Note: For more details see figure 1.9 in the full Report. TFP = total factor productivity.

The internet can also facilitate market entry. Internet firms can start and scale up quickly with relatively little staffing or capital investment. Cloud computing—the leasing of computing and data storage services—reduces startup costs and allows firms to add capacity as the need arises, which also reduces risk to investors. Although many internet firms seem to operate in separate markets, most if not all compete with offline firms. Instant messaging apps compete with telecoms, search engines and social media sites compete with traditional media for advertising revenue, e-commerce firms compete with brick-and-mortar firms, and mobile money competes with traditional banks. Innovations triggered by this online-offline competition generally benefit consumers, especially when offline markets are distorted. Transport service companies such as Uber, Lyft, Olacabs, and Didi-Kuaidi Dache have disrupted taxi markets that tend to be overregulated with restricted entry and high prices. Similarly, TransferWise and Xoom have reduced regulatory rents in the financial sector and cut the prices of international currency transfers by up to 90 percent. In Uganda, eKeebo allows independent or amateur chefs to provide and share home-cooked meals, circumventing restaurant licenses.

The internet supports job creation and makes workers more productive

People have an enormous desire to communicate and connect. The personal welfare gain from having access to digital technology is clearly great. Does it also increase people's economic opportunities? People certainly use mobile phones and the internet more for social purposes than for professional ones. But an emerging literature also indicates that people realize tangible economic benefits. Quantifying these benefits is difficult, but qualitative evaluation of the evidence shows that benefits accrue most to those already better off (table O.1). Those who have the skills to leverage technology will have an advantage. But even the poor benefit to some extent through indirect job creation and better access to work and markets. As governments and the private sector get better at tailoring digital services to the poor, those gains will likely increase.

Creating jobs

The number of direct jobs created by digital technologies is fairly modest, but the number enabled by it can be large. In developing countries, the ICT sector accounts for only about 1 percent of the workforce on average: less than 0.5 percent in Bolivia and Ghana, and just under 2 percent in Colombia and Sri Lanka. In OECD countries, about 3–5 percent of the employment is in this sector. Instagram, a photo sharing app, had just 13 employees in 2012 when it was bought by Facebook for US$1 billion. Facebook had 5,000 employees at the time—compared with 145,000 at Kodak at its peak in photographic film in the 1990s. Yet Facebook's market value is several times what Kodak's was back then.[13] ICT jobs, however, tend to pay well, and each high-tech job generates 4.9 additional jobs in other sectors in the United States.[14] In Kenya, the M-Pesa digital payment system creates additional income for more than 80,000 agents. And China's State Information Center estimates that the recent boom in the country's e-commerce sector has created 10 million jobs in online stores and related services, about 1.3 percent of the country's employment. New opportunities for entrepreneurship and self-employment are also growing rapidly in the digital economy.

The internet's ability to reduce transaction costs increases opportunities for people who face barriers in finding jobs or productive inputs. This promotes inclusion for women, for persons with disabilities,

Table O.1 Benefits of digital technologies for workers and consumers: A scorecard

Channel	Impact so far		Potential impact	
	Poor	Nonpoor	Poor	Nonpoor
Creating jobs				
In the ICT sector and occupations	Negligible	L	Negligible	L
In sectors that use ICT	L	M	L	M
Increasing worker productivity				
Increasing returns to human capital	L	M	L	H
Connecting people to work and markets	M	H	H	H
Benefiting consumers				
Increasing consumer surplus	M	H	H	H

Source: WDR 2016 team.

Note: Poor refers to the bottom 20 percent of the welfare distribution. The differential impact summarizes the discussion in chapter 2 in the full Report and is a qualitative assessment of the evidence. ICT = information and communication technologies; L = low; M = medium; H = high.

Box O.3 Bridging the disability divide through digital technologies

Over 1 billion people around the world have disabilities, and 80 percent of them live in developing countries. Persons with disabilities face barriers to communicate, interact, access information, and participate in civic activities. Digital technologies are helping overcome some of these barriers. Technology enables multiple means of communication—voice, text, and gestures—to access information and engage with others. Voice recognition, magnification, and text-to-speech functionality benefit persons with visual, cognitive, learning, and mobility disabilities. Short message service (SMS), instant messaging, telephone relay, and video captions reduce communication barriers for persons with hearing and speech disabilities. Hands-free navigation and gesture-controlled interfaces assist persons with severe mobility impairments in using digital devices. But the mere existence of technology is an insufficient condition to bridge the gaps in the socioeconomic inclusion of persons with disabilities. A supportive ecosystem is needed to drive the implementation of accessible digital technologies.

Source: Raja 2015, for the WDR 2016.

and for people in remote areas (box O.3). Impact outsourcing brings internet-based jobs to the poor and vulnerable. The government of the Indian state of Kerala set up the Kudumbashree project to outsource information technology services to cooperatives of women from poor families; 90 percent of the women had not previously worked outside the home. Samasource and Rural Shores link clients in the United States and the United Kingdom with workers in Ghana, Haiti, India, Kenya, and Uganda. Of global online workers on the Elance freelancing platform, part of Upwork, 44 percent are women, and many wish to balance work and family life. Among respondents to a survey of online workers for this Report, the ability to work flexible hours from home is considered the greatest advantage of online work.

Increasing labor productivity

For the economy as a whole, the most profound impact of the internet on individuals is that it makes workers more productive. By handing off routine and repetitive tasks to technology, workers can focus on activities with higher value. Judicious use of massive open online courses (MOOCs) or online teaching tools like Khan Academy lets teachers spend more time fostering discussion and working with students who fall behind. Researchers can dedicate more time thinking and innovating rather than searching for information or duplicating other people's work. Managers can work more easily with teams across borders. These benefits are largest for the higher skilled. In fact, there has never been a better time to be a high-skilled worker, as the returns to education remain high—almost 15 percent for an additional year of tertiary education in developing countries.

The biggest gains from digital technologies for the poor are likely to come from lower information and search costs. Technology can inform workers about prices, inputs, or new technologies more quickly and cheaply, reducing friction and uncertainty.[15] That can eliminate costly journeys, allowing more time for work and reducing risks of crime or traffic accidents (box O.4).[16]

Using technology for information on prices, soil quality, weather, new technologies, and coordination with traders has been extensively documented in agriculture (see sector focus 1 in the full Report). In Honduras, farmers who got market price information via short message service (SMS) reported an increase of 12.5 percent in prices received.[17] In Pakistan, mobile phones allow farmers to shift to more perishable but higher return cash crops, reducing postharvest losses from the most perishable crops by 21–35 percent.[18] The impacts of reduced information asymmetries tend to be larger when learning about information in distant markets or among disadvantaged farmers who face more information constraints.[19]

Increasing the consumer surplus

Where the internet has led to a full automation of services, many jobs have been lost—few travel agents, booksellers, or music store employees are left. But these same dynamics have been a boon to consumers. There are new digital goods and services—such as e-books, digital music, and search engines. And the internet has transformed existing ones—such as taxi

Box O.4 Digital dividends and the bottom billion

The poor benefit from digital technologies, but only modestly in relation to the true potential. Nearly 7 of 10 people in the bottom fifth of the population in developing countries own a mobile phone, improving their access to markets and services. In rural Niger, agricultural price information obtained through mobile phones reduces search costs by 50 percent.[a] In rural Peru, access to mobile phones boosted household real consumption by 11 percent between 2004 and 2009, reducing poverty by 8 percentage points and extreme poverty by 5.4 percentage points.[b]

The poor can benefit from digital technologies even when they don't own a mobile phone or a computer. For example, a digital ID, by giving millions of poor people an official identity, increases their access to a host of public and private services. In Narma Dih—a village in Bihar, India, with no electricity or all-weather roads—poor farmers benefit from digitally enabled agricultural extension services from Digital Green, an NGO (nongovernmental organization) that trains farmers using locally produced how-to videos.[c]

Yet the poor are capturing only a modest share of the digital dividends. While a majority of the poor have a mobile phone, they can't access or afford the internet. In Latin America, fewer than 1 in 10 poor households is connected to the internet. In the Central African Republic, one month of internet access costs more than 1.5 times the annual per capita income. Even mobile phones are expensive: the median mobile phone owner in Africa spends over 13 percent of her monthly income on phone calls and texting. And many poor lack the basic literacy and numeracy skills needed to use the internet. In Mali and Uganda, about three-quarters of third-grade children cannot read. In Afghanistan and Niger, 7 of 10 adults are illiterate.

In advanced economies the poor face the prospects of stagnant wages and fewer opportunities, as they are increasingly forced to compete with those displaced by automation. Digital technologies can also exacerbate socioeconomic disparities. For example, the internet voting on municipal budget proposals in the state of Rio Grande do Sul in Brazil and citizen engagement initiatives such as Uganda's U-report show that the new users are more likely to be male, young, university educated, and wealthy—those already better off before the internet's advent.[d]

Rapid technological progress will increasingly enable the poor to afford and use many digital services. But their ability to reap dividends from these investments will be largely determined by providing the analog complements.

Source: WDR 2016 team.

a. Aker and Mbiti 2010.
b. Beuermann, McKelvey, and Vakis 2012.
c. Chomitz 2015.
d. Spada and others 2015; Berdou and Lopes 2015.

and hospitality services, health, education, and retail. This has increased the variety of goods and services available, including those for leisure. The internet thus enhances consumer welfare, but in ways that are hard to measure.

People's perceptions are that digital technologies have certainly made them better off. In 12 countries surveyed in Africa, 65 percent of people believe that their family is better off because they have mobile phones, whereas only 20 percent disagree (14.5 percent not sure).[20] And 73 percent say mobile phones help save on travel time and costs, with only 10 percent saying otherwise. Two-thirds believe that having a mobile phone makes them feel more safe and secure.

Some studies have attempted to quantify the economic value of these gains. A McKinsey survey of consumers in France, Germany, the Russian Federation, Spain, the United Kingdom, and the United States in 2010 found that a household is willing to pay an average of US$50 a month for services it now gets for free on the internet. Time-use data in the United States suggest that the median individual gains more than US$3,000 annually from the internet. In Estonia, digital signatures saved 20 minutes per transaction. And a study of the time costs of searching for information shows that the average online search tends to be 15 minutes faster, the results are more accurate and relevant, and the experience more enjoyable than offline search in a library. On average, people might realize a consumer surplus as high as US$500 a year from such services, adding up to vast benefits when aggregated over all users.

The internet can make governments more capable and responsive

Governments provide services that are typically nontradable, often lack scale, and are not subject to market competition. Raising efficiency in the public sector is thus challenging, and one might expect the internet to bring large benefits in public service provision. There are indeed many examples where the internet has raised the capabilities of the public sector. Better tools for communicating with citizens and providing information also allow greater participation—through inclusion in government assistance programs, or feedback to and monitoring of public officials. And the internet helps citizens to connect online and organize for collective action in order to put pressure when government performance falls short of people's expectations.

Expanding participation

Lack of identity is an impediment for poor people to exercise their basic democratic and human rights. Where civil registration systems are weak or nonexistent, many of the poor are simply not counted. Digital identification can help overcome barriers to participation. Many countries have introduced general-purpose digital identity (ID) schemes or specific systems for elections or to manage postconflict transfers—with numerous benefits, including making the public sector more efficient. Nearly 900 million Indians have been issued digital IDs in the past five years, which they are using to open bank accounts, monitor attendance of civil servants, and identify recipients of government subsidies. Nigeria's e-ID revealed 62,000 public sector "ghost workers," saving US$1 billion annually. But the most important benefit may be in better integrating marginalized or disadvantaged groups into society.

Digital technologies also enable the poor to vote by providing them with robust identification and by curtailing fraud and intimidation through better monitoring. Mobile phones enable citizens to report instances of violence and voter intimidation, improving electoral participation. In Mozambique, SMS messages allowed citizens to report electoral irregularities and increased voter turnout by 5 percentage points.[21] Ushahidi and Uchaguzi are crowdsourced applications that report and map election violence in Kenya. By multiplying the sources of information, the internet can reduce the risk of media capture and make censorship difficult.

Improving public sector capability

The internet raises efficiency and productivity through automation and data-driven management. Almost all countries have tried to automate tax and customs administration, as well as budget preparation, execution, and accounting. Results have been mixed. E-filing reduces tax compliance costs, and one-stop computerized service centers and online portals have improved service efficiency. E-procurement helped India and Indonesia inject more competition into the process by increasing the probability that the winning bidder comes from outside the project's region. This also improved the quality of infrastructure. But a majority of public sector digital technology projects fail to achieve the project objectives, resulting in considerable fiscal waste.[22]

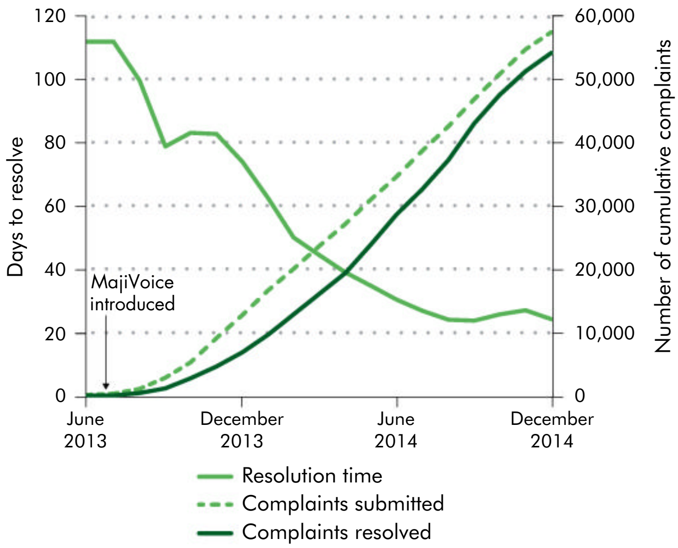
Digital technologies can also improve management by monitoring the performance of workers. A small but growing impact evaluation literature reports generally positive effects of technology-based monitoring on worker absenteeism when combined with other institutional reforms.[23] In Uganda, where teacher absenteeism is estimated at 27 percent, head teachers use mobile phones to record attendance and transmit data to a central database that generates weekly reports. Combined with incentive pay for teachers tied to attendance, the program reduced absenteeism by 11 percentage points. The internet also provides real-time data for better planning and management of service facilities. In Ghana, Kenya, Tanzania, and Zambia, health workers use mobile phones to report counterfeit drugs and stock-outs. Aggregated in a central database and geographically mapped, this information helps administrators address drug and equipment shortages.

Providing citizens the opportunity to give specific feedback quickly has helped improve performance in many instances. Mobile-phone apps like SeeClickFix and FixMyStreet in the United States and the United Kingdom let users report potholes, graffiti, and illegal dumping. Governments can report back on fixes, closing the feedback loop. Internet call centers enabling citizens to report problems and track the status of their requests are now standard in Barcelona, Buenos Aires, Muscat, Rio de Janeiro, Seoul, and Ulaanbaatar, to name a few cities. The Nairobi water company uses MajiVoice, and one of the electricity supply companies in the Dominican Republic, EDE Este, uses a similar system to receive complaints, track their resolution through an automated workflow, and regularly update citizens on progress. When implemented well, citizens eagerly take up the opportunity to give feedback, and resolution time declines (see figure O.12).

Advancing voice

Governments, particularly those in digitally advanced countries like Estonia, the Republic of Korea, and Singapore, are beginning to take advantage of data analytics and digital platforms for faster, more informed, and integrated policy making. The internet also opens new avenues for participatory democracy. Iceland has experimented with crowdsourcing its constitution, and Brazil and Estonia have explored

Figure O.12 More complaints were resolved more quickly in the Nairobi water utility after the introduction of digital customer feedback

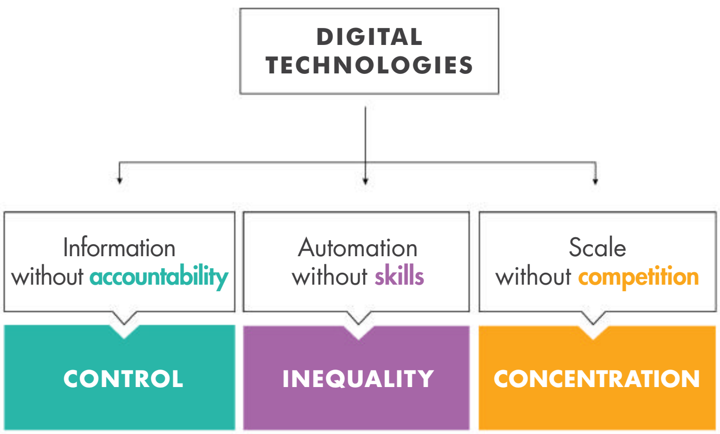


Source: World Bank 2015. Data at http://bit.do/WDR2016-FigO_12.

Note: For more details see figure 3.11 in the full Report.

participatory lawmaking. By dramatically lowering the cost of communication and coordination, social media can overcome the traditional barriers to citizen collective action. A growing empirical literature has also shown that cellphones and the use of Twitter and Facebook aided protests during the Arab Spring in the Arab Republic of Egypt,[24] antiwar demonstrations in the United States,[25] and citizen mobilization across Africa.[26]

Figure O.13 Without strong analog complements, opportunities may turn into risks



Source: WDR 2016 team.

The risks: Concentration, inequality, and control

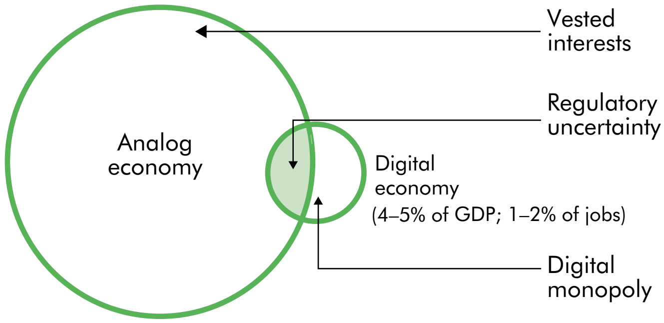
So, the internet can be an effective force for development. But as the Report documents, the benefits too often are not realized, and the internet sometimes makes persistent problems worse. Why? The key insight is that for complex occupations, business activities, or public services, the internet usually can make only a portion of tasks cheaper, more efficient, or more convenient through automation. Another portion still requires capabilities that humans possess in abundance but computers do not. Many traditional tasks of an accountant or bank teller are now automated, such as making calculations or processing withdrawals. Others require complex reasoning or socioemotional skills, such as designing tax strategies or advising clients. Likewise, many public services involving provision of information or routine permissions can be automated. But others, such as teaching or policing, need a high degree of human discretion, tacit knowledge, and judgment.

Many problems and failures of the internet surface when digital technology is introduced but the important analog complements remain inadequate. What are these complements? The main ones are regulations that ensure a high degree of competition, skills that leverage technology, and institutions that are accountable (figure O.13).

- When the internet delivers scale economies for firms but the business environment inhibits competition, the outcome could be excessive ***concentration*** of market power and rise of monopolies, inhibiting future innovation.
- When the internet automates many tasks but workers do not possess the skills that technology augments, the outcome will be greater ***inequality***, rather than greater efficiency.
- When the internet helps overcome information barriers that impede service delivery but governments remain unaccountable, the outcome will be greater ***control***, rather than greater empowerment and inclusion.

The interplay between internet investments and reforms in complementary areas is at the core of policy debates about technology impacts. A 2008 study by Claudia Goldin and Lawrence Katz,[27] drawing on earlier work by Jan Tinbergen, framed these dynamics in the labor market as a “race between education and technology.” As technology progresses, some skills become obsolete. Workers must acquire new skills that help them become more productive with the help of that technology. Adjustment takes time and will be painful for many, but this is how economies progress. The sections that follow discuss risks and complements in the private sector, in labor markets, and in the public sector.

Figure O.14 Factors explaining the lower adoption of digital technologies by businesses



Source: WDR 2016 team.

Growing concentration: The nexus between regulations and technology

One of the main mechanisms for the internet to promote economic growth is competition. Information flows increase and speed up so that customers have more choice and can compare prices more easily. Firms that use technology more effectively will do well and force others to follow suit. There is considerable evidence that this is happening throughout the economy, but three potential problems could emerge.

First, while the internet has spread quickly in the private sector of some countries, adoption among non-ICT firms has been slow in other countries. Larger, fast-growing, skill-intensive, export-oriented, and urban firms tend to use digital technologies more. The causes of these differences are not well understood. Differences in adoption rates may simply reflect differences in income, sector characteristics, and management capabilities, but they could also be due to barriers to adoption (figure O.14). One possibility is high import duties for digital goods and services in some countries. Another is market distortions and protections that allow firms to maintain profits without threats from more innovative entrants. For example, firms in Mexico that faced competition from China increased the number of computers per employee and became twice as likely to use the internet for purchasing as those that didn't face significant competition.

Second, when online businesses enter the turf of their offline counterparts, disruption can be great, and regulators are often unsure whether or how to react. Recently, "on-demand economy" firms Uber and Airbnb have challenged established taxi and hotel industries. Their platform business model is scalable and global and has spawned numerous local imitators. In cities from Paris to Delhi to Beijing, the reaction has been a scramble by offline incumbents to keep these new competitors out, usually by appealing to regulators to enforce established sector regulations such as the knowledge of the city (in the case of London cabbies) or insurance requirements. This can be a valid appeal when regulations protect public safety and ensure minimum service levels. But these new models often succeed because they enter heavily distorted markets with virtual monopolies or oligopolies. The risk of allowing underregulated entrants into a market must therefore be weighed against the benefits to consumers from lower prices and greater convenience.

The third potential risk comes from the dominant position of many online platforms and internet intermediaries. Economic history shows that firms are tempted to exploit a dominant position. Large internet firms may be no exception. The economics of the internet favor natural monopolies,[28] and some platforms now dominate their markets. They enjoy such high profits that they can quickly capture new markets by buying out competitors or developing a rival service; local startups, including those in developing countries, are left with tiny niche markets. Some of the biggest internet firms now face scrutiny from regulators. Google, which captures almost one-third of global digital advertising revenue,[29] has been investigated for preferential placement of its own products, exploiting third-party content, and exclusionary practices in its placement of advertising.[30] Amazon, the largest sales platform for book publishers, has used its market power to enforce its pricing policies. Safaricom, operating the M-Pesa payment system, resisted the entry of competing service providers. The vast amount of identifiable personal information that many of these companies collect raises further challenges (box O.5).

It is too early to tell whether these problems will diminish the overall economic benefits from the internet or be mitigated by the sector's low entry costs and rapid technological change. Consumers have generally benefited from the internet-based business models of existing and new firms. Markets are extremely dynamic, so many advantages from scale or moving first may be temporary. And greater size

Box O.5 What Facebook "Likes" reveal—the convenience-privacy trade-off

When economists such as George Stigler and Richard Posner wrote about privacy and economics in the early 1980s, they raised many issues debated today, but at that time the "storage and retrieval of information, and its accurate dissemination, [were] often extremely expensive."[a] Today, an enormous collection of identifiable information is making service delivery more efficient and more relevant. Service providers can better target or price their products based on known characteristics and preferences. Search engines provide more relevant search results. Health and auto insurers can better price premiums with verifiable information about exercise or driving behavior. And governments can use data systems to reduce the bureaucratic burden for citizens. In Estonia's e-government system, citizens never have to provide the same information twice.

The problem is that few people know how these large amounts of data are collected and used—and who controls them. Users are not always aware of and providers often don't tell what information is collected. The secret snooping by governments can be for legitimate law enforcement reasons, but sometimes violates laws and rights, as the Edward Snowden revelations about spying by the security agencies of the United States, the United Kingdom, and others have shown. A consequence has been a new "data nationalism," where countries are demanding that data about their residents be stored within their territory or favoring domestic technology that may be inferior or more expensive, but is trusted more.

Data collectors often sell the data to others. One data broker assembled an average of 1,500 pieces of information about more than half a billion consumers worldwide from information people provided voluntarily on various websites. But even easily accessible data such as Facebook "Likes" can predict sensitive characteristics including "sexual orientation, ethnicity, religious and political views, personality traits, intelligence, happiness, use of addictive substances, parental separation, age, and gender."[b] And smartphone sensors can infer a user's "mood, stress levels, personality type, bipolar disorder, demographics (e.g., gender, marital status, job status, age), smoking habits, overall wellbeing, progression of Parkinson's disease, sleep patterns, happiness, levels of exercise, and types of physical activity or movement."[c]

The risks? Cybercrime such as identity theft when data stored insecurely fall into the wrong hands. Discrimination when customers are charged a higher premium or interest rate, or denied a job based on erroneous information they can't easily correct. Persistence of dated information that denies protection from embarrassing but irrelevant information or a second chance, which prompted Europe's "right to be forgotten" ruling. And perhaps most important, reduced trust and thus suboptimal use of the internet. These concerns vary across societies. Fifty-eight percent of Nigerians and 57 percent of Indians believe private information on the internet is very secure, but only 18 percent of French and 16 percent of German respondents do.[d]

Sources: WDR 2016 team, based on Peppet 2014; Castro 2013; *Economist* 2014; Kosinski, Stillwell, and Graepel 2013.

a. Posner 1981.
b. Kosinski, Stillwell, and Graepel 2013.
c. See Peppet (2014) for individual references.
d. CIGI and Ipsos 2014.

allows large firms to provide services and products at low cost or free of charge, and their high profits fuel investments in research and development (R&D). At the same time, it is clear that competition and market structure on the internet are in many ways not so different from the offline world. Policies need to ensure that all innovative companies can enter markets and compete on equal terms. Otherwise, the economic performance between firms of different size and in different countries could diverge further and contribute to similarly divergent performance of national economies.

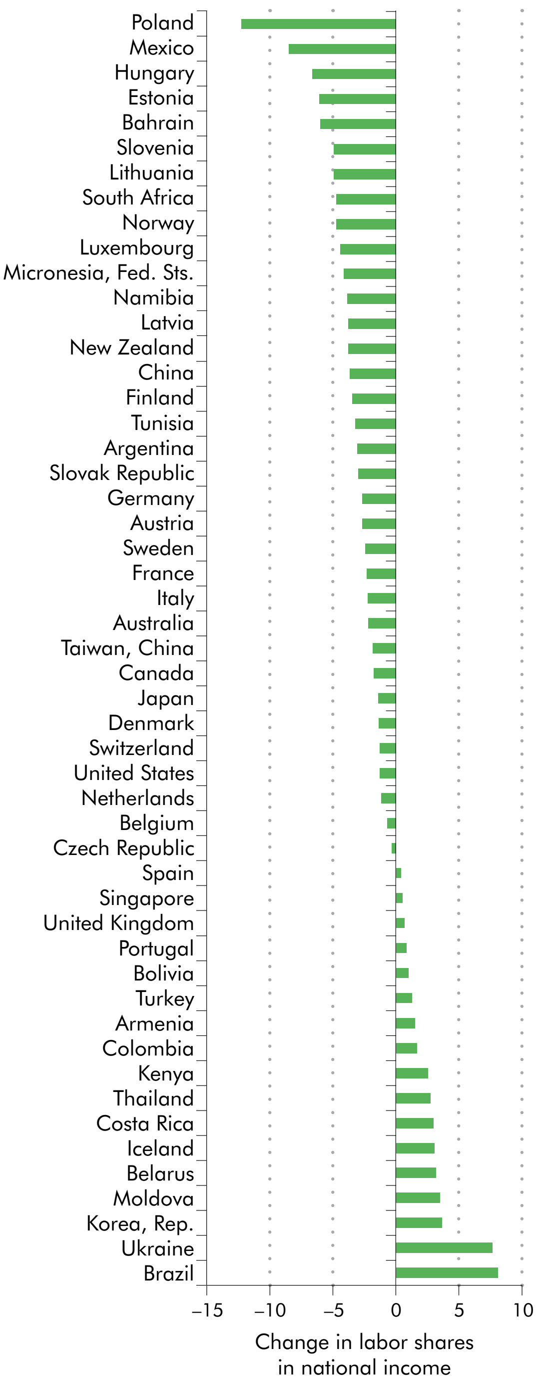
Rising inequality: The race between skills and technology

If the internet and related technologies promote growth, how are the gains shared in the labor market? While digital technologies raise productivity and enhance overall welfare, labor market disruptions can be painful and can result in higher inequality. Global trends provide some indication. One is that the share of national income that has gone to labor, especially routine labor, has fallen quite sharply in many developing countries—though Brazil and Ukraine are exceptions (figure O.15).[31] Inequality has

Figure O.15 Labor shares of national income are falling in many countries, including some developing countries

Trends in labor shares in output since 1975

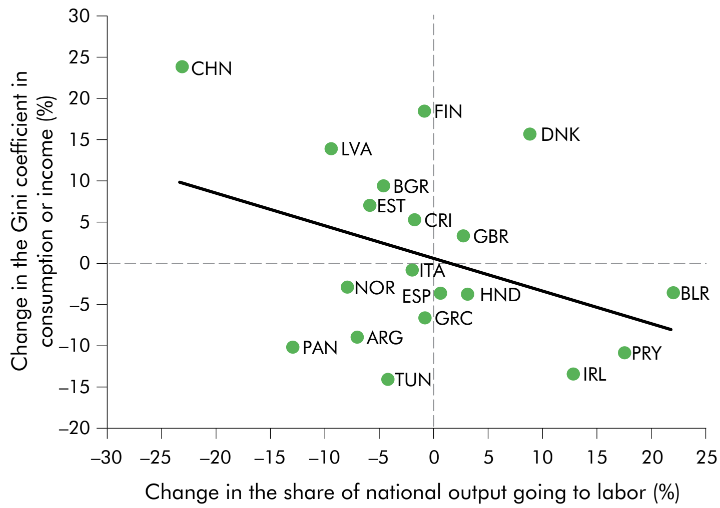
percentage points every 10 years



Source: Karabarbounis and Neiman 2013. Data at http://bit.do/WDR2016-FigO_15.

Figure O.16 Falling labor shares in national income are associated with rising inequality

Change in Gini coefficient vs. growth in labor share in national income, 1995–2010



Source: Eden and Gaggl 2015, for the WDR 2016. Data at http://bit.do/WDR2016-FigO_16.

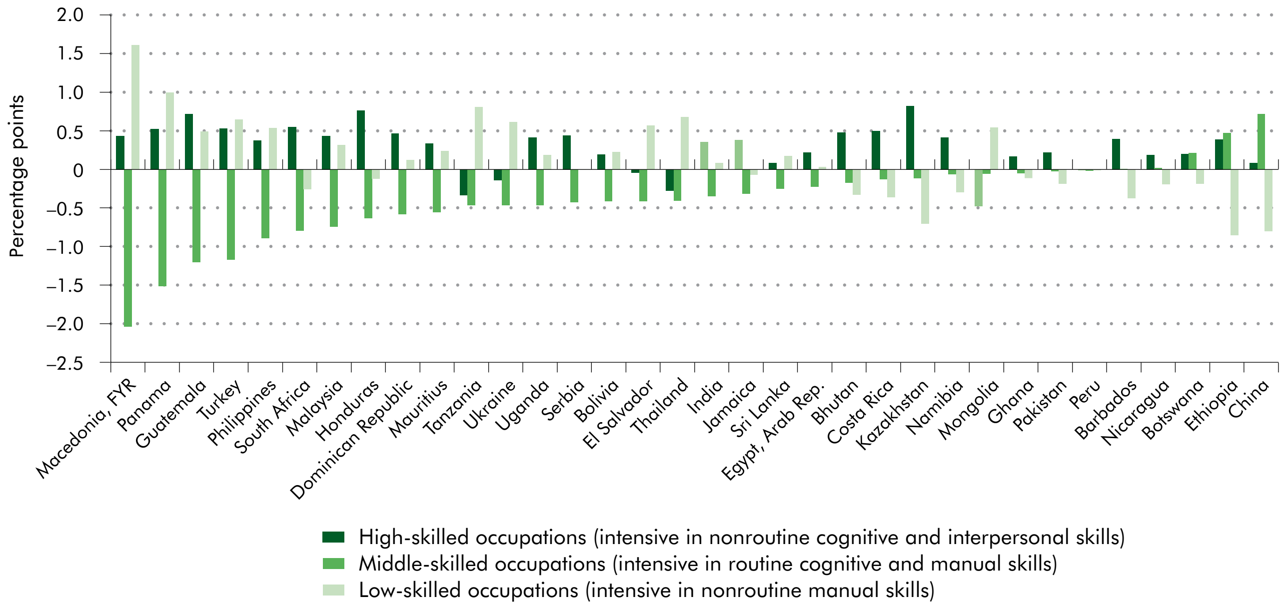
increased more where this shift in incomes toward capital and away from labor has been higher (figure O.16). A number of recent studies have linked technological change to this rising inequality (see chapter 2 in the full Report).

A related trend is the polarization—or "hollowing out"—of the labor market, not only in advanced economies, but increasingly also in many developing countries. The share of employment in high-skilled occupations is up, as is the share of low-skilled jobs. The share of middle-skilled employment, in contrast, is down in most developing countries for which detailed data are available (figure O.17). And these types of jobs are often near the top of the income distribution in low-income countries, as in Africa. A notable exception to these global trends is China, where growing mechanization in agriculture has led to a (perhaps temporary) increase in routine, mid-level labor. Exceptions also include some countries rich in natural resources and commodity exporters, which include several countries in Central Asia and Latin America.

What explains all this? Machines can increasingly perform routine tasks more quickly and cheaply than humans, and much of what is considered nonroutine today—such as translation, insurance underwriting, or even medical diagnostics—computers might do just as well tomorrow. Unlike previous technological transformations such as the mechanization of

Figure O.17 The labor market is becoming more polarized in many developing countries

Annual average change in employment share, circa 1995–circa 2012



Sources: WDR 2016 team, based on ILO KILM (ILO, various years); the International Income Distribution database (I2D2; World Bank, various years); National Bureau of Statistics of China (various years). Data at http://bit.do/WDR2016-FigO_17.

Note: The figure displays changes in employment shares between circa 1995 and circa 2012 for countries with at least seven years of data. The classification follows Autor 2014. High-skilled occupations include legislators, senior officials and managers, professionals, and technicians and associate professionals. Middle-skilled occupations comprise clerks, craft and related trades workers, plant and machine operators and assemblers. Low-skilled occupations refer to service and sales workers and elementary occupations. For more details see figure 2.15 in the full Report.

agriculture or the automation of manufacturing, the internet affects well-paying white-collar jobs even more than blue-collar jobs.

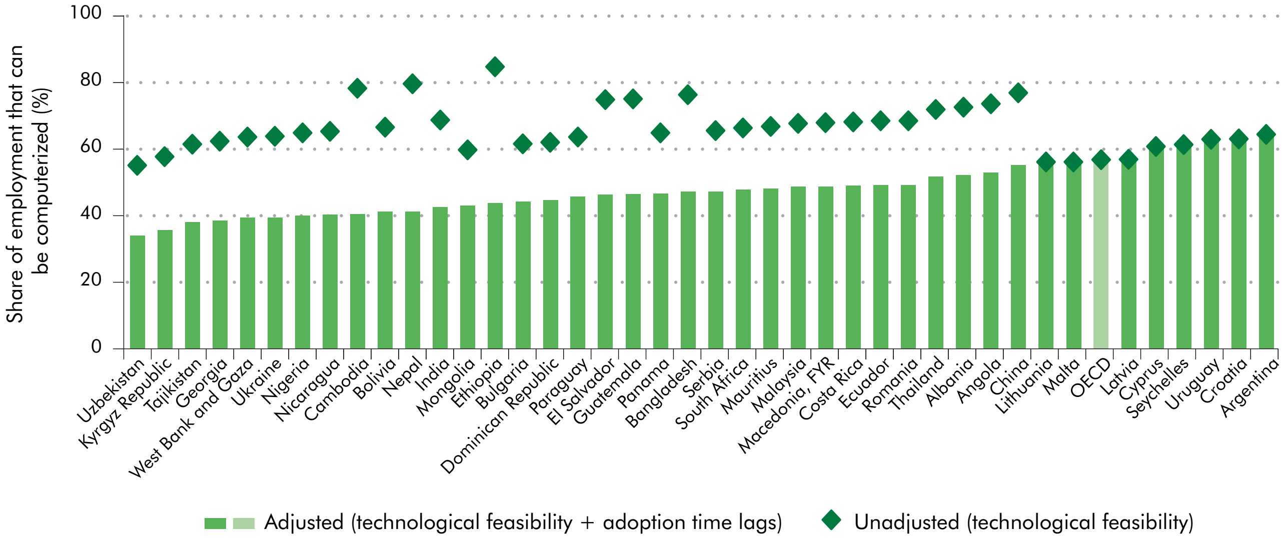
Some mid-level workers will have additional skills that allow them to switch to better-paid nonroutine occupations in which technology tends to augment human capital and make skilled workers more productive. These workers will gain from technological disruption. In developing countries, returns to education are highest among those with tertiary education, and they are higher and rising faster in ICT-intensive occupations.[32] Those who do not have such skills will need to seek work in lower-skilled, nonroutine occupations, such as janitorial services, hospitality, or personal care. Demand for such services could increase, but perhaps not enough to prevent downward wage pressure as the available workforce in these sectors grows. These dynamics are consistent with the rising returns to education and income inequality we see in many countries.

The implications for developing countries depend on the pace of technological disruption. The share of occupations that could experience significant automation is actually higher in developing countries than in more advanced ones, where many of these jobs have already disappeared (figure O.18). But it will likely take longer in lower-income countries. Most of them are still fairly low-tech, with only about one-third of urban jobs in a sample of developing countries using any ICTs at work. And wage rates are still low, with a larger share of manual nonroutine labor, so investments in technology will be less profitable for firms. This does not mean, however, that lower-income countries need not pay attention to these trends. Most important, even without significant employment shifts, the nature of jobs is changing toward skills that remain hard for technology to emulate: that is, advanced cognitive and socioemotional skills. The policy response, besides rethinking social protection systems, is better and more responsive education and training—areas where reforms take many years to pay off.

It is important to keep in mind the historical perspective that job displacement and job losses from technological change are an integral part of economic progress. It is precisely rising productivity—as technology replaces some human labor but augments the skills of remaining and new workers—that generates

Figure O.18 From a technological standpoint, two-thirds of all jobs are susceptible to automation in the developing world, but the effects are moderated by lower wages and slower technology adoption

Estimated share of employment that is susceptible to automation, latest year



Source: WDR 2016 team. See figure 2.24 in the full Report for more details. Data at http://bit.do/WDR2016-FigO_18.

Note: For more details see figure 2.24 in the full Report. OECD = Organisation for Economic Co-operation and Development.

growth and frees human and financial resources for deployment in sectors with higher returns. It also reduces the need for humans to do physically hard, repetitive, or dangerous work. Such trends will be welcome in countries that are rapidly aging or where the population is declining, or in professions where skills are in short supply. Telemedicine and automated diagnostics, for instance, allow medical experts to serve many more people, even remotely in areas with a shortage of doctors.

And fears of "technological unemployment" go back to the industrial revolution. Even such thinkers as the economist John Maynard Keynes and the writer Isaac Asimov submitted to this fallacy. Keynes, in the 1930s, predicted 15-hour workweeks by the end of the 20th century, and Asimov, in a 1964 essay, expected that one of the most pressing problems for humanity by 2014 would be boredom "in a society of enforced leisure." Yet over the centuries, economies have adapted to massive changes in labor markets—the largest by far, being the shift out of agriculture. In 1910, there were 12 million farmworkers in the United States. One hundred years later, there were only 700,000 in a population more than three times larger. Still, nobody can predict the full impact of technological change in coming decades, which may be faster and broader than previous ones. What is clear, however, is that policy makers face a race between technology and education, and the winners will be those who encourage skill upgrading so that all can benefit from digital opportunities.

Engendering control: The gap between institutions and technology

The internet was expected to usher in a new era of accountability and political empowerment, with citizens participating in policy making and forming self-organized virtual communities to hold government to account. These hopes have been largely unmet. While the internet has made many government functions more efficient and convenient, it has generally had limited impact on the most protracted problems—how to improve service provider accountability (principal-agent problems) and how to broaden public involvement and give greater voice to the poor and disadvantaged (collective action problems).

Whether citizens can successfully use the internet to raise the accountability of service providers depends on the context. Most important is the strength of existing accountability relationships between policy makers and providers, as discussed in the 2004 *World Development Report, Making Services Work for Poor People*. An examination of seventeen digital engagement initiatives for this Report finds that of nine cases in which citizen engagement involved a partnership between civil society organizations (CSOs) and government,

Table O.2 Classifying the digital citizen engagement cases

Case	Location	Additional offline mobilization	CSO partners with government	Collective feedback	Impact: Citizen uptake	Impact: Government response
Por Mi Barrio	Uruguay	✓	✓		L	H
I Change My City	India	✓	✓		M	H
Lungisa	South Africa	✓	✓		L	H
Pressure Pan	Brazil	✓		✓	H	M
Rappler	Philippines	✓	✓	✓	H	M
Change.org	World	✓		✓	H	M
U-report	Uganda	✓	✓	✓	H	L
Huduma	Kenya				L	L
Daraja Maji Matone	Tanzania	✓			L	L
FixMyStreet	Georgia		✓		L	L
Check My School	Philippines	✓	✓		L	L
Barrios Digital	Bolivia				L	L
e-Chautari	Nepal				L	L
I Paid a Bribe	India		✓		M	L
Mejora Tu Escuela	Mexico				L	L
Karnataka BVS	India				L	L
Sauti Za Wananchi	Tanzania		✓		L	L

Source: WDR 2016 team, based on Peixoto and Fox 2015, for the WDR 2016.

Note: Examples are arranged by degree of government response. CSO = civil society organization. L = low; M = medium; H = high.

three were successful (table O.2). Of eight cases that did not involve a partnership, most failed. This suggests that, although collaboration with government is not a sufficient condition for success, it may well be a necessary one. Another ingredient for success is effective offline mobilization, particularly because citizen uptake of the digital channels was low in most of the cases. For example, Maji Matone, which facilitates SMS-based feedback about rural water supply problems in Tanzania, received only 53 SMS messages during its first six months of operation, far less than the initial target of 3,000, and was then abandoned.

Political participation and engagement of the poor has remained rare, while in many countries the internet has disproportionately benefited political elites and increased the governments' capacity to influence social and political discourse. Digital technologies have sometimes increased voting overall, but this has not necessarily resulted in more informed or more representative voting. In the Brazilian state of Rio Grande do Sul, online voting increased voter turnout by 8 percentage points, but online voters were disproportionately wealthier and more educated (figure O.19). Even in developed countries, engaging citizens continues to be a challenge. Only a small, unrepresentative subset of the population participates, and it is often difficult to sustain citizen engagement. There is no agreement among social scientists on whether the internet disproportionately empowers citizens or political elites, whether it increases polarization, or whether it deepens or weakens social capital, in some cases even facilitating organized violence.

The use of technology in governments tends to be successful when it addresses fairly straightforward information and monitoring problems. For more demanding challenges, such as better management of providers or giving citizens greater voice, technology helps only when governments are already responsive. The internet will thus often reinforce rather than replace existing accountability relationships between governments and citizens, including giving governments more capacity for surveillance and control (box O.6). Closing the gap between changing technology and unchanging institutions will require initiatives that strengthen the transparency and accountability of governments.

Making the internet universal, affordable, open, and safe

First-generation ICT policies involving market competition, private participation, and light-touch regulation have led to near-universal access and affordability of mobile telephony, but have so far been less successful in spreading internet services. Much of the explanation lies in continued policy failures such as regulatory capture, troubled privatizations, inefficient spectrum management, excessive taxation of the sector, and monopoly control of international gateways. At the same time the absence of global consensus in dealing with the next-generation issues—such as privacy, cybersecurity, censorship, and internet governance—is resulting in more circumspect and diverse approaches to regulating the internet (box O.7 and figure O.20).

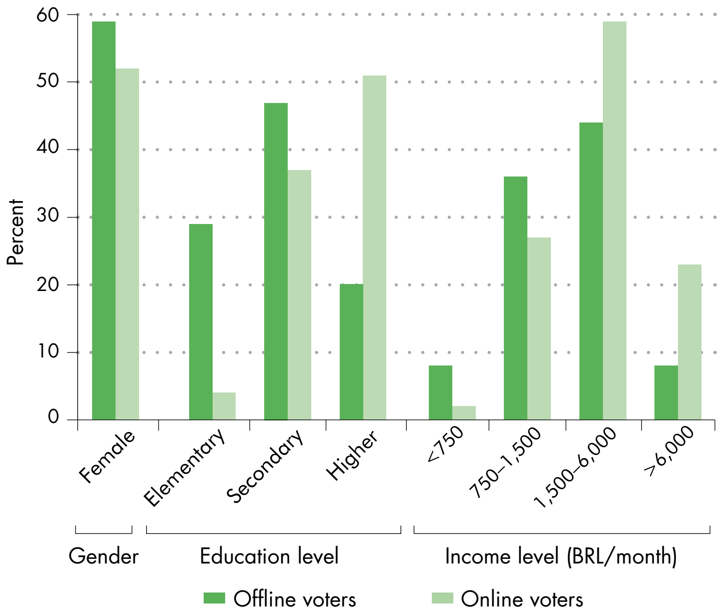
Supply-side policies: Availability, accessibility, and affordability

A useful framework for analyzing supply-side ICT policies is to consider the value chain that stretches from the point where the internet enters a country (the first mile), passes through that country (the middle mile) to reach the end user (the last mile), and certain hidden elements in between (the invisible mile).

- The first mile can be improved by liberalizing the market for satellite dishes and eliminating monopoly status over the international gateway and cable landing stations.
- Strengthening the middle mile involves liberalizing the market for building and operating backbone networks, encouraging open access to the incumbent's network, requiring all major infrastructure programs (such as roads, railways, pipelines, and energy distribution) to include provision for an optical fiber link, setting up internet exchange points, and creating local caches for frequently used content.
- Government policies can encourage the provision of last mile connectivity by permitting competing facilities, especially for intermodal competition (between cable, wireless, and digital subscriber line), and mandating the incumbent to make local access lines available to competitors at wholesale prices (local loop unbundling).
- The most critical portion of the invisible mile involves spectrum management, which requires increasing the amount of spectrum available, ensuring competitive access, encouraging sharing of essential facilities, such as radio masts, and liberalizing the market for spectrum resale.

Figure O.19 Internet voting can increase voter participation but can be biased toward more privileged groups

Profile of online and offline voters in a participatory budgeting vote in Rio Grande do Sul, Brazil, 2011–12



Source: WDR team, based on Spada and others 2015. Data at http://bit.do/WDR2016-FigO_19.
Note: BRL = Brazilian *real*.

In addition to pure ICT policies, almost everything that the private sector, citizens, or governments do on the internet requires some essential building blocks (box O.8).

Demand-side policies: Open and safe internet use

The challenges facing internet stakeholders today are as much about how networks are used (demand) as how they are built (supply). Global interconnectedness introduces new vulnerabilities in areas where coordination mechanisms are weak, still evolving, or based on nongovernment models. Threats to cybersecurity, and censorship are undermining confidence and trust in the internet and increasing costs to businesses and governments, resulting in economic losses

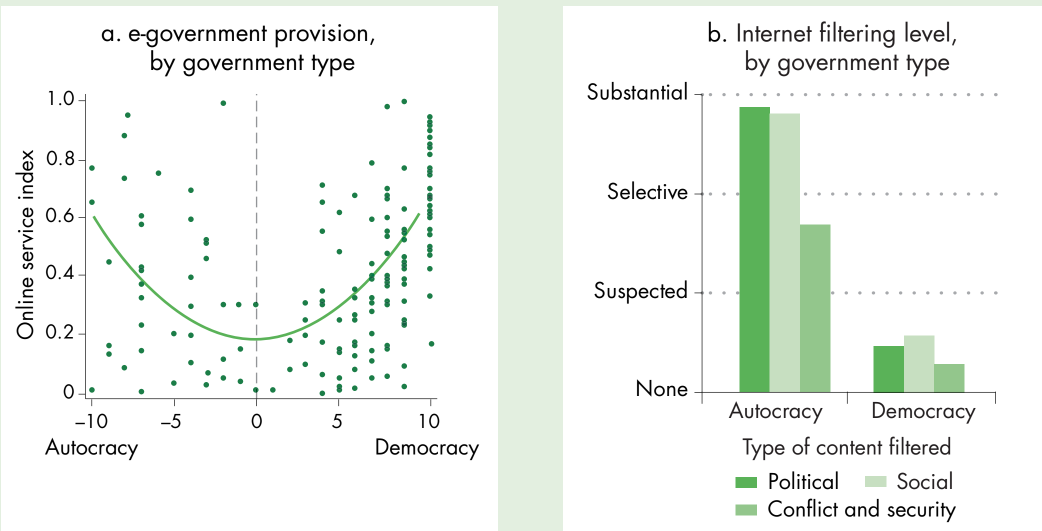
Box O.6 Nailing Jell-O to the wall—restrictions on the flow of information

Governments also interfere directly with digital networks to control access to information. An early internet pioneer, John Gilmore, claimed, "the Net interprets censorship as damage and routes around it."[a] And Bill Clinton in 2000 said, "trying to control the internet is like trying to nail Jell-O to a wall."[b] Yet private software vendors and state institutions have figured out ways to censor access to internet content, whether by shutting down the entire national web domain, as the Arab Republic of Egypt did in 2011 for five days; by preventing access to specific domestic or foreign websites; or by targeting individuals' blog posts or other social media postings. Google received 6,951 requests from governments in 2013 to remove content from search results, with the largest numbers from Turkey, the United States, and Brazil. Other countries, including China and the Islamic Republic of Iran, block Google and some other internet sites completely, although such restrictions may change in the future.

Governments of all types restrict access to content such as child pornography, hate speech, insults, or criticisms of authority figures, challenges to cultural or religious morals, or reporting of uprisings or accidents. When accountable governments determine what should be censored, the result reflects broad societal preferences. In autocratic countries, where use of the internet in government is often as high as in democratic countries (figure BO.6.1), leaders face a dilemma. If they permit open discourse on the internet, they risk challenges to their authority. If they do not, they risk isolating themselves from the global information economy. This is a balancing act, and countries are becoming more sophisticated in calibrating their control—for example, censoring content that might encourage collective action, but not individual criticism.

Internet filtering and censorship impose welfare and economic costs. First, the cost of censoring or filtering internet content diverts public funds from other uses. Monitoring domestic internet traffic and selectively blocking foreign websites requires large financial resources, technical know-how, and dedicated staff—all of which could be deployed for more productive tasks. Second, filtering and methods to circumvent it can slow the speed of internet access, which hurts business users. Third, filtering can restrict access to economically or scientifically useful information, such as the Google Scholar search engine for academic papers—indispensable in universities and labs. Fourth, in the view of the European Union, for instance, blocking foreign

Figure BO.6.1 Autocratic governments have promoted e-government while censoring the internet



Sources: WDR team, based on Polity IV 2015; UN 2014; Open Net Initiative 2013. Data at http://bit.do/WDR2016-FigBO_6_1.

Note: The Polity IV project defines government types based on characteristics such as competitiveness and openness of executive recruitment, constraints on the chief executive, and regulation and competitiveness of participation in the political process. The combined score varies from –10 for a pure autocracy to +10 for a pure democracy. See the Polity IV user's manual for details.

(Box continues next page)

Box O.6 Nailing Jell-O to the wall—restrictions on the flow of information *(continued)*

websites may be considered a nontariff trade barrier. Local companies will fill the gap. This could be considered an economic benefit or transfer rather than a cost. But it prevents domestic users' access to possibly better products, and domestic champions will not face as much innovation-inducing competition. Fifth, widespread censorship means that people avoid discussing and exchanging ideas openly, a prerequisite for an innovative and productive society.

Sources: WDR 2016 team, based on Saleh 2012; King, Pan, and Roberts 2013; Bao 2013; HRW 2015.

a. Elmer-Dewitt 1993.
b. Clinton 2000.

Box O.7 Is the internet a public good?

The internet does not have all of the characteristics of a pure public good. Access to the internet often requires a fee, so individuals can be effectively excluded from its use. But once on the internet, the consumption of information by one user does not reduce its availability to others, so in that sense it is nonrivalrous (although capacity constraints can slow down access). One way to describe the internet is as a club good that is excludable but nonrivalrous, similar to cable television; or if bandwidth is scarce, as a private good with strong positive externalities—everyone benefits as more people come online. As more essential services and information migrate to the web, anyone without access almost becomes a second-class citizen. And all citizens benefit when everyone else is better informed and when public services are provided electronically at lower cost.

The private sector should take the lead in providing internet infrastructure and services because the business case is usually compelling. But public investment or intervention is sometimes justified where the private sector is unable to provide affordable access. Historical precedents include the United States Communications Act of 1934, which called for universal "wire and radio communication service," even in remote rural areas. Some countries have gone further. Finland, for example, has defined access to the internet at broadband speeds as a legal right and pursues a universal access policy.

Source: WDR 2016 team.

Box O.8 The four digital enablers

The WDR 2016 looks at how the internet increases productivity of businesses, opportunities for people, and the effectiveness of governments. Across these domains, four major *enablers of digital development* are critical. Four spotlights in the Report discuss their benefits and potential risks.

Digital finance. Banks have been early and eager adopters of digital technologies, but many of the major innovations, such as online payments, mobile money, and digital currencies, have come from nonbank institutions, including telecom and internet companies. Some of these innovations took root first in developing countries, where they overcame shortcomings in traditional financial systems. Their benefits are distributed widely. Secure online payments fuel e-commerce. Electronic transfers reduce the cost of sending remittances. Peer-to-peer lending can vastly improve the financial access of startups. Governments can make payments and social transfers at lower cost and with less fraud and leakage. However, if financial regulations don't keep pace with the rapid technological progress, these innovations could risk affecting the stability of the overall system.

Social media. Social networks are fundamental to human society, and digital technologies have accelerated their formation. More than one-fifth of the world's population is now believed to be a member of one or more social media platforms. These platforms have been credited with facilitating economically beneficial interactions, channeling users'

(Box continues next page)

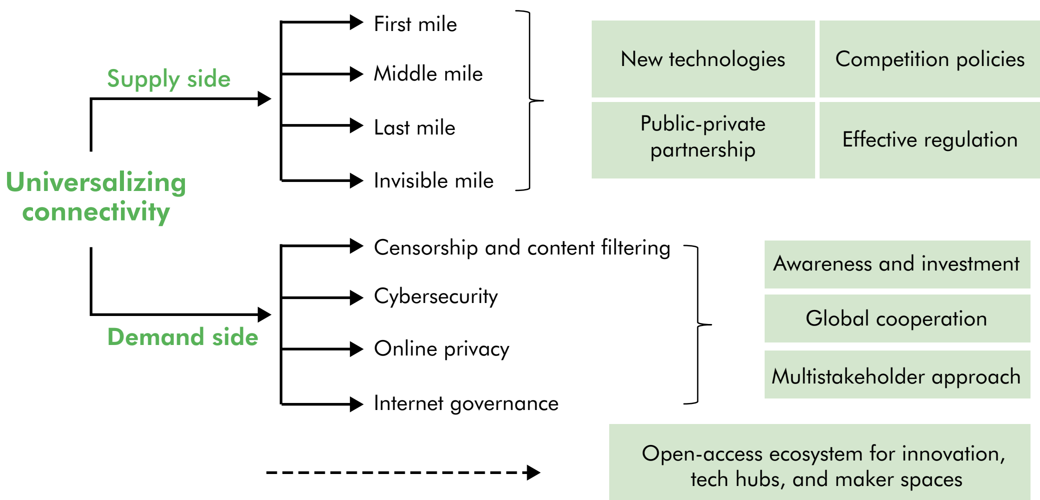
Box O.8 The four digital enablers *(continued)*

behavior in ways that are consistent with development, providing a platform for information and dissemination during natural disasters and emergencies, and encouraging political mobilization and social change. Some analysts think that social media played a critical role in recent events such as the Arab Spring and Occupy Wall Street, and thereby were instrumental in spreading democratic ideas, although many remain skeptical of their actual impact. There is still much to learn about the role social media can play in development. While a source for innovative ideas, social media also remain conduits for gossip, slander, misinformation, harassment, bullying, and crime. One important lesson is that the impact of social media on development seems to be highly specific to context. Variation in access to technology, education, and broader sociopolitical context matters. For instance, there is evidence that people in more autocratic countries are less likely to forward information (for example, by re-tweeting it).

Digital identity. Being able to prove who you are may seem trivial, but it can be transformational for those excluded from jobs and services. Simple electronic identification systems, often using biometric characteristics, have become an effective platform for secure bank transactions, voting, accessing social services, paying utility bills, and much more. Many countries, from Moldova to Nigeria and Oman, have introduced digital IDs. India is on track to register its entire population using its Aadhaar digital ID. In Estonia and other countries, thousands of different types of public and private transactions are verified with a unique electronic ID system, including legally binding contracts and voting in national elections.

Data revolution. In harnessing data for development, attention focuses on two overlapping innovations: "big data" and open data. Big data are voluminous or fast, and they come from myriad sources—from satellites to sensors and from clouds to crowds. Big data analytics is being deployed to improve traffic planning, estimate macro aggregates (also referred to as "nowcasting"), track the spread of epidemics, and improve credit scoring and job matching. Open data are those that are freely and easily accessible, machine-readable, and explicitly unrestricted in use. Governments are, or could be, the most important source of open data. Exuberant estimates of the current and potential economic value of big data and open data range from hundreds of billions to trillions of dollars per year. Yet sustained, impactful, scaled-up examples of big data and open data in developing countries are still relatively rare. Most big data are in private hands—large telecom and internet companies—which are reluctant to share it for fear of jeopardizing customer privacy or corporate competitiveness. Public agencies, too, are reluctant to share data, even when they have large public benefits. For example, of countries surveyed by the Open Data Barometer, one-third of the high-income countries and 85 percent of developing countries had made little or no progress in opening map data. Reasons include lack of technical skills, inadequate resources, and unwillingness to expose data to scrutiny.

Figure O.20 A policy framework for improving connectivity



Source: WDR 2016 team.

as well as higher security spending. For privacy and data protection, different countries are taking quite different approaches. That makes it harder to develop global services. Ensuring safe and secure access will require enhanced international collaboration, based on a multistakeholder model.

Analog complements for a digital economy

The internet has great potential to promote economic development, but only some of that potential has so far been realized. It disrupts established markets for products, services, and labor, and it disrupts the public sector—major reasons for the frequent reluctance to adopt and deploy the internet more broadly. But the benefits will come to those who embrace the changes the internet brings, not to those who resist them. And the way to get internet-enabled inclusive growth without long-term disruption is to strengthen the analog complements of digital investments (box O.9). Three policy objectives emerge from the analysis in the Report:

- A business environment where firms can leverage the internet to compete and innovate for the benefit of consumers
- Workers, entrepreneurs, and public servants who have the right skills to take advantage of opportunities in the digital world
- An accountable government that effectively uses the internet to empower its citizens and deliver services.

What these priorities highlight is that core elements of the development agenda—business regulations that ease market entry, education and training systems that deliver the skills that firms seek, and capable and accountable institutions—are becoming more important with the spread of the internet. Not making the necessary reforms means falling farther behind those who do, while investing in both technology and its complements is the key to the digital transformation.

Internet use still varies greatly between countries, as does the quality of complements, and both tend to move up with income (figure O.21). Policy priorities change as countries move along the digital transformation (figure O.22). Countries where internet use is still low should lay the foundation—such as removing barriers to internet access and adoption, promoting basic and digital literacy, and using the internet for elementary government functions like provision of information. As countries transition to higher levels

Box O.9 Technology and complements: Lessons from academic research

Recent research on growth, labor markets, and governance has taken a fresh look at the interplay between technology and other factors. These insights inform the discussion of policy priorities in this Report.

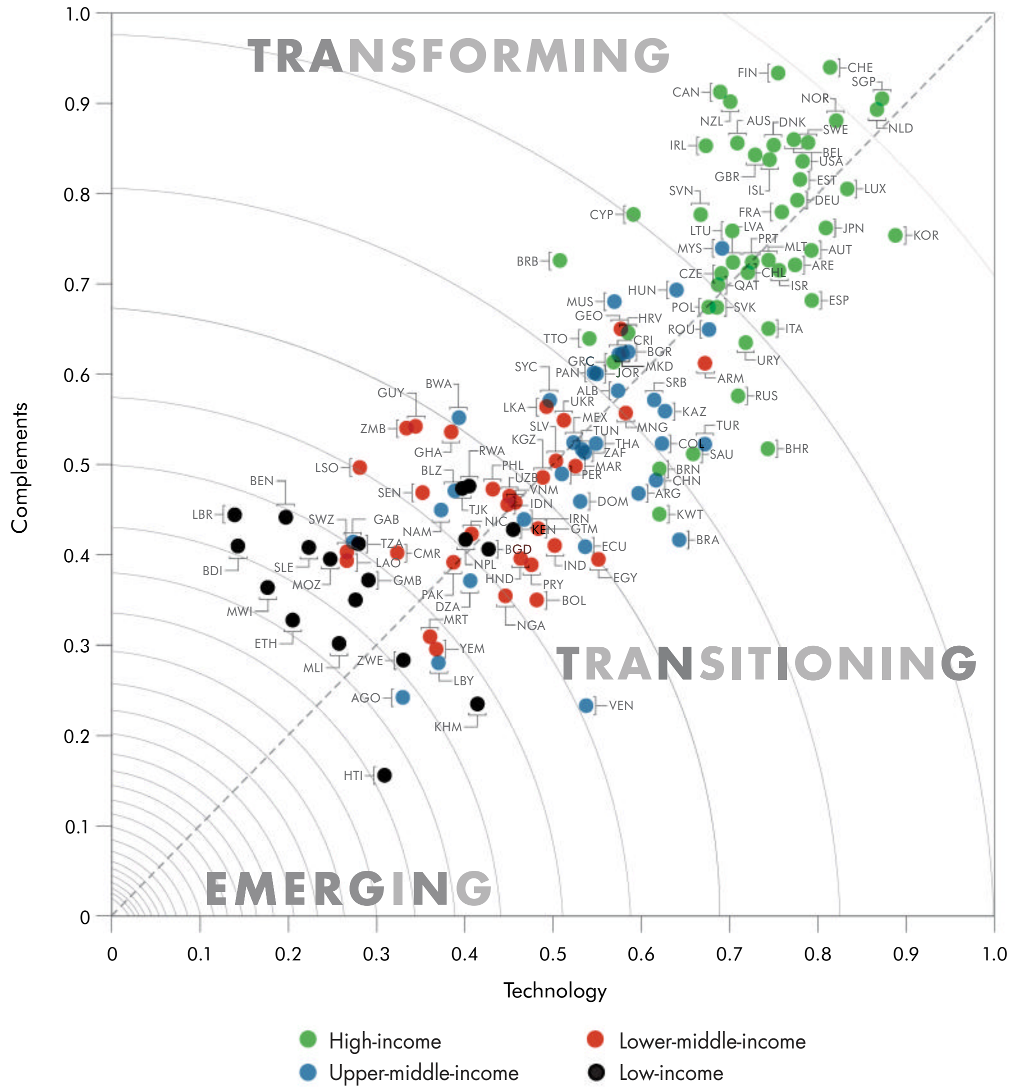
Rules. Technology interacts with rules (such as regulations and standards) to create new ideas, such as new ways of producing goods and services. Technology is traded across markets and borders, while most rules are established locally. When it encounters rules that do not match, technology fails to deliver the expected benefits. New businesses can acquire internet technology to reduce prices and increase convenience for consumers, but they will not be able to enter the market and compete if local regulations protect incumbents.

Skills. Technology interacts with workers' skills. It allows routine tasks to be automated. Workers with the right abilities will leverage technology to become more productive. Consider a modern office assistant who uses digital technologies to perform routine tasks quickly, and now spends far more time on personal interaction, complex scheduling, and other tasks that computers cannot easily perform.

Institutions. Technology interacts with discretion. Many tasks in government can also be automated, but others involve a high degree of judgment. That means that even as the internet can make many public service functions more efficient, the benefits will be limited when government officials and workers do not have the incentives to use the technology for the public good. Teacher attendance can be fairly easily monitored using digital technologies, but the quality of teaching depends on the teacher's training, resources, ability, and motivation.

Sources: Romer 2010; Autor 2014; Pritchett, Woolcock, and Samji, forthcoming.

Figure O.21 The quality of complements and technology rises with incomes



Source: WDR 2016 team. For more details see figure 5.3 in the full Report. Data at http://bit.do/WDR2016-FigO_21.

Note: Technology is measured by the Digital Adoption Index (DAI). DAI is based on three sectoral subindexes covering businesses, people, and governments, with each subindex assigned an equal weight: DAI (Economy) = DAI (Businesses) + DAI (People) + DAI (Governments). Each subindex is the simple average of several normalized indicators measuring the adoption rate for the relevant groups. Similarly, *complements* is the average of three subindicators: starting a business; years of education adjusted for skills; and quality of institutions.

of internet use, they require effective competition regulation and enforcement—including easy firm entry and exit; a greater focus on advanced cognitive and socioemotional skills that are augmented by technology; and effective e-government delivery systems for provider management and citizen engagement. Countries in advanced stages of the digital transformation need to tackle some of the most challenging tasks. They need to find ways to facilitate "new economy" competition, to ensure lifelong learning and respond to the changing nature of work, and to use the internet for most functions of government and for more participatory policy making.

Regulations that promote competition and entry

Digital adoption by firms varies among countries, and there are reasons for it to be slow. Most fundamentally, adoption requires knowledge about the technology, access to it, and knowledge of how to best apply it. But the most important driver is competitive pressure, as firms adopting new technology

Figure O.22 Policy priorities for countries that are emerging, transitioning, or transforming

	EMERGING	TRANSITIONING	TRANSFORMING
REGULATIONS that promote competition and entry	Remove barriers to adoption	Competition regulation and enforcement	Platform competition
SKILLS to leverage digital opportunities	Foundational skills and basic ICT literacy	Prepare for careers instead of jobs	Facilitate lifelong learning
INSTITUTIONS that are capable and accountable	Mobile phone–based services and monitoring	e-government delivery and citizen engagement	Participatory policy making and digital collaboration

Note: ICT = information and communication technology.

raise productivity and those who don't fall behind. This highlights the critical role of a country's business climate. It includes laws and regulations that ensure easy entry and exit of firms, and an open trade regime that exposes companies to foreign competition and investment. There is a political economy dimension to this as well—special interests influence regulators to keep markets closed to competition. This lessens the need for firms to reach for the technological frontier. Where banks are heavily regulated and protected from new market entrants, they have less incentive to invest in efficiency-boosting technology that might also help them serve customers better or reach new ones. But competition policy and enforcement are complex, and many low-income countries lack capacity to design and implement them effectively.

Lower the barriers to digital adoption

In countries where the digital economy is still emerging, the priority is to facilitate connectivity and develop the foundation for effective competition regulation. Although 74 mostly middle- and high-income countries have unilaterally removed tariffs on ICT capital goods, computers and smartphones are still treated as luxury goods in some countries, including Turkey, where taxation adds almost half to the price of mobile handsets.[33] Djibouti's tariff on computers is 26 percent. Many countries treat their telecom firms as cash cows. Where firms may have limited knowledge about how the internet can improve their business, benchmarking exercises and information programs can be effective. And to allow more innovative companies to enter markets easily, countries need to improve firm registration and create greater market transparency to reduce price collusion, market sharing, and rigged public procurement. E-government systems such as online business registration and e-procurement systems can simplify these processes and produce more openness.

Increase competition through effective regulation and enforcement

State control in economic sectors, barriers to entrepreneurship, and restrictions on trade and investment reduce the incentives for firms in protected sectors to use digital technologies. Most countries have a competition authority, although many were set up fairly recently and enforcement varies, especially when the state or politically connected firms benefit from market restrictions. Moreover, the internet makes it easy to deliver services online from anywhere in the world, so how trade in services is regulated becomes increasingly important. Ethiopia, India, and Zimbabwe have the greatest restrictions on service trade, but many other countries restrict specific services such as legal or accounting tasks. Countries can increase the competitiveness of their economies and encourage greater use of digital technologies by gradually reducing market distortions while building up effective competition enforcement. This applies as

Box O.10 Opening the M-Pesa mobile money platform to competition

Safaricom's mobile money system is a well-known success story. It was able to grow quickly because Kenya's banking regulators initially decided to take a hands-off approach. For seven years, Safaricom maintained a dominant position through exclusivity agreements locking agents into the system. Initially such arrangements were perhaps justified because Safaricom incurred high costs developing the system. But in 2014, Kenya's Competition Authority changed the rules and opened the system to alternative mobile operators. The transaction cost of transfers of up to K Sh 500 (US$4.91) fell from K Sh 66 to K Sh 44 (US$ 0.43).

Source: Plaza, Yousefi, and Ratha 2015, for the WDR 2016.

much to traditional businesses that use the internet as to internet platforms (box O.10).

Tailor "new economy" regulations to ensure competition

Internet firms create new business models and change market structure, posing new challenges for regulatory authorities. On-demand economy firms like Uber and Airbnb scaled up traditional ride sharing and subletting to a global scale. But regulators struggle to determine whether these companies are taxi or hotel companies or simply software providers. Offline competitors complain that they do not follow the same regulations. Where these industries tend to be overregulated and their markets distorted, as is often the case in the taxi business, this new competition can encourage a general overhaul of the industry. In the United States, cities like New York and states like Massachusetts have begun to develop appropriate regulations for these platforms, imposing safety and tax obligations but also reducing their competitors' regulatory burdens.

Similar regulatory puzzles are posed by firms such as Amazon, Facebook, and Google. For example, Google is known as a search engine company but is better described as an advertising firm. These firms confound conventional competition law because they do not act as traditional monopolies. Their services are often free to consumers. But given their dominance in the markets for online ads and books, they have considerable leverage over marketers and booksellers. This is similar to credit card companies' position with respect to retailers. Research by economists such as Jean Tirole has shown that regulations in such industries must be carefully tailored to guarantee competition and avoid harm to consumers. These are very challenging problems, and most pressing in the transforming countries. Developing countries have the benefit of being able to learn from the experience in the transforming countries before devising their own solutions.

Skills for the digital economy

Technological change means that many routine tasks will soon be done by machines. In contrast to previous episodes, the internet will also make many tasks carried out in white-collar jobs redundant. This puts a premium on different types of skills that automation complements rather than replaces (figure O.23). Education systems have been slow to respond to this challenge. Furthermore, the pace of change is fast, and the types of skills in demand change quickly. So workers will have to upgrade their skills frequently throughout their careers. These dynamics already play out in many transforming and some transitioning countries, but even for emerging countries it is not too early to prepare.

Start early with foundational skills

Skills development starts at birth and lasts a lifetime. Good parenting and early stimulation prepare children for school, where cognitive and socioemotional foundations are laid. Technology can play a role. Even though the record on simply providing laptops or tablets to students is mixed, videoconferencing with English speakers from the Philippines has improved learning among first graders in Uruguay. Khan Academy provides resources for independent learning, and using a gaming approach to math teaching benefited grade four children in Mumbai. But in these and many other cases, one factor was more important: the quality of teaching. It is no coincidence that Finland, one of the most connected and best-performing countries in educational testing, uses very little technology in the classroom. It takes time to improve the quality of teachers,

Figure O.23 The types of skills needed in a modern economy

Cognitive	Social and behavioral	Technical
Literacy, numeracy, and higher-order cognitive skills (for example, reasoning and creative thinking)	Socioemotional skills and personality traits	Manual dexterity and the use of methods, materials, tools, and instruments
Raw problem-solving ability versus knowledge to solve problems	Openness to experience, conscientiousness, extraversion, agreeability, and emotional stability	Technical skills developed through postsecondary schooling or training or acquired on the job
Verbal ability, numeracy, problem solving, memory, and mental speed	Self-regulation, grit, mind-set, decision making, and interpersonal skills	Skills related to specific occupations (for example, engineer, economist, IT specialist)

Source: WDR 2016 team, adapted from Pierre, Sanchez Puerta, and Valerio 2014.

Note: IT = information technology.

however. But technology can help here as well, as Rio de Janeiro's Educopedia platform shows (box O.11). Using technology to closely guide teaching is a second-best option that can improve learning outcomes at modest cost where teacher training is unlikely to improve quickly. This is the model used by the for-profit Bridge Academy in Kenya and elsewhere, where scripted instruction and automated administrative tasks help provide education at low cost. Although yet to be evaluated rigorously, such approaches hold promise to improve education.

Rethink curricula and teaching methods

Today's education systems need to prepare students for a career and not only a job. Modern labor markets require creativity, teamwork, problem solving, and critical thinking in ever-changing environments—skills that traditional education systems do not teach and that are hardest to measure. Many countries are rethinking their approach. Singapore is moving from a fairly rigid "efficiency driven" model that tried to get the best results from inputs (teachers and finance) to an "ability driven" model that emphasizes project work and fewer assessments in place of frequent testing. Colombia's Escuela Nueva model, now serving 5 million students in 16 countries, also focuses on group learning and problem solving. These approaches change the relationship between teacher and student. No longer simply sources of information, teachers now must instruct students in how to find information and apply it in a new and unexpected context. This requires changes in teacher training. There are many examples of how digital technologies can assist teachers and students—by allowing group

Box O.11 Mobilizing technology in teaching in Rio's Educopedia

Rio de Janeiro's education department developed the Educopedia online platform of lessons and other resources in 2010 to improve public school teaching. The system focuses as much on providing materials for the teacher to improve lessons as on giving students access to learning resources. The system uses multimedia resources including videos, interactive quizzes, and digital libraries. It now serves almost 700,000 students. It has yet to be formally evaluated, but together with other reforms it likely contributed to a more than 20-percent increase in the Basic Education Development Index in middle schools between 2009 and 2012. And 80 percent of Rio's students agreed that Educopedia helps their learning efforts.

Source: Bruns and Luque 2014.

work among classrooms connected online, apps that stimulate creativity and problem solving, and games designed for education ("gamification").

Develop advanced technological skills and encourage lifelong learning

As more and more parts of the economy rely heavily on the internet, demand for advanced ICT skills will also grow. Only a small share of the workforce will be involved in developing software or systems design, but exposing children to coding and basic ICT concepts can influence career choices for some and impart a basic understanding to many. NairoBits, a youth organization in Kenya, exposes underprivileged young people from informal settlements to web design and other ICT skills, while AkiraChix reaches out to "geek girls." Women tend to be underrepresented in ICT fields, and encouraging girls to enter such professions and ICT companies to create welcoming environments for women will increase the available workforce in fields with rising demand for labor. With technology likely continuing to get more advanced and affecting ever more occupations, workers need to continuously reevaluate and upgrade their skills. Much of that will happen outside the formal education system, but governments can provide the incentives for firms and workers to create the mechanisms for lifelong learning.

Institutions that are accountable to citizens

Although the internet has enabled many governments to provide some basic services more efficiently, technology so far has not strengthened accountability. For policies, this implies a dual strategy: tailoring the application of digital technologies to environments with limited accountability in the short term, and strengthening institutions in the longer term (table O.3).

Improve informational services and monitoring

Although internet access is still low in many emerging economies, mobile phones are widespread and have great potential for improving services. In the health sector, simple mobile phone–based reminders for taking medications have been effective for HIV patients in Malawi and for providing maternal health information in the Democratic Republic of Congo. Phones can support the monitoring of teachers or other government workers where absenteeism is a problem, even if monitoring alone is insufficient to improve service quality or outcomes (box O.12). Monitoring also becomes important in provision by nonstate entities in weak institutional contexts, where for-profit or non-profit organizations deliver services often funded by the government. And digital technologies can improve electoral accountability. In Afghanistan, Kenya, and Mozambique, election monitoring using cellphones helped uncover fraud and reduced election violence. This can complement—or, even in low-capacity settings, replace—more demanding approaches such as biometric identification (see spotlight 4 in the full Report).

Strengthen e-government delivery and citizen engagement

Where investments to automate government service delivery have advanced, complementary improvements in regulations, interdepartmental cooperation, and streamlining become more important. Rather than just replicating cumbersome processes such as business regulations online, automation provides an opportunity for simplifying steps, increasing the impact as well as the transparency. E-procurement systems reduce the risk of corruption, but countries have invested less in them than in more complex budget or treasury systems. With greater internet use in a country, the scope for

Table O.3 Priority policies for better service delivery

Emerging countries: Laying the foundation for more effective institutions	Transitioning countries: Building capable and accountable institutions	Transforming countries: Deepening collaborative institutions
• Improve information services to citizens • Strengthen monitoring of and payment to providers • Establish population registers • Scale up nonstate provision of services • Increase electoral accountability	• Strengthen government delivery systems • Strengthen provider management • Get regular user feedback on service quality • Increase transparency in priority areas	• Improve collaboration across and beyond government • Enhance participatory policy making

Box O.12 Can continuous monitoring and small sanctions improve provider performance?

Traditional monitoring systems are expensive and complex. New technologies lower these costs, allowing rewards or punishment to be more immediate and frequent. The idea comes from criminal justice innovations. Usually lawbreakers face a low probability of being caught, but a large punishment. When people face a high probability, but fines are lower, violations become rarer. The idea could be extended to public service monitoring. In Niger, a well-designed monitoring system enabled by mobile phones motivated teachers because they felt their far-away superiors cared about their work and looked out for them.

Sources: Romer 2013; Aker and Ksoll 2015.

digital engagement with citizens also increases. As long as access is not universal, there is a risk of leaving those unconnected behind. But citizen feedback systems have reduced problems such as petty corruption or poor services in the Dominican Republic, Nigeria, and Pakistan. As one Kenyan water utility manager said, "By introducing an automated complaint management system we took a noose and put it around our own necks. We are now accountable!"

Deepen collaboration and participatory policy making

Even in countries with advanced e-government systems, their use remains surprisingly low. Many citizens prefer traditional ways of interacting with the government such as phones or mail, so parallel systems remain in place and savings go unrealized. Providing incentives such as faster tax refunds for e-filing or greater convenience through simplified and closely integrated services across agencies increases their use. Estonia's X-Road framework integrates services from all parts of government as well as private or civil society groups according to protocols that govern data exchange and security standards.[34] Practically any transaction—from paying the parking meter to voting in national elections—can be done from a smartphone. Tangible benefits for citizens will lead to universal use of e-government services, making such platforms also suitable for broad-based participatory policy making.

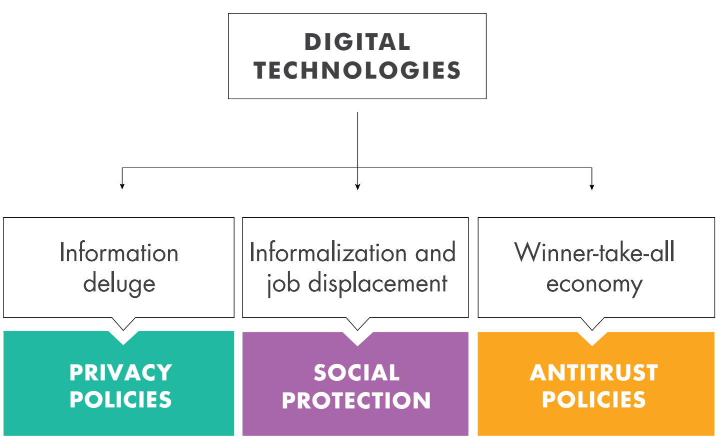
Digital safeguards

Strengthening analog complements will ensure a high social and economic return from digital investments. But a downside risk remains. Returning to the Report's framework (figure O.24), large-scale collection of identifiable information creates privacy and security concerns. Automation changes work in ways that challenge existing social protections and reveal the inadequacy of existing labor laws. And scale economies create antitrust concerns. Digital safeguards that mitigate these risks become increasingly important as the digital transformation proceeds.

Developing privacy policies

The flood of data collected on the internet brings many benefits to consumers and citizens but also raises the risk of abuse through cybercrime, discrimination, or manipulation. As of 2014, some 107 countries had privacy laws, but only 51 of them were developing countries. The basic principles of privacy law are well established. They should give users more control (and perhaps co-ownership) over their data and make

Figure O.24 Digital safeguards in the WDR's framework



Source: WDR 2016 team.

opting out at the point of collection easier. Even when such laws exist, preventing abuse is difficult, especially where legal and enforcement capacity is weak.

Adapting social protection systems to changing labor markets

Better skills will help many workers cope with the effects of internet-enabled automation. But changes in the labor market also require rethinking social protection and tax systems. The on-demand economy leads to more informal employment, transferring insurance and occupational obligations to freelance workers. Strict labor regulations, common in developing countries, and overreliance on labor taxation encourage faster automation by making hiring more expensive. It would be better to strengthen workers' protection independently from work contracts by delinking social insurance from employment, offering independent social assistance, and helping workers retrain and find new employment quickly. In many countries this requires major reforms. And countries just starting to develop social protection systems and deepening labor laws should design them for the 21st-century workplace, rather than copy what industrialized countries created for a very different world of work.

Building antitrust enforcement capacity

Regulatory reform that improves the business environment is the first priority. But even in countries with comprehensive competition policies, including easy market entry and exit, there will be cases in which mergers, collusion, or discriminatory pricing harm consumers by creating overly dominant enterprises or by keeping innovative competitors out. Because the internet is still quite new and its impact on markets constantly evolving, developing the capacity to investigate and prosecute complex violations to competition law will take time. Cases pursued in high-income countries can provide guidance.

Global cooperation to solve global problems

The internet is truly an international network. It can be better managed with coordination across nations and serve as a powerful platform to facilitate global cooperation. Three priority areas are governing the internet, creating a global digital market, and providing global public goods—including those that promote poverty reduction and environmental sustainability.

Governing the internet

The internet emerged from U.S. government research in the 1970s, but as it grew into a global network of networks, its governance structure has evolved. Today, the internet is managed by an international coalition of governments, industry, technical experts, and civil society—in what is referred to as the multistakeholder model. U.S. users are now a small minority of total internet users, given the dramatic growth in the number of users in developing countries, especially in Asia. Many countries are demanding more meaningful representation in the discussions of how the internet should be governed. In addition, the lack of trust among nations following the Edward Snowden episode, the surveillance by state agencies, and the increasing conflicts between national policy and regulations and global norms have raised questions about internet governance.

Several countries have advocated for a multilateral model of governance, which would give national governments greater power in overseeing the internet, much the same way the United Nations, the International Telecommunication Union, or the World Bank are currently governed. The promoters of "multistakeholderism" argue that state control of the internet would not leave space for the range of players currently involved in internet governance and could pave the path for greater suppression of privacy and restrictions on access to information and on rights of free expression. The inability of the stakeholders of the internet to reach a consensus on future governance mechanisms can be costly; some have even suggested that the internet is at risk of splitting up into several local or regional internets. The broad-based, participatory approach involving all stakeholders is seen by many to be best suited to ensure an efficient and unrestricted global flow of information essential for economic development.

Creating a global digital market

The internet is encouraging more cross-border exchanges of goods and services, allowing consumers and firms to bypass national borders. But cross-border issues—such as barriers to data flows and uncoordinated intellectual property rights regimes—are impairing the growth of internet firms and robbing consumers of gains from increased digital trade. This has also meant that many startups from smaller countries with relatively modest domestic markets, particularly in Europe (box O.13), are moving their business to the United States as soon as they achieve a certain scale. The small scale imposed by cross-border barriers may also partly explain why e-commerce firms are

Box O.13 European Union: A fragmented market for digital trade

Despite being a single market with free flows of goods, services, and people for many decades, the European Union (EU) still functions like a fragmented market for digital trade. Consumers in the EU prefer to shop from online stores within their national borders. While 44 percent of consumers made an online purchase from a domestic business in 2014, only 15 percent did so from a business in another EU country. Firms also face many difficulties selling their goods and services online into other EU markets. For example, Copenhagen, Denmark, and Malmo, Sweden, are separated only by an 8-kilometer bridge, but a package sent from Copenhagen to Malmo costs €27, whereas the same package sent from Malmo to Copenhagen costs €42. Firms facing large costs to adapt to various national laws believe that the costs outweigh the benefits of selling online.

In May 2015, the European Commission (EC) announced plans to create a Digital Single Market, in three main policy areas. First, the EC wants to increase the access for consumers and firms to these digital goods and services by facilitating e-commerce, improving parcel delivery, and dealing with geoblocking, where access to online services or content is restricted to specific countries. Second, it will examine the regulatory environment for telecoms, media, online platforms, and data protection. Third, it will encourage more ICT investment and innovation through better standards and interoperability, and more use of "big data" and cloud computing. If EU reforms to create a common digital market are successful, they could become a model for other world regions.

Source: European Commission (EC 2015).

often losing money in Africa while being profitable in China and India.

Some countries are considering regulations that make it legally binding for data of or about their citizens to reside within their national borders, also referred to as data localization or data nationalism. While such barriers may stem from legitimate concerns about privacy and security for their citizens' information, they can be costly. A study of six developing countries and the EU-28 found that such regulations can reduce GDP by up to 1.7 percent, investments up to 4.2 percent, and exports by 1.7 percent.[35] Restrictions on data flows face the risk of becoming a new tool for protectionism—disguised to impede trade and economic activity or to encourage domestic data-driven sectors. At the same time, countries should make it easier for firms to protect their intellectual property (IP) rights—but within limits that do not give excessive protections to large, well-connected firms at the cost of stifling innovation and creativity. The process to apply for IP licenses should be harmonized, streamlined, and globalized—so firms need only to register their patent or trademark in any signatory country to protect it across member countries.

Providing global public goods

Sustainable development and poverty reduction are a focus of global partnerships. Many environmental problems—climate change, ozone depletion, air pollution, epidemics—are features of globally interconnected environmental, economic, and social systems and require global cooperation. What's the role of development agencies, nongovernmental organizations (NGOs), and international organizations in a world where their financial heft is small? The data and technology revolutions arrive in time to bridge the gap between their resources and ambition by amplifying the impacts of action and including more people in the formulation and execution of plans. But for this to work, development actors must tackle policy constraints, internal and external.

Start with the *how* of development operations. With new technologies, development agencies can be more inclusive by tapping on beneficiary wisdom in designing interventions. They can raise efficiency by using rapid feedback to refine and improve their actions through trial and error. But these approaches won't come easily in organizations that emphasize spending and outputs over results, have burdensome structures for accountability, and see any failures as damning rather than informative. If traditional agencies can't adapt, some of their business may be taken up by disruptive newcomers.

Next, the *what*. Development agencies can support information services that help individuals and systems managers make better decisions in ways that promote poverty reduction. These services have fixed set-up costs in software and data assembly, but can have near zero costs for distributing information. So the private sector will tend either to shy away from providing these services, or will price them at a level that shuts out poor people who could benefit. One area where the need for international cooperation and support is particularly acute is the collection and distribution of data on weather, climate, and transboundary water flows, which are critically important to tackle climate change, improve natural resource management, and support agriculture.

External agents and international organizations can help with targeted funding—for instance, filling the gap in African weather stations. They can support the complementary investments for information platforms. And they can find ways to encourage public and private sectors, in both the developed and developing world, to open and share data for public goods.

Reaping digital dividends for everyone

Digital technologies are transforming the worlds of business, work, and service delivery. These advances are making the leading parts of the economy and society more productive—even as many still wait for the most basic benefits of the digital revolution. This Report argues that to ensure that everyone will reap the dividends of the internet, focusing on access to technology is essential but far from sufficient. Why? Because technology needs to be complemented by improvements in areas that determine whether firms, people, and governments can make effective use of new digital tools. The analog foundation cannot be strengthened overnight. It requires overcoming some of the most protracted development challenges: how to create an environment for firms to thrive, how to build effective education and training systems, and how to make service providers more responsive to citizens. The stakes are high, because the digital revolution leaves behind countries that do not make the necessary reforms. For those that do, technology investments will produce ample digital dividends, and these dividends will be widely shared among all stakeholders.

Notes

1. References to this and other data and citations in the overview may be found in the full Report.
2. The lag between technology creation, adoption, and learning to use it most effectively explains some of this. Difficulties in measuring technology's role are another partial explanation for the gap between individual cases of substantial benefits and modest macro effects. Technology impact is diffused throughout the economy, the world of work, and many aspects of personal life. And many benefits come in the form of higher quality or convenience—nonmonetary benefits not reflected in GDP numbers.
3. Even if rapid progress in artificial intelligence could solve some of these problems, it could take decades (see spotlight 6 in the full Report). In the meantime, it would be unwise for policy makers to simply wait and watch.
4. Acemoglu and Robinson 2014.
5. See Comin 2014.
6. See Graham and Foster 2014.
7. While the internet reduces the cost of information, it does not necessarily reduce the effort it takes humans to process that information. In fact, information overload, in combination with behavioral biases, can promote herd behavior, amplify facts, or even be abused for marketing or manipulation.
8. Overcoming information problems also improves market efficiency and could even lead to greater innovation. For expositional simplicity, the Report's framework is simplified and focuses on the most important development outcome associated with each mechanism that is enabled by the internet.
9. Moreover, cross-country regressions measuring the impact of digital technologies on growth could suffer from several other problems involving measurement issues, endogeneity of variables, and small sample size bias.
10. These results are based on Tan 2015; Osnago and Tan 2015.
11. eBay 2013.
12. Baldwin 2011.
13. Brynjolfsson and McAfee 2014.
14. Moretti and Thulin 2013.
15. Goyal 2010; Aker and Mbiti 2010.
16. See Handel 2015; Best and others 2010; Jagun, Heeks, and Whalley 2008; Aker 2011; Martin 2010.
17. Pineda, Aguero, and Espinoza 2011.
18. Asad 2014.
19. Aker and Mbiti 2010; Pineda, Aguero, and Espinoza 2011.
20. The survey was conducted by Research ICT for Africa.
21. Aker, Collier, and Vicente 2013.
22. See box 3.5 in chapter 3 of the full Report.
23. Duflo, Hanna, and Ryan 2012.
24. Acemoglu, Hasan, and Tahoun 2014.
25. Bennet, Breunig, and Givens 2008.
26. Hollenbach and Pierskalla 2014.
27. Goldin and Katz 2008.
28. Varian 2003.

29. Data for 2014 of net digital worldwide ad revenue shares from eMarketer, an online market research company.
30. Wood 2011.
31. Eden and Gaggl 2014.
32. WDR 2016 team estimates, based on household surveys. See chapter 2 in the full Report for details.
33. A landmark agreement that will further boost digital adoption around the world is the Information Technology Agreement, concluded by World Trade Organization (WTO) members on July 24, 2015. It will eliminate tariffs on more than 200 ICT products, valued at $1.3 trillion in global trade.
34. Vassil 2015.
35. Bauer and others 2014.

References

Acemoglu, Daron, Tarek Hasan, and Ahmed Tahoun. 2014. "The Power of the Street: Evidence from Egypt's Arab Spring." NBER Working Paper 20665, National Bureau of Economic Research, Cambridge, MA.

Acemoglu, Daron, and James A. Robinson. 2014. "The Rise and Decline of General Laws of Capitalism." NBER Working Paper 20766, National Bureau of Economic Research, Cambridge, MA.

Aker, Jenny C. 2011. "Dial A for Agriculture: A Review of Information and Communication Technologies for Agricultural Extension in Developing Countries." *Agricultural Economics* 42 (6): 631–47.

Aker, Jenny C., Paul Collier, and Pedro Vicente. 2013. "Is Information Power? Using Mobile Phones and Free Newspapers during an Election in Mozambique." Working Paper 328, Center for Global Development, Washington, DC. http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2364162.

Aker, Jenny C., and Christopher Ksoll. 2015. "Call Me Educated: Evidence from a Mobile Monitoring Experiment in Niger." Working Paper 406, Center for Global Development, Washington, DC. http://www.cgdev.org/publication/call-me-educated-evidence-mobile-monitoring-experiment-niger-working-paper-406.

Aker, Jenny C., and Isaac M. Mbiti. 2010. "Mobile Phones and Economic Development in Africa." *Journal of Economic Perspectives* 24 (3): 207–32.

Asad, Saher. 2014. "The Crop Connection: Impact of Cell Phone Access on Crop Choice in Rural Pakistan." Job market paper, George Washington University, Washington, DC.

Autor, David. 2014. "Polanyi's Paradox and the Shape of Employment Growth." Draft prepared for the Federal Reserve Bank of Kansas City.

Baldwin, Richard. 2011. "Trade and Industrialization after Globalization's Second Unbundling: How Building and Joining a Supply Chain Are Different and Why It Matters." NBER Working Paper 17716, National Bureau of Economic Research, Cambridge, MA.

Bao, Beibei. 2013. "How Internet Censorship Is Curbing Innovation in China." *Atlantic*, April 22. http://www.theatlantic.com/china/archive/2013/04/how-internet-censorship-is-curbing-innovation-in-china/275188/.

Bauer, Matthias, Hosuk Lee-Makiyama, Erik Van der Marcel, and Bert Verschelde. 2014. "The Costs of Data Localization: Friendly Fire on Economic Recovery." ECIPE Occasional Paper 3/2014, European Centre for International Political Economy, Brussels.

Bennet, W. L., C. Breunig, and T. Givens. 2008. "Communication and Political Mobilization: Digital Media and the Organization of Anti-Iraq War Demonstrations." *Political Communication* 25 (3): 269–89.

Berdou, E., and C. A. Lopes. 2015. "The Case of UNICEF's U-Report (Uganda)." World Bank, Washington, DC.

Best, Michael L., Thomas N. Smyth, John Etherton, and Edem Wornyo. 2010. "Uses of Mobile Phones in Post-Conflict Liberia." *Information Technologies and International Development* 6 (2): 91–108.

Beuermann, Diether, Christopher McKelvey, and Renos Vakis. 2012. "Mobile Phones and Economic Development in Rural Peru." *Journal of Development Studies* 48 (11): 1617–28.

Bishop, Sylvia, and Anke Hoeffler. 2014. "Free and Fair Elections: A New Database." Working Paper WPS/2014-14, Centre for the Study of African Economies, Oxford, U.K. http://www.csae.ox.ac.uk/datasets/free-fair-elections/.

Bruns, Barbara, and Javier Luque. 2014. *Great Teachers: How to Raise Student Learning in Latin America and the Caribbean.* Washington, DC: World Bank.

Brynjolfsson, Erik, and Andrew McAfee. 2014. *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies.* New York: W. W. Norton.

Castro, Daniel. 2013. "The False Promise of Data Nationalism." Information Technology and Innovation Foundation. http://www2.itif.org/2013-false-promise-data-nationalism.pdf.

China, National Bureau of Statistics of China. Various years. Population Census. Beijing. http://www.stats.gov.cn/english/Statisticaldata/CensusData/.

Chomitz, Kenneth. 2015. "Information as Intervention: A Visit to Digital Green." *Let's Talk Development* (blog). http://blogs.worldbank.org/developmenttalk/information-intervention-visit-digital-green.

CIGI (Centre for International Governance Innovation), and Ipsos. 2014. "Global Survey on Internet Security and Trust." https://www.cigionline.org/internet-survey.

Clinton, Bill. 2000. Speech presented at the Paul H. Nitze School for Advanced International Studies (SAIS) at Johns Hopkins University, Washington, DC, March 8.

Comin, Deigo. 2014. "The Evolution of Technology Diffusion and the Great Divergence." http://www.dartmouth.edu/~dcomin/files/brookings%20blum%20roundtable.pdf.

Comin, Diego, and Bart Hobjin. 2010. "Technology Diffusion and Postwar Growth." NBER Working Paper 16378, National Bureau of Economic Research, Cambridge, MA.

Conference Board. Various years. "Total Economy Database." https://www.conference-board.org/data/economydatabase/.

Duflo, Esther, Rema Hanna, and Stephen P. Ryan. 2012. "Incentives Work: Getting Teachers to Come to School." *American Economic Review* 102 (4): 1241–78.

eBay. 2013. "Commerce 3.0 for Development: The Promise of the Global Empowerment Network. An eBay Report Based on an Empirical Study Conducted by Sidley Austin LLP." eBay Inc., Washington, DC. https://www.ebaymainstreet.com/sites/default/files/eBay_Commerce-3-for-Development.pdf.

EC (European Commission). Various years. Eurostat (database). European Commission, Brussels, http://ec.europa.eu/eurostat/data/database.

———. 2015. "Strategy Paper on a Digital Single Market." European Commission, Brussels. http://ec.europa.eu/priorities/digital-single-market/.

Economist. 2014. "Defending the Digital Frontier: A Special Report on Cybersecurity." July. http://www.economist.com/news/special-report/21606416-companies-markets-and-countries-are-increasingly-under-attack-cyber-criminals.

Eden, Maya, and Paul Gaggl. 2014. "On the Welfare Implications of Automation." August 20, 2015. https://belkcollegeofbusiness.uncc.edu/pgaggl/wp-content/uploads/sites/36/2014/09/Income_Shares_08-20-2015_WP.pdf.

———. 2015. "The ICT Revolution: A Global Perspective." Background paper for the *World Development Report 2016,* World Bank, Washington, DC.

Elmer-Dewitt, Philip. 1993. "First Nation in Cyberspace." *Time,* December 6.

Frey, Carl, and Michael Osborne. 2013. "The Future of Employment: How Susceptible Are Jobs to Computerisation?" Working paper, Oxford University, Oxford. U.K.

Goldin, Claudia, and Lawrence F. Katz. 2008. *The Race between Education and Technology.* Cambridge, MA: Harvard University Press.

Goyal, Aparajita. 2010. "Information, Direct Access to Farmers, and Rural Market Performance in Central India." *American Economic Journal: Applied Economics* 2 (3): 22–45.

Graham, Mark, and Christopher Foster. 2014. "Geographies of Information Inequality in Sub-Saharan Africa." Oxford Internet Institute, University of Oxford, U.K. http://cii.oii.ox.ac.uk/geographies-of-information-inequality-in-sub-saharan-africa/.

Handel, Michael. 2015. "The Effects of Information and Communication Technology on Employment, Skills, and Earnings in Developing Countries." Background paper for the *World Development Report 2016*, World Bank, Washington, DC.

Hollenbach, Florian, and Jan Pierskalla. 2014. "Voicing Discontent: Communication Technology and Protest." APSA Annual Meeting paper. http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2452306.

HRW (Human Rights Watch). 2015. "Human Rights Watch Submission." Background note submitted to the *World Development Report 2016* team, Human Rights Watch, Washington, DC. https://www.hrw.org/sites/default/files/supporting_resources/hrw_submission_re_wdr_2016_internet_for_development.pdf.

ILO (International Labour Organization). Various years. Key Indicators of the Labor Market (KILM database). International Labour Organization, Geneva, http://www.ilo.org/empelm/what/WCMS_114240/lang--en/index.htm.

ILO (International Labour Organization) Laborsta (database). Various years. ILO, Geneva, http://laborsta.ilo.org/.

ITU (International Telecommunication Union). 2015. *Facts and Figures.* Geneva: ITU. http://www.itu.int/en/ITU-D/Statistics/Documents/facts/ICTFactsFigures2015.pdf.

Jagun, Abi, Richard Heeks, and Jason Whalley. 2008. "The Impact of Mobile Telephony on Developing Country Micro-Enterprise: A Nigerian Case Study." *Information Technologies and International Development* 4 (4): 47–65.

Karabarbounis, Loukas, and Brent Neiman. 2013. "The Global Decline of the Labor Share." NBER Working Paper 19136, National Bureau of Economic Research, Cambridge, MA.

King, Gary, Jennifer Pan, and Margaret E. Roberts. 2013. "How Censorship in China Allows Government Criticism but Silences Collective Expression." *American Political Science Review* 107 (2): 1–18.

Kosinski, Michal, David Stillwell, and Thore Graepel. 2013. "Private Traits and Attributes Are Predictable from Digital Records of Human Behavior." *Proceedings of the National Academy of Sciences* 110 (15): 5802–05.

Lakner, Christoph, and Branko Milanovic. 2013. "Global Income Distribution: From the Fall of the Berlin Wall to the Great Recession." Policy Research Working Paper 6719, World Bank, Washington, DC. http://elibrary.worldbank.org/doi/pdf/10.1596/1813-9450-6719.

Martin, Brandie. 2010. *Mobile Phones and Rural Livelihoods: An Exploration of Mobile Phone Diffusion, Uses, and Perceived Impacts of Uses among Small- to Medium-Size Farm Holders in Kamuli District, Uganda.* Ames: Iowa State University.

Meeker, Mary. 2015. "Internet Trends 2015: Code Conference." http://www.kpcb.com/internet-trends.

Moretti, Enrico, and Per Thulin. 2013. "Local Multipliers and Human Capital in the United States and Sweden." *Industrial and Corporate Change* 22 (1): 339–62.

Nguyen, Huy, and Marc Schiffbauer. 2015. "Internet, Reorganization, and Firm Productivity in Vietnam." Background paper for the *World Development Report 2016,* World Bank, Washington, DC.

OECD (Organisation for Economic Co-operation and Development). 2014. "ICT Value Added (Indicator)." doi: http://dx.doi.org/10.1787/4bc7753c-en.

Open Net Initiative. 2013. https://opennet.net/.

Osnago, Alberto, and Shawn W. Tan. 2015. "The Effects of the Internet on Trade Flows and Patterns." Background paper for the *World Development Report 2016,* World Bank, Washington, DC.

Peixoto, Tiago, and Jonathan Fox. 2015. "When Does ICT-Enabled Citizen Voice Lead to Government Responsiveness?" Background paper for the *World Development Report 2016,* World Bank, Washington, DC.

Peppet, Scott R. 2014. "Regulating the Internet of Things: First Steps toward Managing Discrimination, Privacy, Security, and Consent." *Texas Law Review* 93 (85): 87–176.

Pierre, Gael, Maria Laura Sanchez Puerta, and Alexandria Valerio. 2014. "STEP Skills Measurement Surveys: Innovative Tools for Assessing Skills." Working Paper 89729, World Bank, Washington, DC.

Pineda, Allan, Marco Aguero, and Sandra Espinoza. 2011. "The Impact of ICT on Vegetable Farmers in Honduras." Working Paper 243, Inter-American Development Bank, Washington, DC.

Plaza, Sonia, Seyed Reza Yousefi, and Dilip Ratha. 2015. "Technological Innovations and Remittance Costs." Background paper for the *World Development Report 2016,* World Bank, Washington, DC.

Polity IV. 2015. http://www.systemicpeace.org/polityproject.html.

Posner, Richard A. 1981. "The Economics of Privacy." *American Economic Review* 71 (2): 405–09.

Pritchett, Lant, Michael Woolcock, and S. Samji. Forthcoming. *What Kind of Organization Capability Is Needed?* HKS faculty research working paper, Harvard Kennedy School, Cambridge, MA.

Raja, Deepti Samant. 2015. "Bridging the Disability Divide through Digital Technologies." Background paper for the *World Development Report 2016,* World Bank, Washington, DC.

Research ICT Africa. Various years. Household survey. Capetown, South Africa. http://www.researchictafrica.net/home.php.

Romer, Paul M. 2010. "What Parts of Globalization Matter for Catch-Up Growth?" *American Economic Review Papers and Proceedings* 100 (2): 94–98.

———. 2013. "Small Stakes, Good Measurement." *Urbanization Project* (blog), July 2013. http://urbanization-project.org/blog/small-stakes-good-measurement/.

Saleh, Nivien. 2012. "Egypt's Digital Activism and the Dictator's Dilemma: An Evaluation." *Telecommunications Policy* 36 (6): 476–83.

Spada, Paolo, Jonathan Mellon, Tiago Peixoto, and Fredrik Sjoberg. 2015. "Effects of the Internet on Participation: Study of a Policy Referendum in Brazil." Policy Research Working Paper 7204, World Bank, Washington, DC.

Tan, Shawn W. 2015. "The Effects of the Internet on Firm Export Behavior." Background paper for the *World Development Report 2016,* World Bank, Washington, DC.

UN (United Nations). 2014. "E-Government Survey 2014: E-Government for the Future We Want." United Nations, New York.

UN (United Nations) Population Division. 2014. Population and Development Database, http://www.un.org/en/development/desa/population/publications/development/population-development-database-2014.shtml.

Varian, Hal. 2003. "Economics of Information Technology." Revised version of the Raffaele Mattioli Lecture, delivered at the Sorbonne on March 6, 2003. http://people.ischool.berkeley.edu/~hal/Papers/mattioli/mattioli.pdf.

Vassil, Kristjan. 2015. "Estonian E-Government Ecosystem: Foundation, Applications, Outcomes." Background paper for the *World Development Report 2016,* World Bank, Washington, DC.

Wood, David. 2011. "EU Competition Law and the Internet: Present and Past Cases." *Competition Law International* (April): 44–49.

World Bank. Various years. I2D2 (International Income Distribution database). World Bank, Washington, DC, http://econ.worldbank.org/WBSITE/EXTERNAL/EXTDEC/EXTRESEARCH/0,,contentMDK:20713100~pagePK:64214825~piK:64214943~theSitePK:469382,00.html.

World Bank. Various years. World Development Indicators (database). World Bank, Washington, DC, http://data.worldbank.org/data-catalog/world-development-indicators.

———. 2015. "MajiVoice: A New Accountability Tool to Improve Public Services." Water and Sanitation Policy Note, World Bank, Washington, DC. https://wsp.org/sites/wsp.org/files/publications/WSP-MajiVoice-New-Accountability-Tool-to-Improve-Public-Services.pdf.

SPOTLIGHT 1

ENABLING DIGITAL DEVELOPMENT

How the internet promotes development

To understand how the internet and related digital technologies affect development, it is important to understand what they actually do. It turns out that old economics explains the new economy quite well. In 1937, Ronald Coase—who would receive the Nobel Prize in Economics in 1991—published "The Nature of the Firm," which asked why firms exist.[1] Even though economics considers the market the most efficient way to organize economic activity, large companies tend to operate in a self-contained command-and-control environment. What Coase realized was that using the price mechanism incurred a number of additional costs, such as the effort of finding buyers or suppliers, and negotiating contracts and enforcing them. As long as the cost of making an exchange of an intermediate good or service in the market is larger than the profit from that exchange, it is rational for a firm to produce it in-house.

Most of these Coasian transaction costs stem from the costs of acquiring and sharing information. Many years later, the internet and other digital technologies have vastly reduced many of these costs, with major implications for market and nonmarket exchanges among businesses, people, and governments. This spotlight describes how the decline of these transaction costs affects economic development. But first, a working definition of the technologies covered in this Report.

While the *World Development Report 2016* is not about specific technologies, it generally covers the impacts of digital technologies and services that greatly facilitate the creation, storage, analysis, and sharing of data and information. The Report uses the terms "digital technologies," "internet," and sometimes "information and communication technologies (ICTs)" somewhat interchangeably. "Internet" emphasizes the central importance of connectivity. Faster computers and cheaper storage are useful in their own right. But the reason that all of these technologies have had such a massive impact on almost all aspects of life is that these devices are linked so that information can be distributed and accessed effortlessly from anywhere.

The internet promotes inclusion, efficiency, and innovation

Technology development has vastly reduced the cost and increased the speed of all the digital technologies that drive the internet—in some cases by more than 30 percent per year. This continues a long-term and accelerating decline in the cost of computing. William Nordhaus, in 2007, estimated that since the era of manual computing in the mid-19th century, the cost of a computation has dropped by a factor of between 1.7 trillion and 73 trillion.[2] The result has been a far lower cost of acquiring and using information, which in turn has lowered transaction costs—and often as a consequence, production costs.

By lowering the cost of these transactions, the internet affects economic development in three major, interrelated ways. One is that the internet can help overcome information problems. In some instances, a mutually beneficial transaction might not take place because the two parties simply had no way to find each other or acquire enough information to confidently proceed with the transaction; in such cases, the transaction costs are essentially infinitely high. The emergence of e-commerce platforms has made it much easier for small producers to find customers, and even for individuals who cannot use traditional marketing tools like advertising or trade shows. Rural artisans in Morocco, some of whom are illiterate, have set up Anou, a web shop for their products that has attracted customers from all over the world.[3] The internet, by vastly lowering search and information costs, creates these markets. This has many benefits, but the most important, arguably, is that it fosters *inclusion*—in new and existing markets, in social interaction, or in government service delivery systems. Inclusion for the individual usually means expansion of a market by those on the other side of the transaction, such as a firm or a government that now serves more citizens.

Even when search costs are low, transactions often do not take place when one party to a transaction has much more information than the other. Take the example of extending credit to poor farmers. The high cost of gathering information about poor borrowers is a major deterrent to lending by banks.[4] The poor therefore need to rely on informal moneylenders who charge exorbitant interest rates. But many of the poor possess mobile phones. Companies such as Cignifi have developed methods to judge the creditworthiness of a potential borrower based on their mobile phone records. In Ghana, Cignifi worked with the World Savings and Retail Banking Institute to correlate savings behavior with mobile phone records.[5] The goal is to promote financial inclusion among the unbanked, by assessing the savings potential and creditworthiness of low-income households that own mobile phones but have no access to financial products.

There is a large literature on information problems and asymmetries by economists such as George Akerlof, Michael Spence, and Joseph Stiglitz, who jointly received the Nobel Prize in 2001. Akerlof was motivated to write his most famous paper, "The Market for Lemons," published in 1970, by the fact that when buying a used car, the seller usually has much more information about the car's quality than the buyer.[6] Today, internet sites such as Carfax in the United States let buyers research the history of a car online, including whether it has been in an accident, how many owners it has had, and whether it has complete service records.

The second mechanism is closest to the original Coasian concepts of transaction and coordination costs. Most transactions were already taking place before the digital revolution, but the internet has made them faster, cheaper, or more convenient. In other words, lower transaction costs raise the productivity of existing factors of production. The internet has brought numerous *efficiency* improvements to businesses that, while individually often not spectacular, add up to enormous aggregate benefits. Better communication and information processing improves supply chain management and enterprise resource planning. Retailers now share point-of-sale data with vendors globally in real time, essentially shifting inventory management to their suppliers. Tracking, navigation, and scheduling software improve capacity utilization for logistics and transport companies. The delivery company UPS famously saves about 1 million gallons of gas each year by using routing technology that minimizes left turns, where vehicles are often held up by oncoming traffic. Estonia's X-Road is an e-government system that offers nearly 3,000 services from 900 government and private sector agencies to the citizens online. The number of queries made through X-Road increased from half a million in 2003 to 340 million by 2014. As a result, each citizen saves about five working days per year, adding up to 7 million workdays overall.

For many internet-based businesses or services, fixed up-front costs can be high, but once the online platform is in place, each additional customer, user, or transaction incurs very little extra cost. The marginal transaction cost essentially drops to zero because what previously involved routine human labor can now be fully automated. This has led to enormous *innovation*—the third mechanism—that is typically associated with the "new economy." These dynamics have important implications related to the nature of the scale economies that make this innovation possible, the new business models (and competition problems) this has spawned, and the unprecedented scope for customization of services.

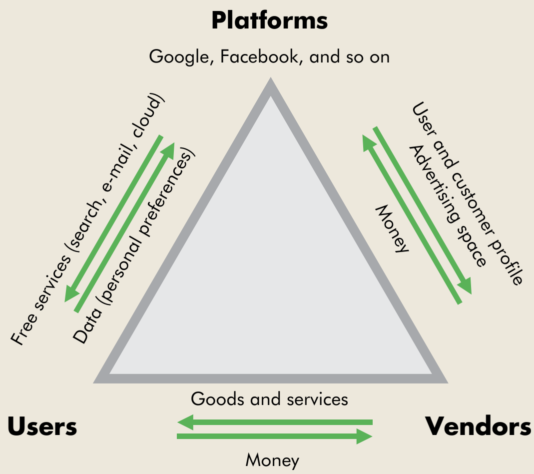
The cost structure of many internet businesses gives rise to various types of scale economies.[7] Supply-side scale economies, where costs drop with an increasing number of transactions, favor the emergence of natural monopolies. Water or electric utilities operate in similar environments. Because entry costs are also high, such sectors tend to be regulated. Many internet-based markets—such as web searches, mobile payments, or online bookstores—are also dominated by a few firms. At least initially, entry costs are low and such websites can scale up extremely quickly, even with relatively few resources. Facebook reached half a billion users with just 500 engineers.[8] Walmart had to build 276 stores before reaching US$1 billion in sales; Amazon needed just six warehouses to reach US$3 billion in 2003.[9] For many of these firms, the product they sell is also purely digital, such as digital music (Spotify in Sweden), e-books (Amazon in the United States), or online news and data.[10] Others sell highly automated brokerage or matchmaking services for travel, jobs, merchandise, or ride sharing. Many of these business models have been replicated by firms in developing countries. But even there, in many of these markets, a high degree of concentration has occurred in the last 10 years. While in the early 2000s internet traffic was distributed across thousands of companies, today just 30 companies account for over half of peak internet traffic in the United States—much of this is due to the explosion of video content.[11]

Scale economies also exist on the demand side. For many services, the more people use it, the more valuable it becomes to its users and the more new users it attracts. Social media sites or digital payment systems like M-Pesa in Kenya are examples. With supply-side scale economies, average cost drops with scale. With demand-side scale economies, average revenue or utility rises with scale. These network externalities benefit users, but can also create lock-in effects; to switch to a different social media platform imposes very little actual cost on the user, but would require collective action by a large number of interconnected users to maintain the same level of utility.[12]

Ultralow marginal transaction costs have powered new business models. Many of these are web services operating platform markets or two-sided markets. The platform owner has two different customers, typically the user of the service and an advertiser who wants to reach the user. Rather than charging both, it makes sense to provide the service for free and increase the user base (at very little cost), which makes the other side of the market more lucrative. A classic 2003 paper by Jean-Charles Rochet and Jean Tirole shows that two-sided markets exist in many industries. [13] But the economics of the internet have led to a particularly effective grand bargain between platform owners, users, and advertisers (figure S1.1). This model raises difficult questions about competition policy. Because platforms often do not charge for a service, they do not actually exert monopoly power over users. But they could do so over vendors buying advertising space. Just four companies—Google, Facebook, Baidu, and Alibaba—now account for half of all digital advertising revenue. And, dominant platforms could exert monopsony power (because there is a single or are just a few buyers). For instance, book publishers depend on Amazon for a crucial share of their total sales.

Because most processes can be automated, there is tremendous scope for customization of services. Most online behavior is automatically monitored—sometimes anonymously, sometimes not. The massive data volumes collected by internet platforms have created a whole new branch of economics—nano-economics—which studies individual, computer-

Figure S1.1 Internet users trade personal data for useful services



Source: Based on Kurbalija 2015.

mediated transactions.[14] The main benefit to the user is that services can be tailored to individual needs and preferences—although at the cost of giving up privacy. For the seller, it allows more targeted advertising and even price discrimination, when automated systems can analyze user behavior to determine willingness to pay and offer different prices to different users.

There is ample evidence that e-commerce sites vary prices based on users' estimated location, browsing history, and even the type of device they use for access.[15] Information can flow both ways, since many commercial websites provide feedback mechanisms that help the provider improve the product, but also allow the customer to assess the quality of a product or service. Businesses use such tools extensively, but the public sector has been slow to adapt them for better service delivery.

Finally, in many, if not most, transactions, more than one of the three mechanisms may be at work. For example, transactions on internet platforms typically involve all three. While the platform running a fully automated service is the main innovation, one side of the transaction often involves a provider of a service, such as an informal driver working through a ride sharing platform or a freelance worker in a remote location. For them, it will often be a case of inclusion in an otherwise inaccessible market transaction. The customer at the other end of the transaction experiences increased efficiency. A service that was typically available through another channel is now more convenient, faster, or cheaper. Figure S1.1.1 in box S1.1 presents a graphic representation of the three mechanisms.

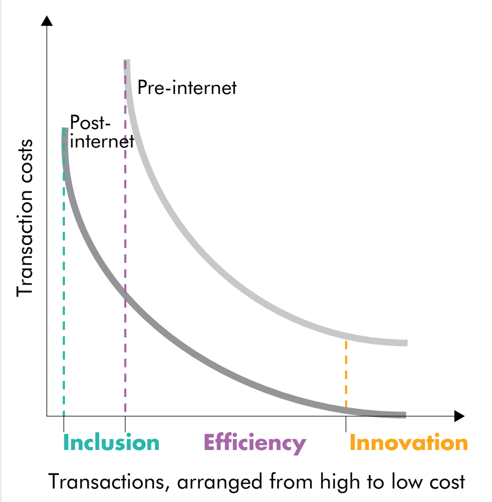
Box S1.1 Three ways in which the internet promotes development

Figure S1.1.1 provides a simple graphic representation of the effect of falling transaction costs. Imagine all transactions in an economy arranged by the transaction costs they impose, from most costly on the left to least costly on the right. The upper curve shows these costs before the introduction of the internet. With the internet, many such costs drop, and three things can happen. On the left, there were some transactions for which the cost was so high in the pre-internet era, that there was essentially no market—the transactions did not take place. Making these transactions possible promotes inclusion as well as market expansion.

For example, women with small children or persons with disabilities have sometimes been unable to engage in work outside the home, but can now engage in telework.[a] Many poor or disadvantaged populations will now receive public services because governments can use digital IDs to verify their eligibility.[b] And skilled workers and small firms in poor countries can trade their services in global markets, where they can earn higher returns. These are all examples where the internet, by overcoming information problems, contributes to greater inclusion.

In the middle of the figure, the internet lowers the cost of existing transactions—that is, those occurring even before the advent of the internet. This raises the efficiency of a vast range of activities. Purchasing goods, executing bank transactions, searching for a home or a job, paying taxes, or renewing a driver's license generally used to require a trip to a shop or office, but can now be done with a click or a tap. Similarly, the internet has reduced costs for businesses when connecting and negotiating with buyers or suppliers, finding workers through job-matching services, and monitoring contract fulfillment or employee performance. Many of the same benefits extend to governments, as well. These individually unspectacular efficiency gains may, in the aggregate, represent the lion's share of benefits from the internet.

Figure SB1.1.1 A graphic representation of how the internet promotes development



Source: WDR 2016 team.

The most dramatic impact of the internet is on the right-hand side of the figure. For many internet-based businesses or services, fixed up-front costs can be high, but once the online platform is in place, each additional customer, user, or transaction incurs very little extra cost. In many cases, the marginal transaction cost is essentially zero because what previously involved routine human labor can now be fully automated. For purely digital products, such as e-books, the marginal production cost is also close to zero. This cost structure gives rise to various types of scale economies, often reinforced by network effects, where the more users a system has, the more useful it becomes.[c] Most of the so-called "new economy" firms are in this space.

Source: WDR 2016 team.

a. Melhem, Morrell, and Tandon 2009.
b. Gelb and Clark 2013.
c. Varian and Farrell 2004.

Notes

1. Coase 1937.
2. Nordhaus 2007.
3. http://www.theanou.com.
4. Banerjee and Duflo 2011.
5. Cignifi and WSBI 2014.
6. Akerlof 1970.
7. Shapiro and Varian 1999; Varian and Farrell 2004.
8. Levin 2011.
9. Ellison and Ellison 2005.
10. Shapiro and Varian 1999.
11. Congressional testimony of Craig Labowitz, chief scientist of the software company, Arbor, quoted in http://www.wired.com/2014/06/net_neutrality_missing/.

SPOTLIGHT 1

12. Switching costs are far higher when replacing a widely used software package, since it will require a lot of retraining and associated investments, such as enterprise resource planning or operating systems.
13. Rochet and Tirole 2003.
14. Varian 2014; Varian and Farrell 2004.
15. Pasquale 2015.

References

Akerlof, George A. 1970. "The Market for 'Lemons': Quality Uncertainty and the Market Mechanism." *Quarterly Journal of Economics* 84 (3): 488–500.

Banerjee, Abhijit, and Esther Duflo. 2011. *Poor Economics: A Radical Rethinking of the Way to Fight Global Poverty.* New York: PublicAffairs.

Cignifi and WSBI (World Savings and Retail Banking Institute). 2014. *Mobile Phone Data as the Key to Promoting Financial Inclusion.* Cambridge, MA: Cignifi and WSBI.

Coase, Ronald H. 1937. "The Nature of the Firm." *Economica* 4 (16): 386–405.

Ellison, Glenn, and Sara Fisher Ellison. 2005. "Lessons about Markets from the Internet." *Journal of Economic Perspectives* 19 (2): 139–58.

Gelb, Alan, and Julia Clark. 2013. "Identification for Development: The Biometrics Revolution." Working Paper 315, Center for Global Development, Washington, DC.

Kurbalija, Jovan. 2015. *An Introduction to Internet Governance.* 6th ed. DiploFoundation.

Levin, Jonathan D. 2011. "The Economics of Internet Markets." NBER Working Paper 16852, National Bureau of Economic Research, Cambridge, MA.

Melhem, Samia, Claudia Morrell, and Nidhi Tandon. 2009. "Information and Communication Technologies for Women's Socioeconomic Empowerment." Working Paper 176, World Bank, Washington, DC.

Nordhaus, William D. 2007. "Two Centuries of Productivity Growth in Computing." *Journal of Economic History* 67 (01): 128–59.

Pasquale, Frank. 2015. *The Black Box Society.* Cambridge, MA: Harvard University Press.

Rochet, Jean-Charles, and Jean Tirole. 2003. "Platform Competition in Two-Sided Markets." *Journal of the European Economic Association* 1 (4): 990–1029.

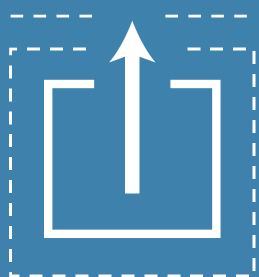
Shapiro, Carl, and Hal R. Varian. 1999. *Information Rules: A Strategic Guide to the Network Economy.* Cambridge, MA: Harvard Business School Press.

Varian, Hal. 2014. "Big Data: New Tricks for Econometrics." *Journal of Economic Perspectives* 28 (2): 3–28.

Varian, Hal, and Joseph Farrell. 2004. *The Economics of Information Technology: An Introduction.* Cambridge, MA: Cambridge University Press.

1. Accelerating growth

2. Expanding opportunities



3. Delivering services

PART 1

FACTS AND ANALYSIS

CHAPTER 1

Accelerating growth

Digital technology creates opportunities to accelerate growth, but these are often missed because firms in sectors where technology's impact is greatest are frequently protected from innovative competitors. Firms that face more competition use digital technology more intensively and effectively—it enables them to reduce their costs to outperform their competitors. But firms in developing countries do not necessarily have the incentive to adopt new technologies to increase their cost effectiveness because they are often protected from domestic or foreign competition. And it is precisely in protected sectors such as retail and wholesale trade, finance, transport, or public utilities where digital technology can increase productivity the most. Harnessing those opportunities thus requires policies that lower the barriers to competition and market entry, in addition to investments in infrastructure and skills. Only then will firms use new digital technologies more intensively and effectively—and only then will countries avoid falling behind.

Firms across the world are becoming more connected. For instance, the share of firms with at least five employees using broadband internet in lower-middle-income countries rose from 39 percent to 68 percent from 2006–09 to 2010–14. And the growth rates and valuations of internet firms across the world are surging. Less visibly, but more importantly, digital technologies have transformed traditional production structures, facilitating new, more cost-effective processes. Indeed, the vast majority of efficiency gains emerge outside the information and communication technology (ICT) sector, where firms use the internet to sell and market their products online or share real-time information with suppliers to minimize their inventory and with customers to optimize their services.

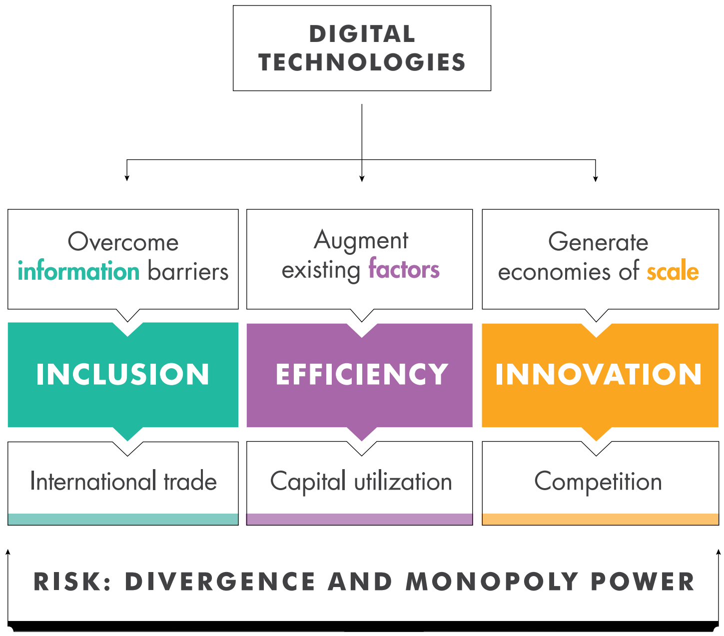
The impact of digital technology on economic growth is mediated through three mechanisms—inclusion, efficiency, and innovation. It promotes the inclusion of firms in the world economy by enabling more firms to trade new products to new destinations. For instance, firms selling their goods online through Alibaba, China's leading e-commerce company, are smaller and younger and export more products to different destinations than firms selling offline. It raises efficiency by allowing firms to make better use of their capital and labor. For instance, real-time data help equipment manufacturers in China turn over their inventory stocks five times faster than suppliers not connected to the internet. It enhances innovation by enabling firms to exploit scale effects through online platforms and services that compete with conventional business models in retail, transport, lodging, and banking, to name a few. These three mechanisms thus boost growth by expanding trade, increasing capital and labor utilization, and intensifying competition (figure 1.1).[1]

But the benefits are neither automatic nor assured. Despite great opportunities, firms' use of digital technologies differs substantially across countries due to variations in skills and infrastructure and in barriers to competition and market entry. Competition from China induced firms in member-countries of the Organisation for Economic Co-operation and Development (OECD) to adopt new technologies to escape the competition from low-cost producers, accounting for 15 percent of their investment from 2000–07. Manufacturing firms in Mexico responded to higher competition from low-cost Chinese producers in the domestic and the U.S. (export) market by using digital technologies more intensively and productively. Manufacturing firms in Brazil facing an increase in competition are more likely to invest in e-commerce systems. Firms in Africa facing an increase in competition are more likely to use the internet to market their products or to manage their inventories. Firms' use of digital technology also varies with barriers to competition across sectors in the same country. Business process outsourcing in the Philippines has few entry barriers, and firms use digital technology intensively—the retail sector on the other hand faces substantial restrictions to entry and is dominated by incumbent firms, with few of them offering e-commerce.

Harnessing the full growth potential of digital technology is thus predicated not just on investments in skills (chapter 2) and infrastructure (chapter 4) but also on reforming regulatory barriers by overcoming vested interests to encourage all firms to compete by investing in these new technologies (chapter 5). This also involves overhauling regulatory regimes in the digital economy, especially in sectors where online and offline firms increasingly compete, such as retail, transportation, printing and publishing, lodging, and finance. The initial entry of internet firms into these sectors promotes competition and can disrupt traditional monopolies. But internet firms can be prone to anticompetitive behaviors by exploiting scale and network effects. So the regulators need to level the regulatory regime to guarantee free market entry and prevent market shares from becoming too concentrated. The greater digital adoption therefore needs to be accompanied by unified standards, full interoperability, and competition across platforms and contracts.

The goal is to have firms' use of the internet promote competition, which encourages more firms to use the internet. But that will not happen if vested interest groups are strong enough to capture regulators and create new barriers to competition and technology adoption. A level playing field for business was always important—digital technologies have made it an imperative.

Figure 1.1 A framework for the internet and economic growth



Source: WDR 2016 team.

Connected businesses

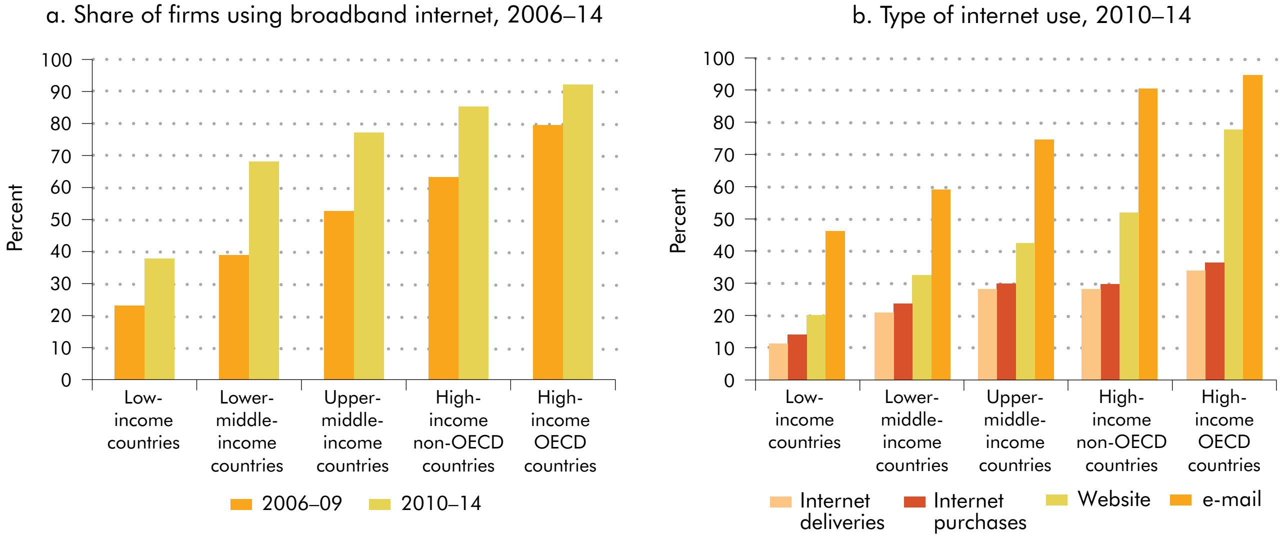
The adoption of broadband internet has increased for firms in all country income groups. Almost all firms in high-income OECD countries (with at least five employees) used a broadband internet connection between 2010 and 2014, with usage rising from 79 percent in 2006–09 to 92 percent in 2010–14 (figure 1.2, panel a). The increase between the two periods was even stronger for lower-income countries. The share of firms in lower-middle-income countries using broadband internet rose from 39 percent in 2006–09 to 68 percent in 2010–14. The share in low-income countries in 2010–14 is still fairly low (38 percent), but with some notable exceptions.

More than 90 percent of firms in high-income countries, and 46 percent in low-income countries, used electronic mail (e-mail) to communicate with clients between 2010 and 2014 (figure 1.2, panel b). The differences are greater when the internet is used for more demanding business activities. For instance, 42 percent of firms in upper-middle-income countries had a website, and 30 percent purchased goods or services online. Only 14 percent of firms in low-income countries purchased goods or services online, and only 11 percent delivered them online.

Developing countries such as Vietnam have invested heavily in the rollout of (broadband) internet infrastructure in recent years. As a result, the share of manufacturing and service firms in Vietnam using the internet for business activities rose to 71 percent in 2007 and 86 percent in 2011. Internet access was up almost uniformly across all provinces (map 1.1).[2]

But many advanced digital technologies have not yet diffused widely, even in high-income countries. Almost all European firms with at least 10 employees use a personal computer (PC) and broadband internet. About 80 percent have a website, and 60 percent use supply chain management software that is integrated with the ICT systems of customers or suppliers outside of the firm (figure 1.3). But less than 20 percent

Figure 1.2 More firms are using broadband internet



Source: Hussain (2015) based on World Bank Enterprise Surveys, various years. Data at http://bit.do/WDR2016-Fig1_2.

Note: The data cover firms with at least five employees. Panel a is based on 10,161 firms in 100 countries (2006–09) and 33,467 firms in 88 countries (2010–14). The survey question is, "Does this establishment have a high-speed, broadband internet connection on its premises?" Panel b is based on 100 countries in 2010–14 with 45,892 firms (e-mail), 45,872 firms (website), 20,480 firms (internet purchases), and 17,099 firms (internet deliveries). OECD = Organisation for Economic Co-operation and Development.

of European firms purchase or sell goods or services online and use any cloud computing services. Only 8 percent use cloud computing services to acquire management software and computing power. And only 3 percent use radio frequency identification devices, which are wireless microchips used to connect machines with one another (the "internet of things").

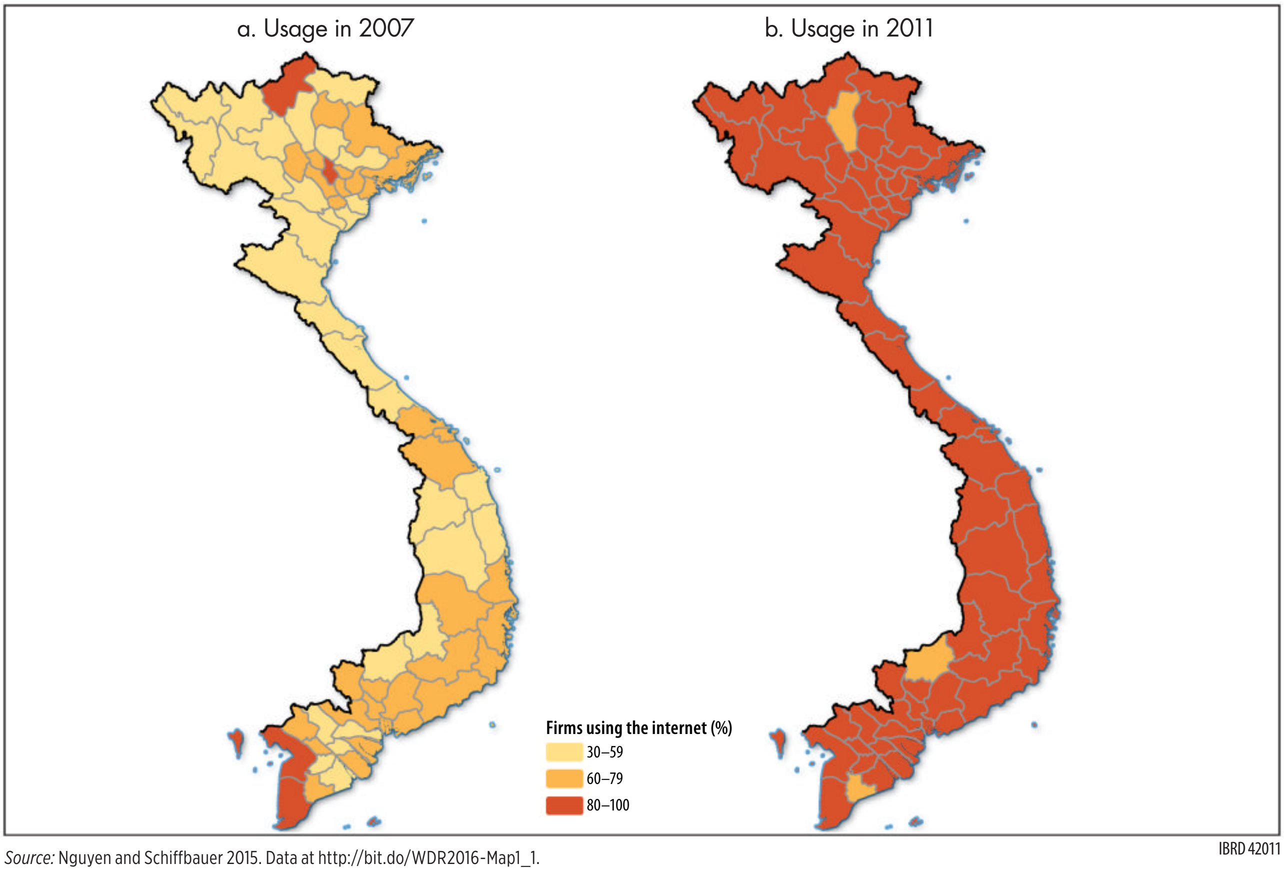
The use of digital technologies is still basic in most developing countries. In Vietnam, only 2.2 percent of all firms sold their goods or services online in 2011 (up from 0.6 percent in 2007). In Turkey, 92 percent of all firms with at least 10 employees had internet access in 2012, but only 71 percent used it for banking; 55 percent had a website; and 10 percent made orders or reservations online. In Mexico, 84 percent of firms with at least 10 employees used the internet in 2012, but only 26 percent of employees had internet access; and only 13 percent of firms used e-commerce for purchases, and 9 percent for sales. In Brazil, 63 percent of all manufacturing firms with at least 10 employees bought or sold products online, but only 28 percent provide an online catalogue or feature online orders on their website; and only 6 percent allow online payments. And less than half the manufacturing firms in Brazil have an information technology (IT) department or use software supporting management, either for resource planning or customer relations.[3]

More productive firms are early adopters of the internet

More productive firms are more likely to adopt the internet and use it more intensively. The percentage of firms having a website and selling or buying goods or services online tends to increase with firm productivity in all country income groups (figure 1.4).[4] Firms in the most productive quintile are most likely to have a website or use broadband internet.[5] The correlation between firm productivity and e-commerce is stronger in upper-middle-income countries. In lower-middle-income countries, less than 13 percent of the most productive firms sold or bought goods or services online. The results suggest that only the more productive firms in developing countries overcome (unobservable) barriers to using the internet more effectively.

African firms using the internet have on average 3.7 times higher labor productivity than nonusers and 35 percent higher total factor productivity (TFP) (figure 1.5). But the most productive firms that do not use the internet have TFPs comparable to high-productivity internet users. The differences are also found to be larger for labor productivity than for TFP, implying that African firms using the internet are not only more productive but also more capital intensive.[6]

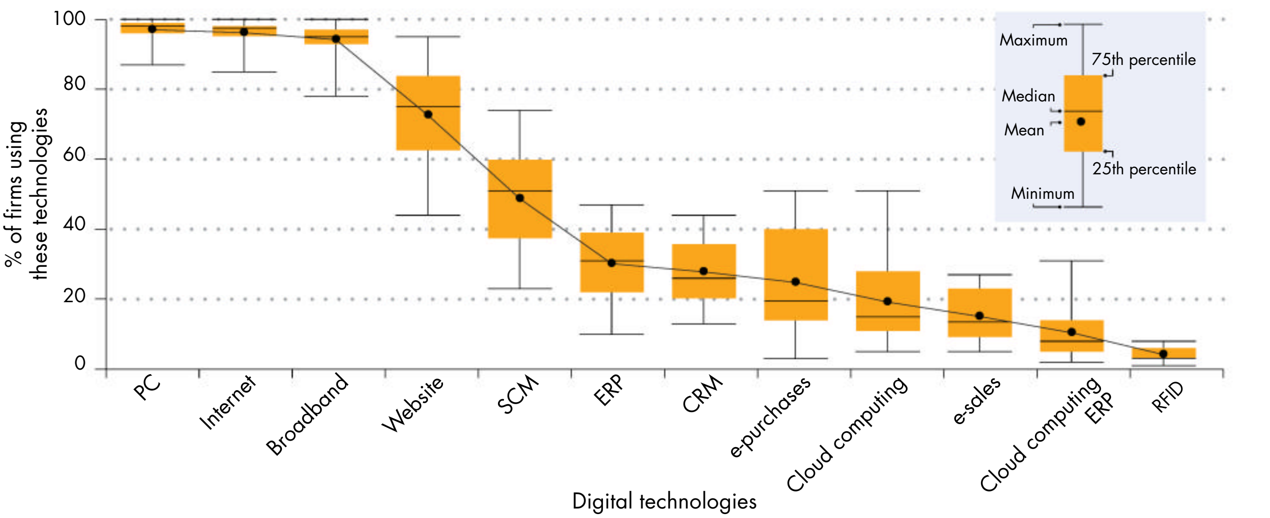
Map 1.1 Many more firms are using the internet in Vietnam



Source: Nguyen and Schiffbauer 2015. Data at http://bit.do/WDR2016-Map1_1.

Note: The census of Vietnamese firms includes more than 300,000 observations each year.

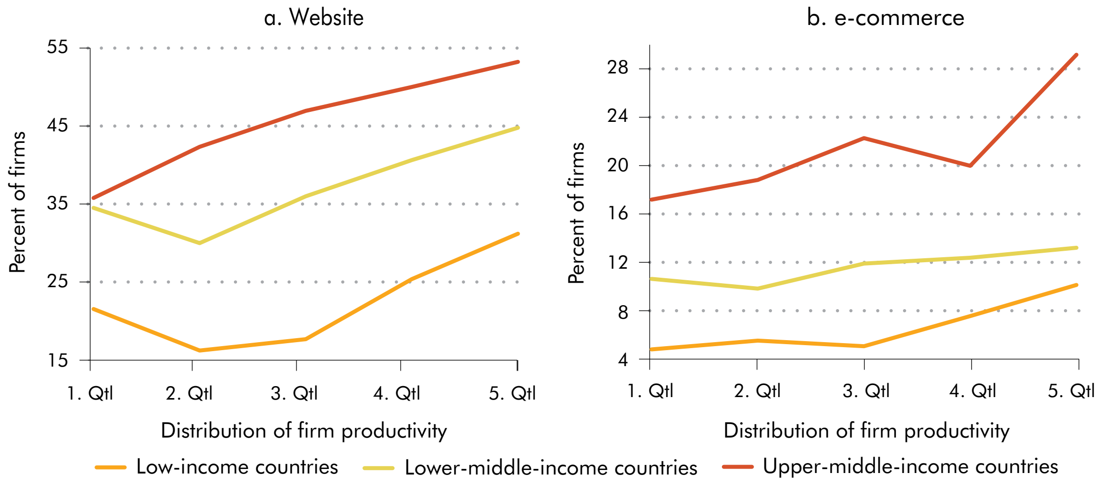
Figure 1.3 Many advanced digital technologies have not yet diffused across firms in high-income countries, 2014



Source: Eurostat, circa 2014 (EC, various years). Data at http://bit.do/WDR2016-Fig1_3.

Note: For each technology, the chart shows the distribution across 32 high-income countries of the share of firms (with at least 10 employees) that use that technology. Data are for 2014 or the last available year. CRM = customer relationship management software; ERP = economic resource planning software; PC = personal computer; RFID = radio frequency identification technologies; SCM = supply chain management software.

Figure 1.4 Higher-productivity firms are more likely to use the internet, 2010–14

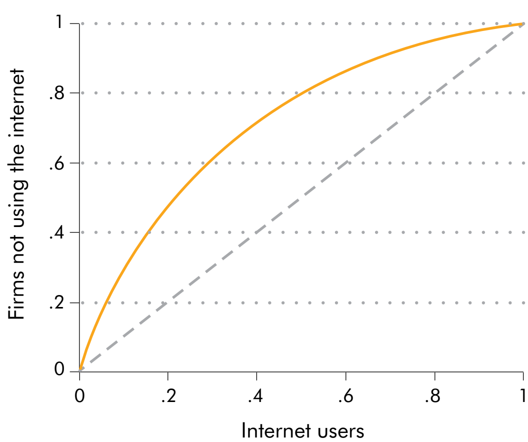


Source: Hussain (2015) based on World Bank Enterprise Surveys, various years. Data at http://bit.do/WDR2016-Fig1_4.

Note: The figures show the share of firms that have a website or use e-commerce among the different labor productivity quintiles across country income groups. "Qtl" refers to log labor productivity quintiles. The data, pooled for all years between 2006 and 2014, cover firms with at least five employees.

Figure 1.5 African firms using the internet are more productive, 2014

Distribution of sales per worker



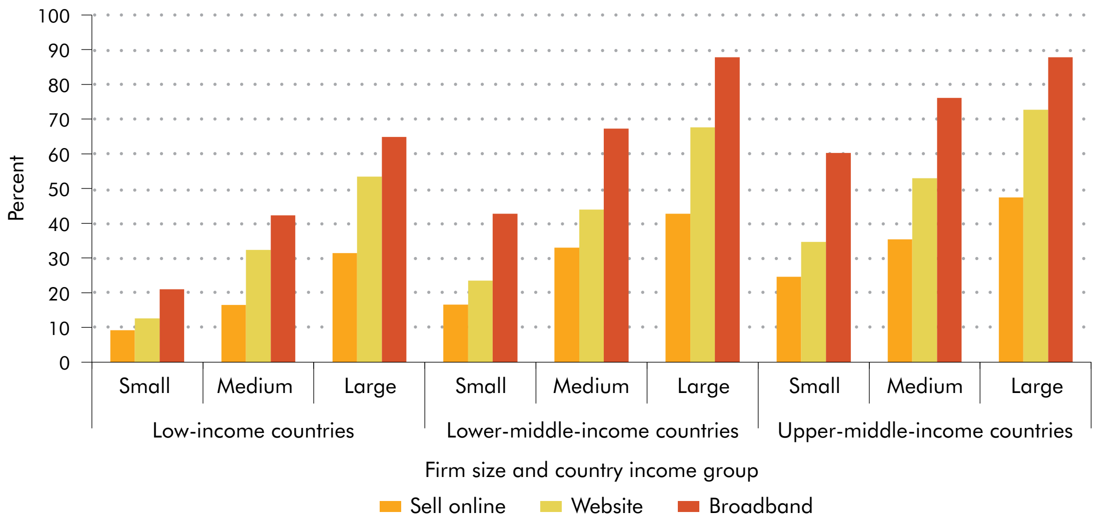
Source: Cirera, Lage, and Sabetti 2015. Data at http://bit.do/WDR2016-Fig1_5.

Note: The figure shows the relative distribution of productivity for firms that use the internet and firms that do not. Productivity is measured by sales per worker, estimated at the sector level. Results are similar using value added instead of sales. Observations on the 45-degree line indicate that firms in both groups have the same productivity. Firms not using the internet are less productive (above the 45-degree line) throughout the distribution of labor productivity. For instance, the median productivity firm among nonusers has about the same productivity as the 20th percentile firm of the productivity distribution among internet users. The surveys are representative of all firms with at least five employees in six African countries: the Democratic Republic of Congo, Ghana, Kenya, Tanzania, Uganda, and Zambia.

Firms that use digital technologies intensively also share other characteristics of high-productivity firms. They tend to be larger, fast-growing, skill-intensive, export-intensive, and located in the capital city.[7] Larger firms use the internet more intensively across all country income groups (figure 1.6), and 65 percent of large firms but only 21 percent of small firms use broadband internet in low-income countries. The differences are comparable for firms that use the internet for more demanding business activities: 17 percent of small firms deliver goods or services using the internet in lower-middle-income countries, compared with 43 percent of large firms.

Census and detailed survey data from Mexico, Turkey, and Vietnam confirm the positive correlation between internet use and the characteristics of high-productivity firms. Firms in Turkey using the web for online orders or reservations are 11 percent more productive, 25 percent larger, and twice as likely to export.[8] Those having a website are twice as productive, twice as large, and more than twice as likely to export as firms that do not have a website. In Mexico and Vietnam, firms are more productive if they have more computers per worker, conduct e-commerce, or have a higher share of workers using the internet.[9]

Figure 1.6 Larger firms use the internet more intensively across all income groups, 2006–14



Source: Hussain (2015) based on World Bank Enterprise Surveys, various years. Data at http://bit.do/WDR2016-Fig1_6.

Note: The figure shows the percentage of manufacturing and service firms that deliver orders over the internet, have a website, and use broadband internet by firm size across low-income, lower-middle-income, and upper-middle-income country groups. The data, pooled for all years between 2006 and 2014, cover only firms with at least five employees. Small firms have between 5 and 19, medium firms between 20 and 99, and large firms more than 100 employees. The statistics are based on about 100 countries (some countries being surveyed twice) and 27,035 firms selling online, 94,083 with a website, and 43,628 using broadband.

More trade, higher productivity, and greater competition

Digital technologies raise growth, but quantifying their aggregate impact is difficult

The accumulation of ICT capital accounted for almost 20 percent of global growth between 1995 and 2014, growth accounting approaches suggest. However, the results need to be regarded with some caution, as the approach involves some severe measurement problems (box 1.1). The impact was largest between 2005 and 2009, when it raised aggregate annual growth by 1.3 percentage points a year in developing countries, out of a total of 6.6 percent among these countries, or 19 percent (figure 1.7). And among high-income countries, it contributed 0.4 percentage points out of 1.2 percent, or 38 percent.[10]

Digital technologies accounted for a higher share of aggregate growth in high-income countries, pointing to greater digital use. The accumulation of ICT capital accounted on average for 27 percent of aggregate growth (2.1 percent) from 1995 to 2014 in high-income countries and 14 percent of aggregate growth (5.4 percent) in developing countries, consistent with their less intensive use of ICTs. Firms in developing countries have considerable room to adopt digital solutions that have led to growth in high-income countries, such as using the internet for e-commerce or inventory management.

The true contribution to growth can be larger if ICT complements other production factors, but also smaller if it substitutes for them. Productivity externalities beyond measured production factors are ascribed to the residual TFP growth. A necessary (but not sufficient) condition to accurately measure productivity externalities is analysis at the firm level.

Assessing the growth opportunities of the internet warrants more detailed analysis of the mechanisms for it to affect growth. Against this background, it is instructive to draw insights from the economics of the internet as well as from the past industrial revolutions (see box 1.2). The internet reduces transaction costs, allowing firms to enter new markets, enhance their efficiency, and exploit economies of scale, leading to innovation. It does this by reducing information frictions, search costs, and the costs to communicate. The decline can be dramatic if firms adapt their business models to automate data-intensive transactions, generating economies of scale.

Box 1.1 Tracing back growth to a single, new technology suffers from severe measurement problems

My view is that pinpointing precisely which (explanatory) variables matter for growth is impossible.
—Robert Barro, 2015

The limited number of observations relative to the seemingly open-ended list of other potential growth correlates at the country level makes it almost impossible to reject alternative interpretations of the same macroeconomic correlation. Faster-growing countries, for instance, have more resources and economic opportunities available to invest in information and communication technology (ICT) infrastructure; thus, the direction of causality may run from growth to ICT rather than the other way around. Moreover, there are severe endogeneity issues, since differences in the provision of ICT infrastructure across countries are likely to be positively correlated with (time-varying) unobservable, country-specific GDP correlates such as government accountability and other institutional factors, leading to an upward bias in ICT-growth elasticity estimates.

Cross-country growth regressions are not an appropriate tool to draw inference on the impact of ICT on growth. Numerous studies find a positive correlation between GDP growth and (lagged) values of different forms of ICT capital stocks based on cross-country growth regressions.[a] It is tempting to take the estimated ICT-growth elasticities at face value to quantify the impact of digital technologies on growth. But this approach has serious shortcomings. Most important, compared to the seemingly open-ended list of potential growth correlates, the sample sizes in cross-country growth regressions are fairly small due to the finite number of countries and the typically limited low-frequency time-series variation in the data.[b]

Growth accounting provides a less ambitious approach; it decomposes aggregate growth into the contribution of each production factor without getting to the issue of causality. But its precision also hinges on the ability to compute ICT capital stocks, which requires measuring depreciation rates and price indexes for digital technologies that appropriately reflect quality changes.[c] The approach also assumes that the contribution of each factor of production to output is proportional to the corresponding share in total input costs. So, the true contribution to growth can be larger or smaller.

Firm-level studies comprise large sample sizes and allow comparisons of the performance among firms operating in similar institutional environments. ICT investment is a firm's decision—still it is not plausible to assume that it is independent of performance. A positive productivity correlation in the data might simply capture that more productive firms use digital technology more effectively, indicating that other potentially unobservable firm-specific factors explain the positive correlation between digital technologies and firm productivity. In fact, many firm-level studies claiming to find productivity externalities still suffer from measurement and reversed causality problems.[d,e]

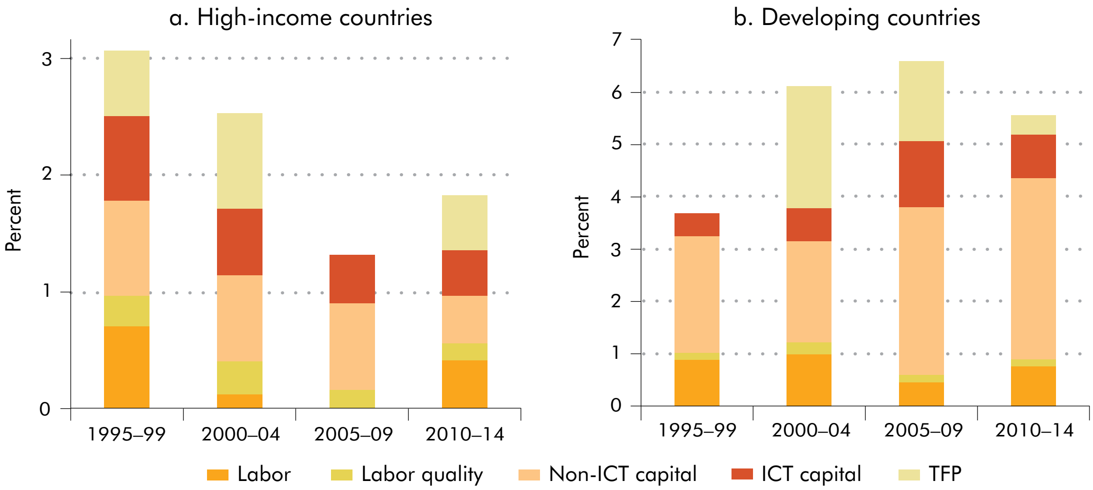
a. See Czernich and others (2009), Koutroumpis (2009), or Niebel (2014) for more recent contributions using cross-country regressions to assess the impact of broadband infrastructure on GDP growth. Qiang, Rossotto, and Kimura (2009); Cardona, Kretschmer, and Strobel (2013); and Minges (2015) provide surveys of the literature using cross-country regressions to assess the correlation between ICT capital and broadband internet on GDP growth, respectively.
b. Several researchers use methodologies, such as generalized method of moments (GMM) panel estimators, to address the endogeneity issue in cross-country growth regressions, but the results are typically not robust to small variations in the included countries, time periods, or control variables due to the large number of necessary country-level control variables, given the open-endedness of potential factors correlated with growth and ICT capital investments (Hauk and Wiczarg 2009).
c. But the acceleration in computing power (Moore's observation) involves a severe measurement problem, as conventional price indexes do not capture changes in quality of hardware or software. Jorgenson (2001) addresses this problem for hardware by constructing a constant quality index of computer prices using hedonic techniques. The Conference Board (2015) uses the World KLEMS data following this methodology, harmonizing the most recent techniques across countries.
d. See, for example, Gordon (2010, 2014) or Acemoglu and others (2014).
e. For instance, Draca, Sadun, and Van Reenen (2007) argue that causality has not yet been convincingly demonstrated.

The reduction in transaction costs thus increases inclusion (market access), efficiency, and scale, which translate into economic growth primarily through the three channels of trade, capital utilization, and competition.

Inclusion—facilitating international trade

Online marketplaces can reduce differences in the information available to buyers and sellers (for example, information asymmetries), enabling more firms in developing countries to engage in international

Figure 1.7 ICT capital accounted for nearly one-fifth of global growth, 1995–2014



Source: Conference Board 2015. Data at http://bit.do/WDR2016-Fig1_7.

Note: The figure shows the average contribution of factor inputs and TFP to aggregate growth for 39 high-income countries and 91 emerging economies. ICT = information and communication technology; TFP = total factor productivity.

Box 1.2 Is this time different? Predicting labor productivity growth at the technological frontier based on lessons from past industrial revolutions

History shows that productivity growth driven by general purpose technologies can arrive in multiple waves; it need not simply arrive, give what it has, and fade away forever thereafter.

—Chad Syverson, 2014

It is easy to find echoes of today's debates about the internet in the history of the industrial revolution. Each technological breakthrough comes with its own idiosyncratic variations, but much can be learned by studying the deliberations and experiences of the past.

Technological revolutions often take a long time to have significant impacts. The maximum impact of steam power on British productivity growth was not felt until the third quarter of the 19th century, nearly 100 years after James Watt's patent.[a] The benefits of railroads were fairly small initially, but grew as railroad productivity improved and rail output rose as a share of economic activity.[b] Similarly, investments in electrical capital equipment did not have important spillovers until the 1920s.[c] Initially, factory owners simply replaced large steam engines with large electric ones. It took nearly 40 years after electricity was widely available in the United States for organizational methods to catch up and develop more efficient decentralized production lines.

How do information and communication technologies (ICTs) stack up with past major general-purpose technologies? For instance, electricity led to the invention of air conditioning, elevators, and home appliances half a century later. Arguably, the internet can be regarded as a major follow-up invention from the computer (or microchip), just as the internal combustion engine led to the interstate highway system in the United States 60 years later. The internet boosts the productivity of computers and mobile phones in the same way that highways boosted the productivity of cars and trucks.

U.S. data show that labor productivity increased on average by 2.4 percent annually after the inventions of the internal combustion engine, electricity, and running water between 1891 and 1972. Then it slowed, averaging only 1.4 percent annually between 1973 and 1996. Between 1996 and 2004, it surged again, growing 2.5 percent annually, which scholars ascribe to the fast spread of the internet.[d]

(Box continues next page)

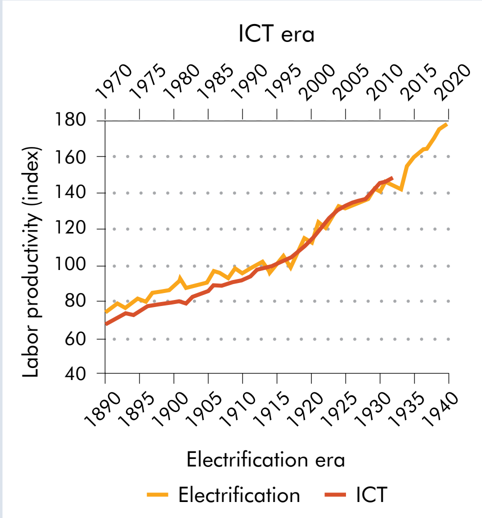
Box 1.2 Is this time different? Predicting labor productivity growth at the technological frontier based on lessons from past industrial revolutions *(continued)*

Since 2004 aggregate productivity growth has returned to its pre-1996 level, averaging 1.3 percent annually.

Does the 2004–13 productivity slowdown in the United States reflect a petering out of the ICT revolution? Gordon interprets this as a sign that the IT (or internet) revolution does not have the same lasting impact as previous industrial revolutions triggered by the internal combustion engine or electricity.[e] But the difficulty of tracing a country's growth performance to a single new technology, given severe measurement and endogeneity problems, allows alternative interpretations of the same recent historical trend.

Syverson overlays U.S. labor productivity in the electrification era and the ICT era to show that productivity growth in both eras has exhibited remarkably common patterns so far (figure B1.2.1).[f] During the electrification era, labor productivity growth over the first 25 years was relatively slow, just as it was in the ICT era from 1970 to 1995. Then both eras saw decade-long accelerations in productivity growth, spanning 1915–24 for electrification and 1995–2004 for IT. Analogous to the 2004–12 slowdown, labor productivity growth slowed again in the electrification era in 1924–32. Then labor productivity growth in the electrification era sped up again, averaging 2.7 percent annually in 1932–40. This does not necessarily suggest that labor productivity in the United States will pick up again in coming years.

Figure B1.2.1 U.S. labor productivity during the electrification era (1890–1940) shares remarkably common patterns with the ICT era (1970–2012)



Sources: Syverson 2013; Crafts 2015.

Note: ICT series years are labeled on the upper horizontal axis; the series is indexed to a value of 100 in 1995. Electrification series years are labeled on the lower horizontal axis; the series is indexed to 100 in 1915. ICT = information and communication technology.

a. Von Tunzelmann 1978.
b. Fogel 1965.
c. David 1990.
d. Gordon 2014; Syverson 2013.
e. Gordon 2010, 2014. Byrne, Oliner, and Sichel (2013) use a growth decomposition of long-term time-series data and come to a similar conclusion.
f. Syverson 2013.

trade (box 1.3). To purchase any product, the buyer must find a seller, make a payment before receiving the goods, and trust that the seller will deliver the correct amount and quality on time. As a result of these information asymmetries, only the most productive firms export—typically the larger and older firms.[11] Online marketplaces help solve all three problems. They provide an organized marketplace for firms to advertise their products and find buyers in overseas markets.[12] They thus reduce the costs of trade by enabling firms to avoid intermediaries to establish trade connections or participate in costly trade fairs to market their products. Online marketplaces that operate internationally, like eBay, Amazon, and Alibaba, operate websites in local languages. Online marketplaces also include rating systems, allowing the buyer and seller to assess each other's performance. The ratings and individual comments, visible to anyone, build trust for future transactions and encourage more responsible behavior. Many online marketplaces also provide payment and delivery services to reduce the cost of e-commerce. Digital technologies also lower communication costs facilitating the unbundling of tasks, allowing firms to offshore production processes and services to developing countries at lower costs.

Box 1.3 Is the internet reshaping economic geography? Not yet.

Fifteen years ago, a widely read study pronounced the death of distance and concluded that, with better and cheaper communication technology, geography will no longer influence individuals and firms. It argued that the internet is making it easier and cheaper to communicate over long distances. Goods and services, increasingly virtual and weightless, can be delivered over the internet. That makes location irrelevant to what an individual consumes, to where an individual works, or to where the firm establishes its business.[a]

Even though the internet has reduced the economic distance between countries, geography still determines flows of goods and services. Bilateral trade between countries is still negatively related to the distance between them after controlling for the effects of the internet.[b] And online transactions are still negatively related to distance: transaction values on online market platforms like eBay in the United States and MercadoLibre in Latin America decline when the distance between buyers and sellers increases.[c] Internet websites hosted in countries closer to the United States receive more visits by U.S. consumers.[d] More generally, the number of online transactions globally declines when the bilateral distance between buyers and sellers increases.[e] Even so, the relationship between trade flows and geography is weaker for online transactions than for offline transactions.

The impact of distance on digital goods may at first seem counterintuitive, given that they are weightless and delivered over the internet. But distance might be capturing taste preferences that can influence online activities. The effects of distance are not uniform across all website visits. Instead, websites selling digital goods that are differentiated and dependent on taste (music and games) are affected by distance, but more standard digital goods (software and financial information) are not.[f] The effect of distance on online transactions also differs across product categories, where goods that appeal to a local market (tickets and sports memorabilia) are most affected by distance.[g]

The impact of the internet on the location decisions of firms and the geography of jobs is less clear. The internet facilitates the dispersion of firms by allowing better communication between workers performing complex tasks and greater disintermediation of production processes. And it enables the dispersion of jobs, as individuals find work regardless of their location through online labor exchanges (chapter 2). But it also opens locations previously considered economically unfeasible and allows firms to cluster in locations to take advantage of comparative advantage, further enabled by better communication technology.[h] Jobs are clustered in these locations because the firms want to access the dense labor market and specialized inputs suppliers. The equilibrium effect of the internet on the location of firms and jobs is difficult to determine, but the final global pattern of firm location could be many clusters connected by the internet.[i]

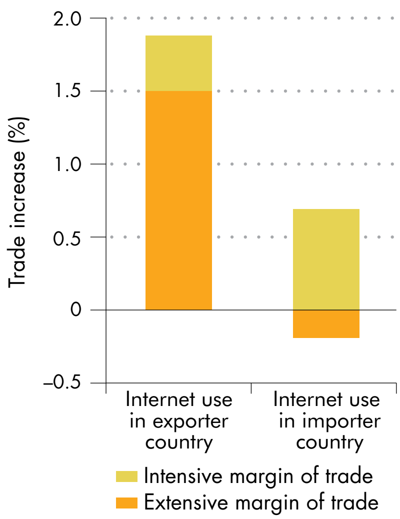
a. Cairncross 2001.
b. Freund and Weinhold 2004.
c. Hortaçsu, Martínez-Jerez, and Douglas 2009; Lendle and others 2012.
d. Blum and Goldfarb 2006.
e. Cowgill and Dorobantu 2014.
f. Blum and Goldfarb 2006.
g. Hortaçsu, Martínez-Jerez, and Douglas 2009.
h. Leamer and Storper 2001.
i. Venables 2001.

More internet use in a country is positively related to the growth of bilateral exports of goods and services.[13, 14] The relationship tends to depend on country income. Higher internet use in a developing country is related to higher exports to high-income countries, but not necessarily to other developing countries. Higher internet use in developed countries, in turn, has no effect on their exports. The similarities in internet use between trading partners can also affect how the internet affects trade. The trade between two countries is 25 percent higher if both countries have high internet use and 31 percent higher if the exporter has high internet use and the importer has low internet use, relative to two countries with low internet use.[15]

Enabling more firms to reach new markets

The internet makes it easier to reach new markets and thereby increases the extensive margin of trade—more firms start to export and more products get exported. A 10-percent increase in internet use in an exporting country increases the number of products traded between two countries by 1.5 percent; this increase in the extensive margin can account for as much as 78 percent of the total effect of the internet

Figure 1.8 The internet enables more firms to reach new markets, 2001–12



Source: Osnago and Tan 2015. Data at http://bit.do/WDR2016-Fig1_8.

Note: Extensive margin of trade: more firms start to export and more products get exported; *intensive margin of trade:* exporters increase the amount of their exports for the same products.

on trade (figure 1.8). The impact of the internet is largest if both countries have high internet use.[16]

Online platforms allow smaller firms to become exporters. The firms selling on eBay in Chile, Jordan, Peru, and South Africa are younger and have smaller market shares than firms in the offline markets.[17] The Alibaba platform has a larger fraction of small firms than the offline market.[18] Firms exporting through Alibaba also sell more products per firm.[19]

Online platforms enable firms to reach new export destinations, changing trade patterns. Marketing goods globally on the internet is cheaper, and customizing the marketing information to suit the local context and language is easier. So, firms trading through online platforms can reach more destinations than their offline peers. Chinese companies selling on Alibaba reach an average of 3 and a maximum of 98 export destinations,[20] up from an average of one and a maximum of 50 export destinations for the offline firms.[21] The set of export destinations also differs for firms exporting online or offline in China. And a larger share of the online exports reach emerging markets such as Brazil, Colombia, India, Nigeria, the Russian Federation, and Ukraine, compared with exporting offline, which is more intensive in low-income countries or traditional high-income markets such as Germany, Japan, and the United States (map 1.2).

Looking forward, the rise of online marketplaces can accelerate the integration of developing countries into world markets, opening substantial opportunities for trade and future growth. In China, Alibaba already enables smaller and younger firms to sell more products and reach more new consumers or businesses in foreign countries. Online marketplaces also emerged in other developing regions, but so far only on a (much) smaller scale or for market niches. The Moroccan online platform Anou enables artisans in rural areas to directly export their products online, cutting out traditional middlemen.[22] The Kenyan online platform iProcure prescreens its vendors to provide reliable local procurement services connecting agricultural businesses and institutional buyers.[23] So, e-commerce platforms should have substantial growth effects if they achieve sufficient scale in developing regions (see box 1.4).

Increasing the volumes of exported products

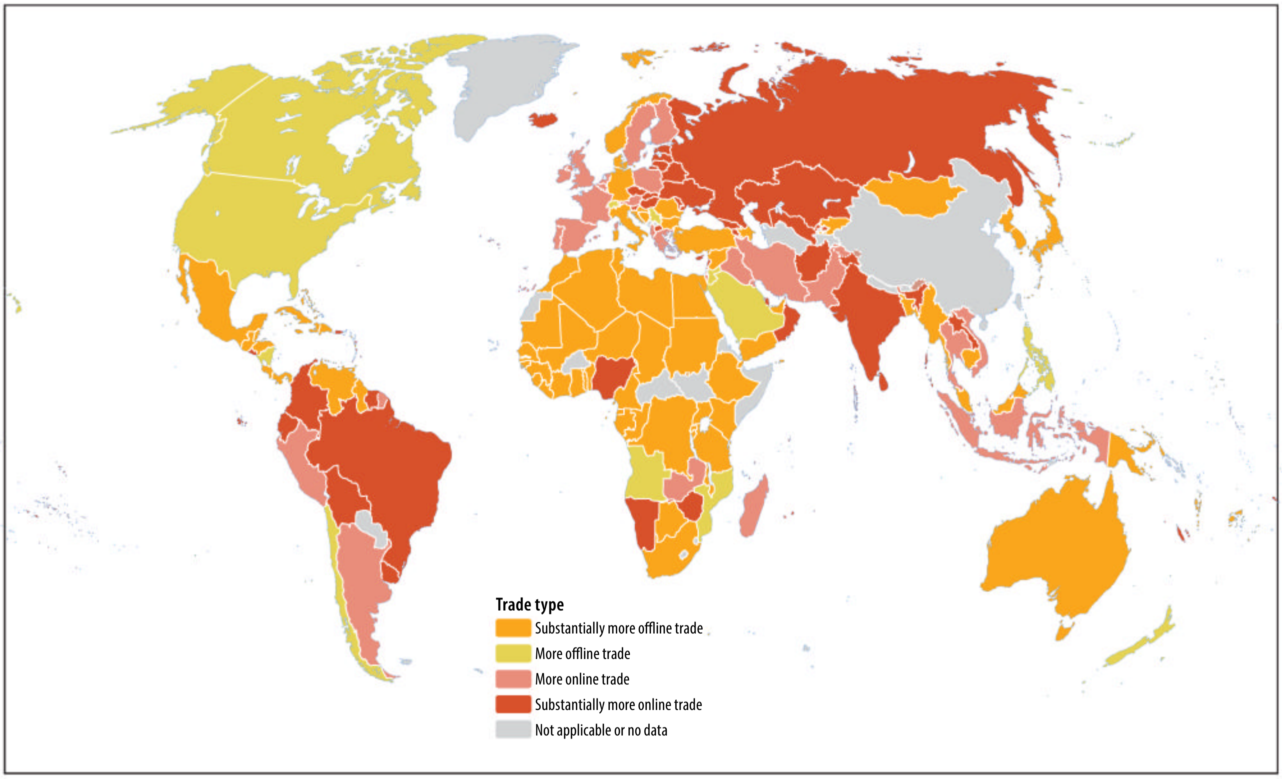
The intensive margin of trade—defined as the average trade per firm or product—increases with the internet penetration of countries. A 10-percent increase in the internet use of a country pair increases the average bilateral trade value per product by 0.6 percent. More specifically, the average export value per firm increases by 1 percent if internet use increases by 10 percent in the exporting country; it increases by 0.5 percent if internet use increases by 10 percent in the importing country.[24]

The rollout of broadband infrastructure boosted exports and labor productivity in China even in the era before Alibaba, from 1999 to 2007. The number of internet users increased across all provinces between 1997 and 2007, though it was stronger in coastal areas in the earlier years and in several inland provinces in later years.[25] The value of real exports seems to have followed a similar pattern.[26] The increase in internet domains and users per capita had a positive impact on firms' manufacturing exports in ICT-intensive sectors.[27] It raised the number of firms that export, the firms' share of export in total sales, and the real value of firms' exports. The higher share of internet domains and users also increased firms' real output and labor productivity.

Facilitating the unbundling of tasks

Better communication technologies have facilitated the unbundling of tasks, the "second unbundling" of international trade.[28] Businesses can locate different stages of their production in different host

Map 1.2 China's export destinations differ for firms using online platforms, 2006 and 2014



Source: Chen and Xu 2015. Data at http://bit.do/WDR2016-Map1_2.

Note: Countries are grouped according to their share of total revenue in online trade relative to offline trade. Online trade is measured by Alibaba platform transaction data, and offline trade by customs data. *Substantially more offline trade* is a ratio below 0.5 for the share of a country's online exports in world online exports divided by the share of its offline exports in world offline exports. *More offline trade* is a ratio between 0.5 and 1. *More online trade* is a ratio between 1 and 4.75 (75th percentile). *Substantially more online trade* is a ratio above 4.75.

Box 1.4 Successful online platforms account for local context and institutions

Successful online platforms cannot necessarily be transplanted to a foreign country without adapting to the local market and local institutions. The entry of eBay into China illustrates this. Both eBay and Taobao, Alibaba's consumer-to-consumer (C2C) platform, entered the Chinese market in 2003. eBay immediately established its dominant market share of 85 percent by acquiring the Chinese market leader, EachNet.[a] Taobao, however, quickly assumed a dominant position. By 2014, it accounted for over 80 percent of the Chinese C2C market (eBay exited the Chinese market in 2006).

Alibaba's success can be explained (at least in part) by its ability to adapt to local market conditions and culture to remove the information asymmetries unique to the Chinese C2C market. The Taobao website, for instance, indicates whether sellers are online and allows buyers to communicate instantly with the sellers through an online messaging system.[b] Alibaba further guarantees foreign buyers in-time delivery of their money and implemented a system to verify sellers on its website for business-to-business (B2B) transactions. Firms can buy a gold supplier status to have a third-party verification company conduct on-site quality control.

a. Wulf 2010.
b. Ou and Davidson (2009) note that Chinese consumers want to be able to communicate with their sellers and solve any problems relating to the transaction immediately.

countries to achieve greater efficiency in each stage. This unbundling of tasks allows firms to outsource production processes and services to developing countries at lower cost, which in turn increases trade in intermediate goods and places more importance on global supply chains. This trend has, for example, enabled the strong growth in business process outsourcing in Eastern Europe, India, and the Philippines. The foreign value added content of exports increased substantially along all major trade routes over the past 20 years, particularly among Asian economies.

Digital technologies reduce the costs of offshoring, especially when the host country has significant human capital. So, production structures become more globalized, and more firms choose to offshore different stages of their production. Higher use of ICTs by firms allows headquarters to manage increasingly complex functions, enabling them to confidently send these functions overseas.[29] As communication costs decline, exports of headquarter services to foreign affiliates, such as professional and technical services, increase.[30] These functions are, however, complex, implying that firms select host countries based on their human capital.[31]

Better use of digital technology in a country encourages multinational firms to locate their subsidiaries there. Many foreign subsidiaries are in countries with high business use of the internet, and the entry of a multinational into a foreign market is positively correlated with business use.[32] And the provision of digital technology in the host country has a stronger effect on the entry of multinational firms when the firm is in an industry that uses communication technology more intensively and has fewer routine tasks.

The unbundling of tasks has driven the tripling of service trade over the past 15 years, particularly for business, professional, and technical services such as legal, advertising, consulting, and accounting. The internet makes it easier for headquarters to transmit information, supervise their factories, and coordinate the supply chain across borders, encouraging firms to outsource not only manufacturing but also service tasks. Trade in education and professional services has also increased.[33] Trade in education services prior to the internet was conducted through correspondence courses, with textbooks and course materials mailed between instructors and students. Now websites provide massive open online courses, known as MOOCs, with video and other materials over the internet. They also connect health service providers enabling the spatial unbundling of health services, such as radiology. Similarly, professional and technical services can be supplied internationally over the internet. Online platforms like Upwork (formerly Elance-oDesk) create marketplaces for freelancers to provide these services (see chapter 2).

Efficiency—raising firms' utilization of capital and labor

Digital technologies help firms save costs by automating data-intensive production processes and reorganizing their business models, increasing their productive use of capital and labor.[34] Computers and software allow firms to routinize processes, increasing management efficiency and replacing personnel with, for instance, human resource or supply chain management software. The internet further increases the opportunities for cost saving by connecting machines, suppliers, and clients, so that firms can manage their supply chains and inventory more effectively in real time. The extent to which digital technologies raise labor productivity depends on firms' activities, but examples abound across countries and economic sectors.

The vast majority of efficiency gains emerge outside the ICT sector, where firms use the internet to sell and market their products online or share real-time information with suppliers to minimize their inventory and with customers to optimize their services. The digital economy accounts for about 6 percent of GDP in OECD countries (box 1.5). Less visible but more important for growth, incumbent firms in traditional sectors invest in digital technologies to save costs by optimizing their production and management processes. Retail companies such as Walmart, for instance, have integrated (global) supply chains to minimize their inventory holdings by linking electronic cash registers at retail outlets and business-to-business ordering systems with order dispatch and transportation scheduling at remote factories. So far, the largest efficiency gains from firms using digital technologies have been found in wholesale and retail trade, business services, insurance, finance, and selected manufacturing sectors. The following section highlights selected illustrations of how digital applications boost firms' efficiency.

Increasing management efficiency

Crowdsourcing information through mobile phone applications is helping farmers in Tanzania to prevent the outbreak of diseases. In Tanzania's Lake Zone, 60 groups of farmers from 10 districts belonging to the Digital Early Warning Network prevent the outbreak of the cassava disease by crowdsourcing

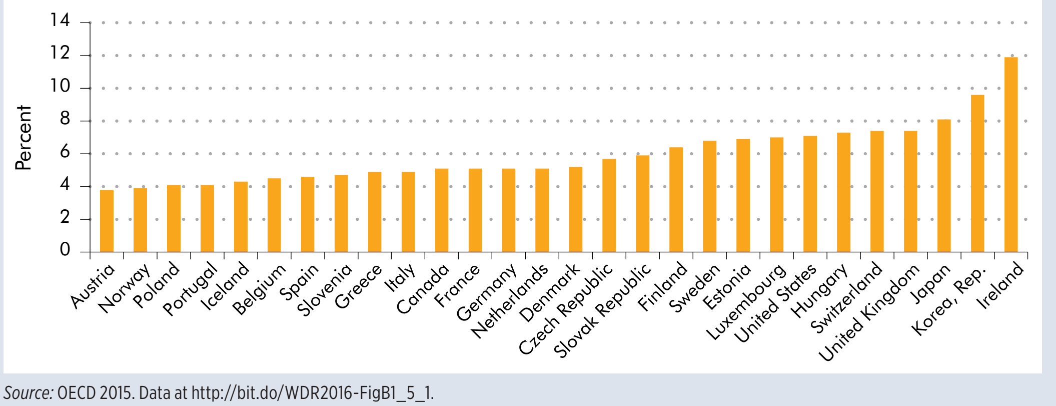
Box 1.5 The growth impact is largest when firms in traditional sectors use digital technologies to modernize their business

The digital economy accounts for about 6 percent of gross domestic product (GDP) in OECD (Organisation for Economic Co-operation and Development) countries (figure B1.5.1).[a] In the United States, which hosts some of the biggest tech companies, the value added of information and communication technology sectors in GDP is 7 percent, compared with 13 percent in real estate, renting, and leasing; 12 percent in wholesale and retail trade; and 8 percent in finance and insurance or health and social services.[b] The value added of information and communication technology (ICT) sectors in GDP is the highest in Ireland (12 percent), thanks to large inflows of foreign direct investment. In Kenya, which hosts one of the largest ICT sectors among African countries, the value added share of ICT services in GDP was 3.4 percent in 2013; that includes telecommunications (and thus mobile money).[c]

Despite the strong growth and high market valuations of internet firms offering conventional services, their market shares in these traditional sectors to date have been relatively small. Consider Amazon. In the United States, its home market, Amazon accounted for only 1.7 percent of the retail market in 2014; e-commerce accounted for about 7 percent of the U.S. retail market in 2015. By contrast, offline sales accounted for more than 99 percent of all sales of food and beverages; 84 percent of clothing and furniture; and 59 percent of books, magazines, and music.[d]

Less visible but more important for growth, incumbent firms in traditional sectors invest in digital technologies to save costs by optimizing their production and management processes. The McKinsey Global Institute estimates that 75 percent of the economic impact of the internet in 12 large developing and developed countries originates in firms in traditional sectors—firms that would exist without the internet but that use it to increase their cost-effectiveness.[e] The findings are consistent with studies showing that the bulk of U.S. productivity growth over the past 15 years originated in ICT-using, not-producing sectors.[f]

Figure B1.5.1 The ICT sector accounts for 4–7 percent of GDP in most OECD countries, 2011



Source: OECD 2015. Data at http://bit.do/WDR2016-FigB1_5_1.

Note: ICT value added is the difference between the ICT sector's gross output and intermediate consumption. The data are from 2011. The aggregate of information industries here includes ISIC rev. 4 division 26 (manufacture of computer, electronic and optical products) and section J (information and communication), which in turn comprises divisions 58–60 (publishing and broadcasting industries), 61 (telecommunications), and 62–63 (computer programming, and information service activities). ICT industries are broadly defined, as they include publishing and broadcasting, trade and repair activities, and media and content industries (Division 63.9).

a. The McKinsey Global Institute (Manyika and others 2011) used a different approach to compute the contribution of the internet to GDP. It computes the total value of three main activities based on the internet: activities using the internet as support (e-commerce, online content, or advertising); internet service providers; and software and internet service activities such as IT consulting, hardware manufacturers (computers, smartphones, or hardware equipment). They find that these activities account on average for 3.4 percent of GDP among the G-8 countries, Brazil, China, India, the Republic of Korea, and Sweden in 2009. The impact is largest among the developed countries. The shares include publishing and broadcasting activities and media and content industries.
b. The classification includes internet firms such as search engines, but not online retailers. The market share of online retailers is, however, still relatively small: Amazon accounted for only 1.7 percent of the retail market in the United States in 2014; see http://www.bea.gov/.
c. World Bank 2015.
d. *Economist* 2014, 2015b.
e. McKinsey Global Institute (Manyika and others 2011). The results are based on a survey of 4,800 small and medium enterprises in the following 12 countries: Canada, China, France, Germany, India, Italy, Japan, the Republic of Korea, the Russian Federation, Sweden, the United Kingdom, and the United States.
f. See, for example, Jorgenson 2001, 2011.

information.[35] Each farmer has a topped-up phone card and has been trained to recognize early symptoms of cassava mosaic disease and brown streak disease. The farmers use the mobile phones to send monthly text messages to researchers about disease incidence. In return, they receive advice on disease control, and disease experts visit the area when more than 10 percent of the members of a group report the disease. The network, part of the Great Lakes Cassava Initiative, supports more than 1 million farmers in six countries.

Digital technologies help farmers in Botswana meet quality and traceability requirements for beef exports to the European Union. The farmers use the Livestock Identification Trace-Back System, based on transponders inserted into each animal, transmitting information automatically to databases in 46 district offices. The centrally stored data allow exporters to trace beef to the individual cattle and their owners, necessary to meet traceability requirements for imports into the European Union. The technology also helps improve veterinary services and save costs by optimizing feeding schedules.

Digital interventions in agriculture seem to work best when the information provided to farmers is simple, such as real-time prices or weather forecasts. Based on simple mobile phone applications or internet kiosks, real-time data improve farmers' access to prices, local weather forecasts, and more detailed advice on agricultural practices and input use (see sector focus 1).

Real-time data help equipment manufacturers in China turn over their inventory stocks five times faster than suppliers not connected to the internet. Supply chains and logistics operations account for 10–20 percent of Chinese equipment manufacturers' costs, so companies using real-time data to optimize inventories and transportation routes can achieve substantial efficiency gains. Anji Logistics, a wholly owned subsidiary of Shanghai Automotive Industry Corporation, connects its IT systems with dozens of Chinese equipment manufacturers to manage logistics. General Motors China has cut costs and improved customer satisfaction by building internet connectivity into cars, so that dealers can check faults remotely and send maintenance alerts to owners. With only 20–25 percent of small manufacturing firms in China estimated to have used the internet in 2013, there clearly is more scope to improve manufacturing efficiency.[36]

The Egyptian logistics firm RW uses the online platform En2ly to optimize supply chains, shortening the time to deliver goods. The platform ensures more efficient real-time communication and coordination with clients and gives RW access to a large pool of independent carrier trucks. Each truck has a global positioning system (GPS), so RW can track shipments in real time and be notified once the shipment is delivered. The technology shortens the supply chain gap between shipment and delivery in the domestic market, allowing RW to provide superior transport services at more competitive rates.

Connected water metering systems help municipalities identify leaks or changes in water use, reducing water losses by up to 10 percent. At its research center in France, U.S. manufacturer Itron developed water metering systems with wireless devices allowing remote reading over large distances, so that municipalities can reorganize maintenance and respond immediately to water waste or losses in the distribution network. The data also improve water consumption analysis to optimize client service and tariff structures. Itron's production of communication devices has increased fifteenfold since 2000, and its production of water meters threefold. Such connected metering systems have great potential to save drinking water—more than 30 percent of the drinking water produced worldwide never reaches the customer (often due to leaks).[37]

Looking forward, the internet of things should further increase the labor productivity of firms, implying substantial opportunities for more efficient business models and thus future growth (see spotlight 6). For instance, the German truck body and trailer manufacturer Schmitz Cargobull uses telematics (the integrated application of telecommunications and data) in its trailers for real-time sharing of data with drivers, freight agents, and customers on maintenance, loaded weights, cargo temperatures, and truck locations. The company adjusted its organizational structure and management practices to maximize efficiency gains and escape competition from low-wage countries. As a result, the firm's production pace necessary to meet customer demand fell by 90 percent, internal failures decreased by 92 percent, and yearly accidents declined by 95 percent between 2000 and 2013, as its market share for refrigerated trailers in Europe rose to 50 percent.[38]

Enabling online marketing and distribution

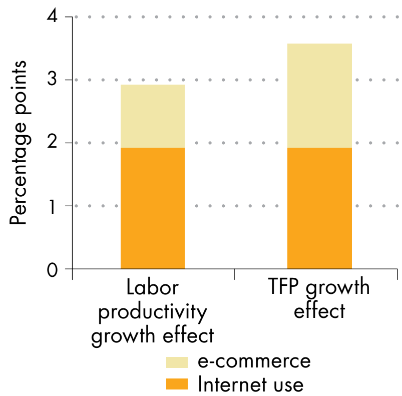
Firms are finding new and more efficient ways to market and distribute their products online. Carmakers represented on the internet in China can attend to about 10 million searches each day on Baidu, reducing their marketing and sales costs relative to nonconnected manufacturers. Volkswagen, for instance, is selling cars online to Chinese customers through its own website and on the e-commerce site Tmall.[39] Other manufacturers in China have been working with search engines to gain deeper insights into customer preferences to incorporate them in product development.

Vietnamese firms using the internet for e-commerce had 3.6 percentage point higher productivity growth in subsequent years. The rollout of broadband internet infrastructure in Vietnam (see map 1.1) is positively correlated with firm productivity growth. Using the internet increased TFP growth by 1.9 percentage point; firms also doing e-commerce increased TFP growth by an additional 1.7 percentage point (figure 1.9). The effect of e-commerce is larger in sectors that use ICT more intensively, consistent with a causal impact on productivity growth (see box 1.6).[40]

Innovation—intensifying competition and creating new business models

Online services and platforms eliminate search and communication costs, increasing price transparency and lowering the fixed costs to start a business. Lower fixed and marginal costs enable new startups to exploit scale economies from the beginning, supporting their rapid growth. The transaction costs for each new customer is almost zero for some services,

Figure 1.9 Vietnamese firms using e-commerce have higher TFP growth, 2007–12



Source: Nguyen and Schiffbauer 2015 for the 2016 WDR. Data at http://bit.do/WDR2016-Fig1_9.

Note: Results are based on a regression of TFP or labor productivity growth on the one-year lag of a dummy if the firm used the internet and the one-year lag of a dummy if the firm also conducts e-commerce. The regressions control for year fixed effects, province fixed effects, industry fixed effects, firm age, firm size, foreign ownership, exports status, state ownership, and the share of workforce with a secondary schooling degree. The internet or e-commerce effects are significantly larger in ICT-intensive industries, measured by World KLEMS two-digit sector-level data for Japan or the United States; two-digit sector-level data on telecommunication expenses in China; or four-digit sector-level data from a Vietnamese firm census, 2007–12, with more than 300,000 observations each year. ICT = information and communication technology; TFP = total factor productivity.

Box 1.6 Do digital technologies embed productivity externalities?

Firms' total factor productivity (TFP) growth in high-income countries is often positively associated with information and communication technology (ICT) capital accumulation.[a] The relation has been stronger in the United States relative to the European Union, particularly in ICT-using sectors, such as retail and wholesale trade, finance, and other business services.[b] The few studies for developing countries show that the correlations between firms' ICT capital stock and TFP growth in Brazil and India are comparable to those estimated for high-income countries.[c] A few recent studies focus on the impact of rolling out broadband infrastructure on firm productivity growth, but the results are ambiguous.[d]

Knowledge spillovers?

Some recent studies suggest a causal impact of firms' use of digital technologies on their TFP growth.[e] Identifying a causal impact requires that the spatial sequencing of ICT infrastructure rollout must be independent from productivity growth in the different locations. Such a case is arguably provided by the limited funding of a public program rolling out broadband internet access points in Norway in the early 2000s; the expansion of broadband increased firms' productivity.[f] Another study shows that establishments owned by U.S. multinational companies in the United Kingdom use their ICT capital stock more productively (after takeovers) relative to domestic firms and establishments owned by multinationals from other countries. This productivity differential is highest in exactly the same sectors that were responsible for the U.S. productivity surge from ICT investments in the 2000s, pointing to a causal impact of ICT on firm productivity among U.S. firms in these sectors.[g]

Foreign direct investment spillovers?

Foreign direct investment (FDI) in Jordan's ICT sector did not lead to growth spillovers among domestic firms

(Box continues next page)

Box 1.6 Do digital technologies embed productivity externalities? *(continued)*

interacting with the foreign tech companies. Neither domestic firms supplying goods or services to foreign tech companies (backward linkages) nor domestic firms consuming their services (forward linkages) grew as results of such linkages. The lack of measurable growth spillovers could be due to the relatively small number of foreign multinationals in the ICT sector (8 in ICT-producing sectors, and 160 in ICT-using sectors). And there are still relatively few domestic ICT companies in Jordan, such as software programmers, which are expected to benefit most from linkages with foreign tech companies. Furthermore, foreign firms like Microsoft or Oracle might use Jordan primarily as a hub to support regional activities involving few linkages to the domestic economy. The lack of spillovers to ICT-using sectors in Jordan suggests that Jordanian firms import ICT services rather than depend on the presence of foreign tech companies in the country.[h]

Producing new products and processes?

Broadband internet increases innovation. A study of German firms shows that broadband (DSL) infrastructure rollout between 2001 and 2003 increased firms' process and product innovation once broadband internet was available within their districts (measured by the postal code).[i] A study of six African countries finds that more intensive use of computers or the internet enabled more product and process innovation in 2014.[j]

Production technologies differ in whether they are more or less widely applicable across products or industries. That is, some knowledge can be more readily adapted for use in related production processes while other knowledge is limited in its application. So, products or industries embodying more applicable technologies also have more scope for technology externalities. A recent study uses patent citation data from the U.S. Patent and Trademark Office to trace the bilateral direction and intensity of knowledge flows between technologies. It finds that digital technologies typically are more widely applicable in driving the discovery of new technologies.[k]

Increasing international technology diffusion?

The internet reduces geographic distances, which are the main predictor of international technology diffusion. Technology spillovers provide an indirect channel for digital technologies to boost efficiency and thus firm productivity growth beyond firms' measured ICT capital stocks. For instance, the internet might facilitate the (international) diffusion of technologies by providing access to relevant information or inducing knowledge spillovers between users. The literature suggests that geographic distances are barriers to international technology diffusion.[l] Likewise, several studies find that bilateral trade flows embed learning externalities, spurring the diffusion of technologies. This Report provides evidence that the internet enhances trade and reduces distance, suggesting that the internet facilitates the international diffusion of technologies, even though the growth contribution of this channel is difficult to verify empirically.

a. Cardona, Kretschmer, and Strobel 2013.
b. See, for example, Inklaar, Timmer, and van Ark 2008; Schiffbauer, Serafini, and Strauch 2011; Bloom, Sadun, and Van Reenen 2012.
c. Commander, Harrison, and Menezes-Filho 2011.
d. Haller and Lyons (2015); Colombo, Croce, and Grilli (2013); and Bertschek, Cerquerab, and Kleinc (2013) do not find a significant impact of the rollout of broadband infrastructure on firm productivity in Ireland, Italy, and Germany, respectively. By contrast, Grimes, Ren, and Stevens (2012) and Akerman, Gaarder, and Mogstad (2015) find a positive impact in New Zealand and Norway, respectively. The results might suggest that moving from basic internet access to broadband leads to only marginal productivity improvements. However, it might also be too early to measure the effect of high-speed internet in firm-level data, since firms' use of the internet is often still relatively basic.
e. Most studies attempt to address the endogeneity problem by using lagged ICT or human capital variables as instruments. However, unobserved transitory shocks (or unobservable firm-specific factors) lead to serial correlation in ICT and productivity measures that make these types of instrumental variables invalid.
f. Akerman, Gaarder, and Mogstad 2015.
g. Bloom, Sadun, and Van Reenen 2012.
h. See Lamla and Schiffbauer 2015.
i. See Bertschek, Cerquerab, and Kleinc (2013). The authors analyze the impact of DSL infrastructure rollout in Germany in an early phase, when about 60 percent of German firms already used broadband internet.
j. Cirera, Lage, and Sabetti 2015.
k. Cai and Li 2015.
l. See Keller 2002; Keller and Yeaple 2013.

enabling scale effects and increasing the profits from innovation. Such scale effects inspire new business models based on the internet in services ranging from retail trade, transport, and logistics to tourism and finance. Innovations include mobile money, digital marketplaces, price comparator websites, online media, and the sharing economy. The substantial scale effects for some activities have also led to digital goods trading exclusively online, as for e-books, online search, and streaming music and videos—making transport, storage, and distribution obsolete.

Intensifying competition

Price comparator websites enhance transparency in prices and result in lower and less dispersed prices for consumers. Consider term-life insurance, where average prices have fallen up to 15 percent in the United States after the introduction of comparator sites.[41] These websites emerged in 1996 and eliminated the previously high markups. The potential customer fills out a medical questionnaire online, and the sites report quotes from companies that offer a suitable policy. In almost all cases, the individual does not buy the product directly online but gets connected instead to the offline seller. Comparator sites essentially provide an information platform between the consumer and the life insurance company that formerly was available only to brokers. In contrast, the prices of whole-life insurance, which were not covered by these sites, were not affected—whole-life insurance is a more complex product including built-in saving components, leaving more room for asymmetric information across buyers and sellers; a decline in search costs is thus less relevant.

Online registration systems can lower the cost of entry for new players, increasing competitive pressure for incumbents. The number of newly registered limited liability firms has increased, on average, 56 percent after the introduction of online registration systems (from 2.7 per 1,000 working-age population in years before the reform to 4.2 in the years after).[42] But this positive average impact masks heterogeneity across countries (figure 1.10). Thirty-three countries introduced online registration systems for firms between 2006 and 2012. The entry density declined somewhat in 8 of the 33 countries.

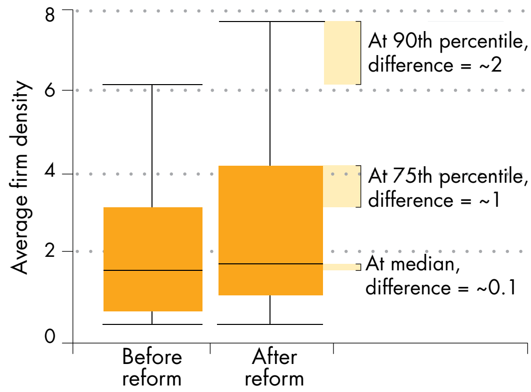
Two out of three firms experience moderate or severe competition from digital innovations. The share of firms reporting competitive pressure from traditional competitors is somewhat higher than the share of firms reporting competitive pressure from digital technology startups (figure 1.11). Firms in traditional sectors using digital technologies to modernize their business are thus an important source of competition (see also box 1.5).[43]

Bringing competition to incumbent firms

The internet has created new types of startups that base their business model entirely on the web but offer traditional services such as retail trade, finance, transport, logistics, tourism, media, publishing, and advertising. These new business models dissolve the boundaries between the online and offline economies and can help break existing regulatory barriers to entry in sectors that are often protected from competition.

Mobile money spurs competition in finance. Safaricom, the leading telecom firm in Kenya, launched the mobile money service M-Pesa in 2007, allowing users to transfer money through a simple text-based menu

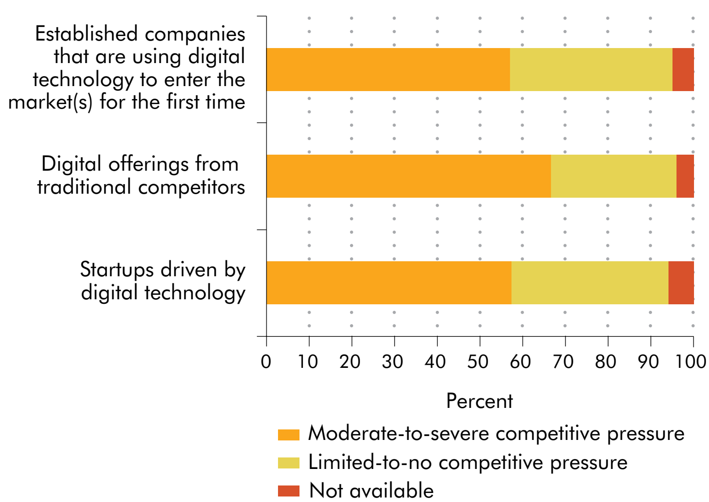
Figure 1.10 Firm entry rates rose after countries introduced online registration systems, 2006–12



Sources: World Bank Doing Business database, 2007–12; World Bank Entrepreneurship Database, 2006–12. Data at http://bit.do/WDR2016-Fig1_10.

Note: The entry densities are based on regression coefficients using the reform years in the Doing Business database. The reform year is either the year when the online business registration was introduced or when significant digital measures were undertaken to make the online registry more effective.

Figure 1.11 Two out of three firms report competitive pressure from digital innovations, 2014



Source: Economist 2015a. Data at http://bit.do/WDR2016-Fig1_11.

Note: The data are based on a global survey with 561 respondents.

available on the most basic mobile phone. By the end of 2013, 17 million Kenyans, or more than two-thirds of the adult population, were using the service to pay for taxi rides, electricity bills, or daily supermarket purchases. M-Pesa also created new opportunities for innovation. Kopo Kopo partnered with Safaricom to offer mobile money services to businesses. One of the key factors underpinning M-Pesa's success in Kenya was the regulator's decision to permit the scheme to proceed as an experiment without formal approval: similar schemes in other countries have typically been held up by opposition from banks and regulators. Firm-level data show that M-Pesa reduces the prices of competing services in the financial sector.[44]

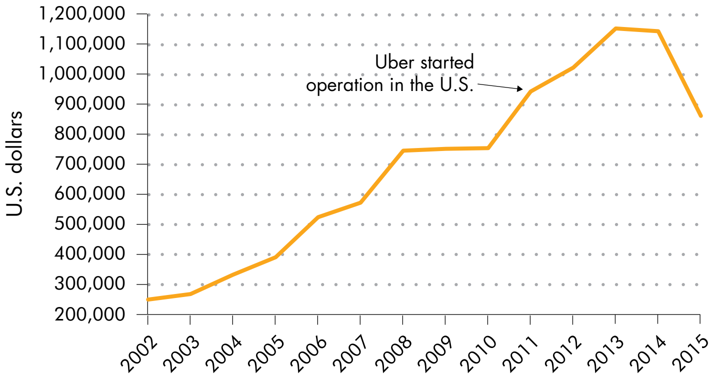
Internet startups offering financing based on "big data" analysis to target unbanked customers increase the competitive pressure for traditional banking services. For example, in China, regulations in the financial sector have been restrictive, with deposit interest rates partially liberalized only recently. In contrast, internet platforms for businesses are often loosely regulated, allowing them to offer financial services that bypass regulations in the financial sector.[45] Yu'E Bao, Tencent's online bank, and WeBank, for instance, offer online banking services in China. They collect deposits from households and lend money using big data analytics to assess the creditworthiness of potential borrowers. Yu'E Bao had 150 million subscribers by the end of 2014. These internet firms threaten the profitability of traditional banks, increasing competitive pressure. Similar startups have emerged in other countries. ZestFinance, LendUp, and Wonga currently target unbanked subprime customers in Canada, Europe, South Africa, and the United States. German startup Kreditech and Hong Kong SAR, China, startup Lenddo use information from social media profiles and networks to determine the creditworthiness of potential customers. Lenddo targets the thriving middle class in developing countries, which often lacks access to local financial services. Ghanaian startup Cignifi uses borrowers' mobile phone records to judge their creditworthiness.

Online marketplaces exert competitive pressure on brick-and-mortar retailers to innovate. The most prominent are online retailers and wholesalers such as Amazon and eBay in the United States, Alibaba in China, Flipkart and Snapdeal in India, Ozon in Russia, Jumia and Konga in Nigeria, and Takealot and Kalahari in South Africa. In the United States, online sales accounted for 25 percent of all retail sales for computers, electronics, and appliances in 2013. The competition from online retailers has led many large traditional retailers in the United States to combine digital and physical consumer experiences by offering online orders and in-store pickup services to improve their efficiency. And some online retailers such as Amazon started to open brick-and-mortar stores to enjoy potential (marketing) advantages of traditional retailers.

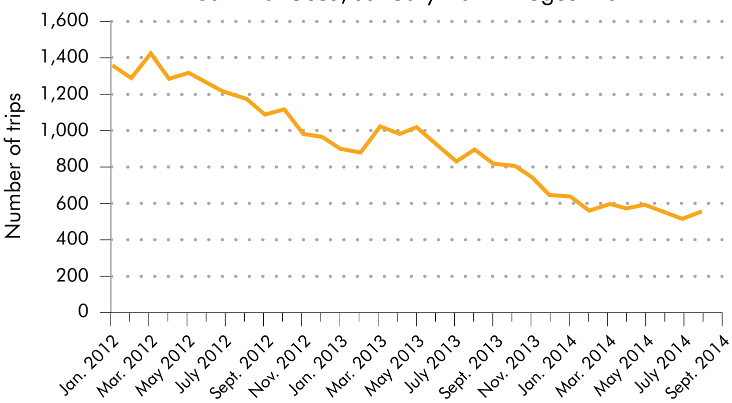
Ride sharing services enhance competition and the efficiency of transport services. Many cities around the world require drivers to hold a license to operate a taxi; entering the market is often associated with high fixed costs since licenses are issued rarely and must be bought from current owners. The licensing system, together with growing urban populations, has led prices for taxi medallions to skyrocket in large cities worldwide; in New York City, the cost of a single-taxi medallion increased from about US$400,000 in 2004 to more than US$1,100,000 in the beginning of 2013 (figure 1.12, panel a). But the new

Figure 1.12 Prices of taxi medallions have started to decline following the entry of on-demand services and reduced demand for traditional taxis

a. Sales price of New York City taxi medallion, 2002–15



b. Average monthly number of trips per traditional taxi in San Francisco, January 2012–August 2014



Sources: Wei and Mozur 2014; Metropolitan Transportation Agency (New York), http://www.mta.info/; Golovin 2014. Data at http://bit.do/WDR2016-Fig1_12a.

competition from ride sharing services reversed the trend. In San Francisco, the home city of these companies, taxi use fell 65 percent (figure 1.12, panel b). After decades of steady increases, single-taxi medallion prices in New York City started to slump, falling to about US$800,000 by the end of 2014 (the trend is similar in other cities).[46] The new competition also forces taxi companies around the world to reduce their prices or improve their services. Taxi companies in various cities have begun to develop joint smartphone applications enabling online payment, rating, and vehicle tracking in real time to compete with the ride sharing services. The trend is not confined to high-income countries. While Uber operates in more than 57 countries and 300 cities, regional competitors have emerged, such as Lyft and Sidecar in the United States, Hailo and BlaBlaCar in Europe, Kuaidi-Didi Taxi in China, Olacabs in India, and Easy Taxi in Nigeria.

Digital innovations increase welfare in many ways that are not necessarily captured by GDP statistics. These welfare gains are even more difficult to quantify, but a growing literature is shedding more light to these "unmeasured benefits" of the internet (box 1.7).

Internet platforms also reduce the entry costs in other service sectors contesting conventional business models. Airbnb operated in more than 40 countries in 2014, enabling owners to let their homes for short-term rents. This puts competitive pressure on the hotel and tourism industry, which has frequently enjoyed high rents due to local market segmentation or exclusive contracts in developing countries. The Estonian startup TransferWise and the U.S. startup Xoom match requests for international currency transfers online, saving direct and indirect transaction fees by clearing reciprocal currency transfer requests. The startups reduce regulatory rents by reducing the prices of international currency transfers by up to 90 percent. Postmates and Parcel provide local logistics services in U.S. urban centers and are starting to compete with traditional service providers such as Federal Express, but also with existing e-commerce platforms by matching customers demanding any type of locally available goods with a pool of couriers. And Kenyan startup Sendy provides a platform accessible by simple mobile phones connecting customers with motorcycle couriers to offer delivery services payable with mobile money.[47] Upwork (formerly Elance-oDesk) matches firms in high-income countries with freelancers offering professional service tasks in developing countries. The Ugandan internet platform eKeebo connects

Box 1.7 Much of the benefit from the internet is unmeasured

The internet offers many benefits to individuals that are not captured in the gross domestic product (GDP) statistics. Countries compute GDP based on activities measured in monetary terms and exclude activities that do not generate monetary transactions. But many online activities generate substantial benefits for the individual, such as time saved, consumer convenience, expanded choice, better quality leisure time, and access to more knowledge. These benefits can be understood as the consumer surplus: the difference between the price individuals are willing to pay and the actual price for the product or service, which is often free on the internet.

Economists are developing new techniques and collecting new data to present a more accurate estimate of the consumer surplus from the internet. One method is to analyze the price and quality outcomes of using the internet in a sector. A recent study compares the online and offline prices of used books, finding that online prices are lower than the prices in brick-and-mortar bookstores. It infers that the buyers and sellers are better matched online.[a] This stylized fact is an example of the "Long Tail" argument, which notes that online stores provide a larger variety of products and can sell niche products to more consumers.[b] The same study also estimates that the consumer surplus is higher when consumers shift to purchasing used books online.[c] A study of the music industry finds that variety and diversity have improved since 2000, mostly because independent labels and musicians can operate online and release their music digitally.[d]

Another way to calculate the consumer surplus from the internet is to directly measure individuals' willingness to pay for the internet (online products and services are often free and funded through advertisements). A McKinsey survey of consumers in France, Germany, the Russian Federation, Spain, the United Kingdom, and the United States in 2010 found that an average household would be willing to pay approximately €38 a month for internet services that it

(Box continues next page)

Box 1.7 Much of the benefit from the internet is unmeasured *(continued)*

currently receives for free.[e] Similarly, an examination of time-use data estimates that the median individual gains more than US$3,000 annually from the internet.[f]

A study comparing the outcomes of online searches to offline searches in a library finds that the average online search tends to be faster by 15 minutes, the results are more accurate and relevant, and the experience is more enjoyable than the offline search.[g] Also attempting to measure consumer surplus, another study finds that users of Google obtain a surplus of US$500 a year, on average, or a total of US$150 billion for a 300-million user base.[h]

The increase in time saved and in quality—and thus the productivity of work from using the internet—can indirectly increase GDP statistics. Conversely, the internet has also reduced productivity by providing an easy way to procrastinate and distract oneself with social networking sites and cute animal videos. The aggregate effects of the internet use of individuals are difficult to determine—an interesting avenue for further research.

But all this is not new. The initial gains from past technological change were also undercounted in GDP. For example, the cost savings from railroads made up about three-fourths of the total gains in GDP in the mid-19th century; by the early 20th century, this had fallen to about one-fourth. Time saving became by far the more important benefit as commute times shortened and the leisure time of working-class customers increased. Similarly, U.S. national accounts did not reflect the output from automobiles for nearly 15 years after the Ford Model T, the first mass-produced car, was available.

Source: Crafts 2015.

a. Ellison and Fisher Ellison 2014.
b. See Anderson 2006.
c. Ellison and Fisher Ellison 2014.
d. Waldfogel 2013.
e. McKinsey Global Institute (Manyika and others 2011).
f. Goolsbee and Klenow 2006.
g. Chen, Jeon, and Kim 2014.
h. Varian 2011.

individuals who want an authentic home-cooked meal with independent or amateur chefs, circumventing restaurant licensing, which can be a source of rent-seeking in developing countries.

Cloud computing can reduce the costs of entry in developing countries, implying substantial opportunities for innovation and competition and thus future growth.[48] It provides computing infrastructure (processing, memory, and storage of data), platform applications, and software services for firms with access to the internet. Firms can use these services, for a fee, without investing in the underlying hardware or software infrastructure. Cloud computing has significantly reduced the fixed costs of starting a business in the last decade. Startups can use the latest computing infrastructure, video conferencing services, or online payment systems at much lower cost. The reduction in entry costs has so far materialized mainly in high-income countries. Although local providers have emerged in developing regions, such as Angani in Kenya and Data Park in Oman, these have not yet achieved sufficient scale.

Digital technologies can lead firms and countries to diverge

Divergence—with benefits short of expectations

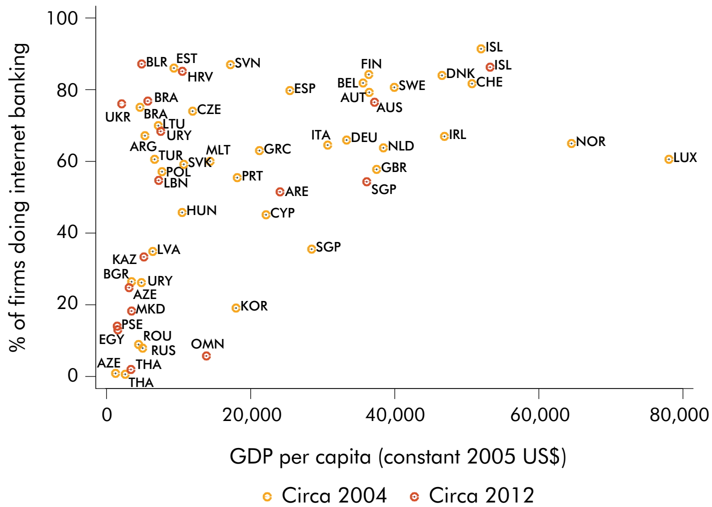
Despite the opportunities, firms' use of digital technologies differs substantially across sectors and countries; the differences prevail when comparing the ICT intensities of the same sectors across countries with a similar GDP per capita. The share of firms that used the internet for banking in 2012, for example, was below 20 percent in several middle-income countries, but more than 80 percent in others (figure 1.13).

This divergence in the intensity of internet use for firms in the same sector is confirmed by more detailed survey data from six African countries in 2014. The share of manufacturing and service firms with at least five employees using the internet ranged from 22 percent in Tanzania to 73 percent in Kenya. Of manufacturing firms in Kenya, 41 percent used it to manage their inventories, compared with 27 percent in Zambia and only 6 percent in Uganda (figure 1.14). Of service firms in Kenya, 41 percent used the internet to manage their inventories, compared with 15 percent in Zambia, 12 percent in Uganda, and only 8 percent in the Democratic Republic of Congo and Tanzania. The divergence in the shares of manufacturing or service firms that sell goods online or use the internet for marketing was comparably large across these six countries.[49]

The share of retail firms that sell their products online varies substantially across Latin American countries with a similar GDP per capita. In Bolivia, 52 percent of all firms with at least five employees in the retail sector sold their products online in 2010 (figure 1.15). Peru had a slightly higher GDP per capita in 2010, but only 14 percent of retail firms with at least five employees sold online. Only 18 percent of retail firms in Brazil sold online in 2010, and only 27 percent in Panama. In Mexico and Uruguay, about half of all retail firms sold online; in Argentina 62 percent. Variations in the share of retail firms that do e-commerce are comparably large in the other developing regions.

The share of firms that use connected customer relationship management (CRM) platforms to facilitate sales, customer support, and related interactions with customers or other businesses varies substantially across sectors and countries in Europe (figure 1.16). In Austria, 60 percent of retail and wholesale firms use integrated CRM systems, but only 28 percent do in the United Kingdom. Half of all manufacturing firms in Germany use these systems,

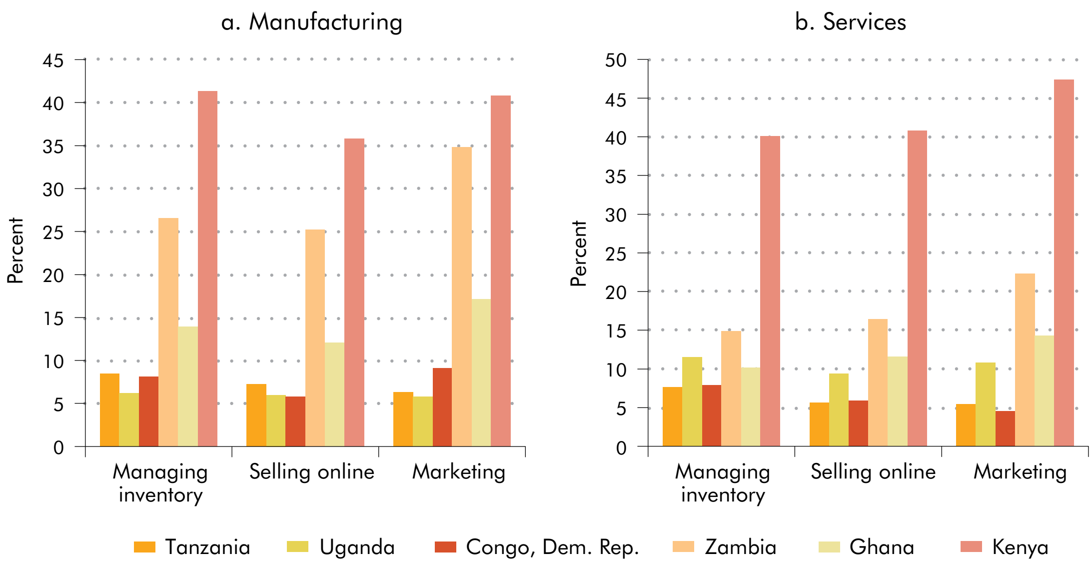
Figure 1.13 Firms' use of online banking varies substantially across countries at comparable incomes, 2003–06 and 2008–13



Source: UNCTAD, http://unctad.org/en/Pages/Statistics.aspx. Data at http://bit.do/WDR2016-Fig1_13.

Note: The figure shows all countries with available data for the latest year with available data from 2003–06 and 2008–13.

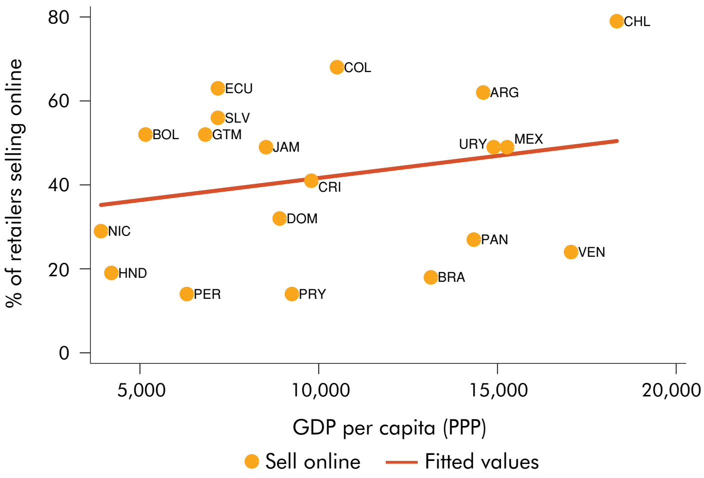
Figure 1.14 Firms' use of the internet varies among six African countries, 2014



Source: Cirera, Lage, and Sabetti 2015. Data at http://bit.do/WDR2016-Fig1_14.

Note: The figures show the shares of firms in the manufacturing and services sectors that use the internet to manage their inventory, sell their goods or services, and do marketing. The results are based on 2,843 firms (1,458 manufacturing and 1,385 service firms) in these six African countries in 2014.

Figure 1.15 The share of firms in the retail sector that sell their products online varies substantially among Latin American countries, 2010



Source: World Bank Enterprise Surveys data 2010. Data at http://bit.do/WDR2016-Fig1_15.

Note: GDP = gross domestic product; PPP = purchasing power parity.

compared to only 32 percent in Norway, 20 percent in Poland, 18 percent in Estonia, and 12 percent in Croatia. In Finland, 25 percent of professional service firms sourced CRM software from the cloud in 2014, but only 5 percent did in France or Lithuania.

These findings are consistent with previous studies showing that digital technologies diffuse much more slowly within developing countries than previous major technologies (for example, electricity or the steam engine).[50] This lack of internet penetration in developing countries contributes to cross-country divergence in incomes.

Why are the differences so large? In most countries, the physical infrastructure barriers to internet use are fairly small for most firms in urban areas. Differences in the affordability of the internet across countries have been an important factor (see chapter 4). But equally important are other structural barriers that limit firms' ability or incentives to use the internet more intensively. That three-fourths of all retail firms in Panama do not conduct e-commerce, for instance, might be related to a regulatory barrier protecting domestic retailers: foreign-owned firms are not allowed to operate in Panama's retail sector, reducing competitive pressure among domestic firms to increase their efficiency (see figure 1.15). By contrast, there are no restrictions to foreign entry into the retail sectors in Argentina, Mexico, and Uruguay—where retailers use e-commerce more extensively.

Market power—scale and network effects can lead to anticompetitive behavior

The digital economy can be highly concentrated. Facebook is the leading social network. Amazon sold 40 percent of all e-books in 2014. Google is the dominant search engine in most countries: it accounted for about 25 percent of the display-ad market, while Yahoo and Facebook accounted for about 10 percent each.[51] And while the sharing economy is increasing the number of market players in various services, Airbnb and Uber are its major platforms so far.

Figure 1.16 The share of firms using integrated customer relationship management platforms varies substantially among sectors and countries in Europe, 2014

Source: Eurostat (EC, various years). Data at http://bit.do/WDR2016-Fig1_16.

Note: The figure shows the shares of European firms in manufacturing, wholesale and retail, and professional services that used integrated customer relationship management software in 2014. Customer relationship management systems allow firms to track, record, and store data to facilitate sales, customer support, and related interactions with customers or with other businesses.

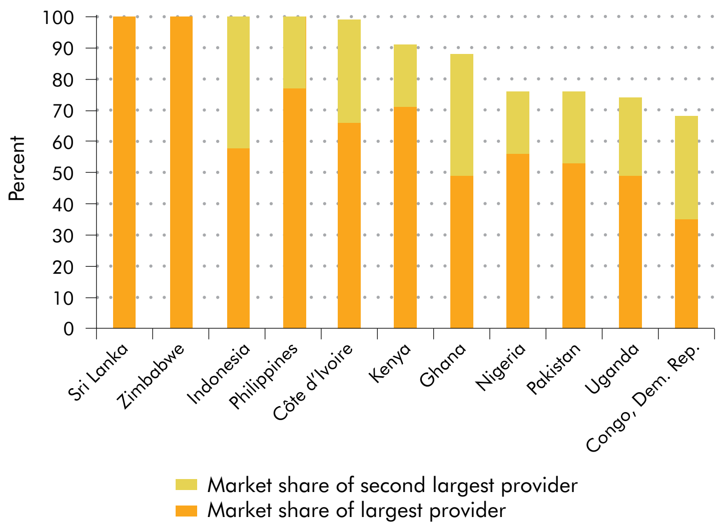
Domestic mobile money markets are often controlled by one or two operators. Safaricom, creator of the mobile money service M-Pesa, controls more than two-thirds of the mobile money market in Kenya (figure 1.17). The mobile money market in the Philippines is a duopoly, with the largest operator controlling 77 percent of the market.

What matters for antitrust regulators, however, is not the concentration of a sector per se, but the entry costs for new entrants or switching costs for consumers.[52] The concentration of various markets in the digital economy—often two-sided markets in which platforms match service providers or sellers with users or buyers[53]—is not surprising. When the transaction costs to serve additional customers are close to zero, the most innovative firm—say, the one with the best search algorithm or online platform—will be frequented by the most customers. As long as the fixed entry costs are low, the industry remains dynamic, in the sense that entrepreneurs programming more efficient search engines or applying superior business models will be able to enter and disrupt the existing incumbent (through creative destruction). AltaVista, for instance, was once the most popular search engine, but it lost ground in 2001 to new market entrant Google, which provided more efficient services.

Network effects or anticompetitive behavior can, however, create barriers for startups. For instance, the more people who use Facebook, the higher the value for users to create content on its website. Similar network effects (or switching costs) might exist for other online services. Google has been accused of using its dominant position in the market for online display advertising to curb competition and push companies toward its other services. Several Google competitors, including Microsoft and Yelp, had argued that Google unfairly demoted rivals in its search engine results to direct users toward its services. Similarly, Amazon has been accused of abusing its market power by delaying the shipping times of products from publishers that did not agree with its pricing mechanism.

The room for anticompetitive behavior varies among digital products and services. Network effects and switching costs appear to be large for search engines, allowing them to create barriers to scale for new firms offering this service. By contrast, programming ride sharing platforms can be imitated fairly easily, and drivers can use more than one platform at the same time in the absence of exclusivity contracts. Indeed, multiple ride sharing platforms competing with each other have emerged. And traditional taxi companies have also started to use the technology.

Figure 1.17 Mobile money markets are often controlled by one or two operators, 2014



Source: Evans 2015. Data at http://bit.do/WDR2016-Fig1_17.

New digital solutions can also raise fixed costs and thus lower competition in sectors such as manufacturing due to high up-front costs of software, data storage, analytics, and security.

Safeguarding a level playing field for business can thus also involve overhauling the regulatory regimes in the digital economy, including sectors in which technology is dissolving the boundaries between online and offline firms. The initial entry of internet firms into these sectors can disrupt monopolies, but regulators need to level the regulatory regime and prevent market shares from becoming excessively concentrated.

The nexus of technology and regulation

The potential impact of the internet on firm productivity is highest for activities where the internet can achieve large-scale effects and where contracts are easier to enforce—and thus can be automated. Economic activities can be classified by the degree of their amenability to the internet, based on:

- *Contract complexity.* Some goods and services are contract-intensive, because they embody a higher share of intermediate inputs that require relationship-specific investments that are more difficult to enforce by written contracts.[54] The less complex that goods or services are, the easier it is to enforce contracts and use internet platforms to

Table 1.1 The internet impact is highest for data-intensive activities that involve easy-to-enforce contracts

Data-intensive activities	More scalable	Less scalable
Less complex products (contracts easier to enforce)	Retail and wholesale trade, transport, insurance, banking	Legal services
More complex products (contracts more difficult to enforce)	Agriculture, education, health care, hotels and restaurants, manufacturing, real estate, utilities	Construction

Source: WDR 2016 team.

Note: The approximate grouping of sectors is based on the literature; among others, on Bloom, Sadun, and Van Reenen (2012).

market these products and match buyers and sellers (table 1.1).[55]

- *Scale effects*. The impact of the internet is larger if the internet can help achieve scale effects. For instance, longer value chains require more intensive real-time communication or sharing of large amounts of data between different stages of production or with suppliers and clients. The internet reduces these transaction costs, enabling scale effects and increasing management efficiency.[56]

Firms using digital technologies need to invest in skills and reorganization

As for any new technology, integrating digital solutions into firms' business models can be risky and lead to costly failures. Digital technologies have often been called on to help meet supply chain needs, but not all have brought the expected widespread benefits. Five or ten years ago, radio frequency identification tags for tracking individual goods were considered the major source for efficiency gains. U.S. retailer Walmart required its biggest suppliers to use the tags, but their use has not taken off in the extended supply chain.

The successful use of digital technologies depends on firms' complementary investments in skills and organizational restructuring. That more productive firms use digital technologies (more intensively) suggests that there are barriers to firms using them more effectively. Two such barriers for firms are the skills of the workforce and the ability to reorganize management processes to make better use of the efficiency gains that digital technologies can provide. There is even evidence that investing in ICTs without business process reorganization can reduce firms' productivity growth.[57]

The correlation between firm productivity and ICT capital stocks among firms in India and Brazil increases significantly after firms have reorganized their production structures or hired more skilled labor. Firms in Vietnam with a more educated workforce or a higher share of managers relative to total staff had a stronger correlation between firms' use of the internet (such as selling products online) and TFP growth in subsequent years.[58]

The majority of firms in Eastern Europe and Central Asia that use broadband internet have not reorganized their businesses, pointing to potential inefficiencies in the way it is deployed. Only one-fourth of firms using ICTs have adjusted their organizational structures or management practices (table 1.2).

The differences in these complementary investments help explain the heterogeneity in the use and impact of digital technologies. For instance, firms' investments in computerized information (digital technologies) are comparable among firms in the United States and Brazil (figure 1.18). But U.S. firms

Table 1.2 Many firms use the internet without changing their organizational structures, limiting its impact, 2010–14

percentage of firms

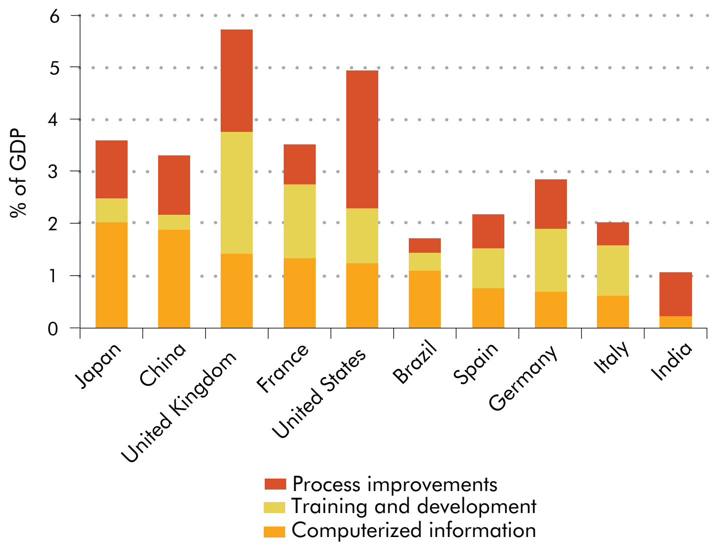
Did your firm introduce new or improved organizational structures or management practices?	Firms that use broadband		Firms that use e-mail		Firms that have a website	
	Yes	No	Yes	No	Yes	No
Yes	23	10	22	7	26	12
No	77	90	78	93	74	88

Source: Hussain (2015) based on World Bank Enterprise Surveys, various years.

invest substantially more in training and development (skills) and in business process improvements (reorganization), explaining why the impact of digital technologies on firm productivity is higher for U.S. firms. Similarly, firms in Japan and China had the highest investments in digital technologies, but they invested less in skills than France, Germany, the United Kingdom, and the United States.

Complementary skills and reorganizations are more important for more advanced digital technologies, potentially explaining the slow diffusion of some of these technologies across firms (see figure 1.4). Implementing customer relationship or supply chain management software and integrating it with ICT systems of customers and suppliers requires a well-trained workforce and the adoption of new organizational processes incorporating real-time information flows.

Figure 1.18 **Firms' ICT investments as a share of GDP in several countries are comparable to those of U.S. firms, but they invest much less in complementary skills and reorganization, 2006**



Sources: Corrado and others 2013; Hulten and Hao 2011; Hao, Hulten, and Jaeger 2013; Dutz and others 2012. Data at http://bit.do/WDR2016-Fig1_18.

Note: The countries are ordered by their investments in computerized information (digital technology) as a share of GDP.

Countries need to invest in skills and logistics to enable firms to use ICT more effectively

Since a shortage of skills can lower aggregate productivity growth despite investments in broadband infrastructure, countries need to invest in education to complement investments in new digital technologies (chapter 2). They also need to invest in infrastructure such as electricity, trade logistics, and payment systems.

Online marketplaces for nondigital goods enable scale effects if trade infrastructure is adequate. After an online transaction has been completed, the timely delivery of (physical) goods requires offline trade infrastructure.[59] Countries thus need ports with enough capacity to connect domestic firms to international markets and efficient domestic logistics infrastructure to complete the "last mile" delivery.

Online retailers in some countries still struggle to deliver their parcels to domestic customers. In 38 countries in 2012—27 of them in Africa—less than 50 percent of the population had access to home postal delivery (figure 1.19).

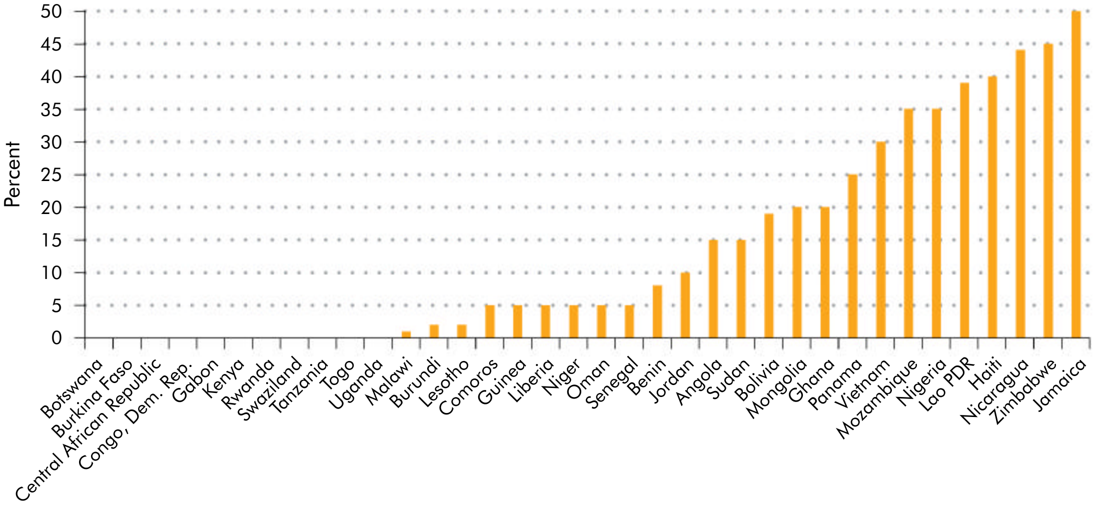
Faced with such difficulties, many e-commerce companies have come up with their own solutions. Alibaba has partnered with logistics firms in China to create a network for delivering parcels to Chinese cities within a day. Flipkart has partnered with the Dabbawalas, the deliverymen famous for their reliable delivery of hot lunches, to deliver parcels in India. Russian online retailer Ozon created its own logistics service company to increase the speed of deliveries.

Online payment services are available to firms in many countries but not in most African and Central Asian countries (map 1.3). Consumers and firms need a way to pay for online transactions. e-commerce relies on the ability of firms and consumers to pay for their products online. Credit cards are accepted on most online platforms, but many individuals do not have credit cards: less than 10 percent of the population in developing countries had a credit card in 2012.[60] Online payment systems providing business accounts, such as PayPal, MercadoPago, and PayU, are alternatives. For instance, MercadoPago provides online payment services to small businesses that do not have bank accounts.

The low share of firms using e-commerce in some developing countries can also originate from network effects in internet use. Network effects are present because the value of the internet to a firm depends on the number of internet users (creating online content). Thus low rates of domestic internet use by individuals, firms, and government reduce the benefits of e-commerce. But the argument is only relevant for firms that target the domestic market in developing countries with few internet users; exporting firms targeting world markets face over 3.5 billion potential online customers. The rapid increase in the number of internet users worldwide in recent years,

Figure 1.19 Many countries still have poor postal delivery systems

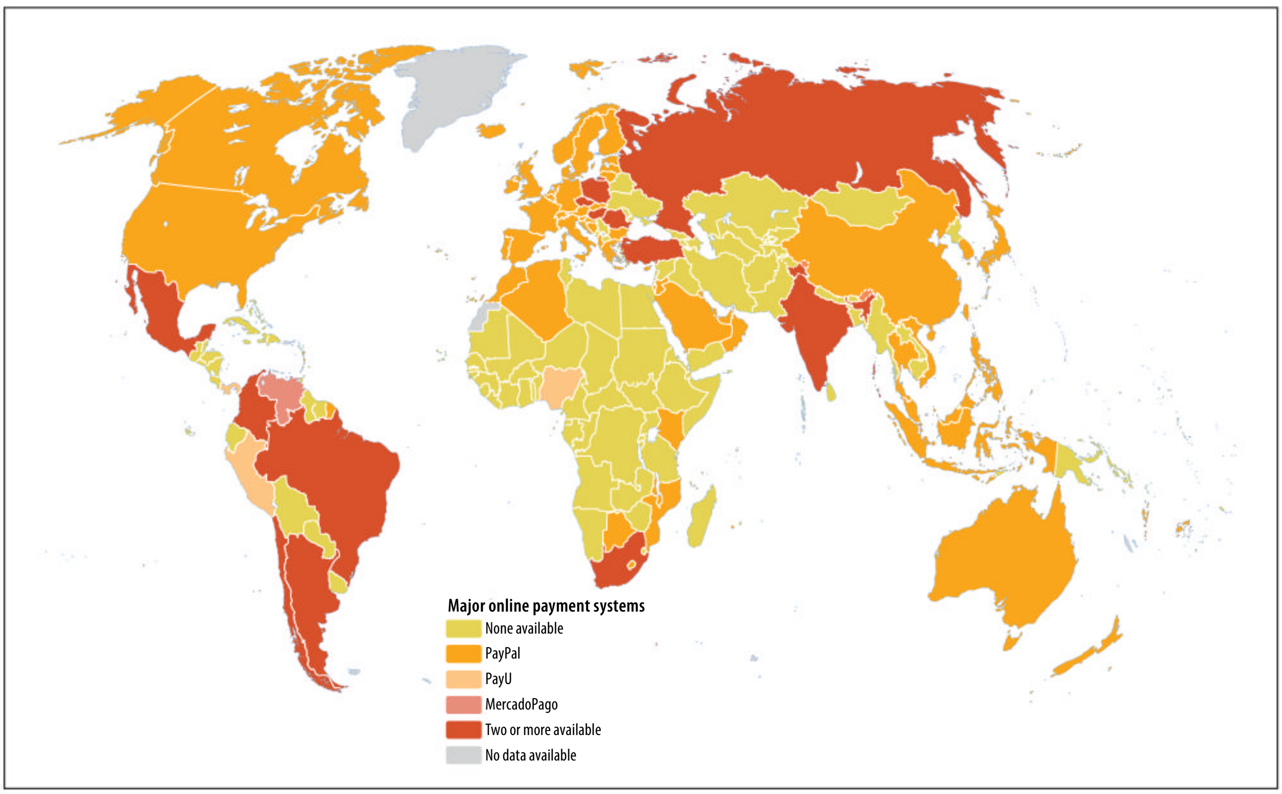
Percentage of population receiving home postal delivery in 2012



Sources: Universal Postal Union (http://www.upu.int/en.html); UNCTAD 2015. Data at http://bit.do/WDR2016-Fig1_19.

Note: The figure shows the 36 of 130 countries where less than 50 percent of the population receives mail delivery at home. Qatar and the United Arab Emirates have been excluded because they have a comprehensive public postal delivery system even though they usually do not deliver mail to homes but instead to local post offices.

Map 1.3 International online payment systems for businesses are unavailable in many parts of Africa and Central Asia, 2012–14



Sources: World Bank staff calculations; UNCTAD 2015. Data at http://bit.do/WDR2016-Map1_3.

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together with the lower transaction costs in online marketplaces should, in turn, encourage more firms (in developing countries) to use the internet to export to foreign markets in coming years.

Countries need policies to encourage competition

Domestic or foreign barriers to entry and competition reduce firms' incentives to invest in digital technologies or complementary skills and reorganization. Without competitive pressure, private firms lack incentives to invest in costly or risky new technologies. The complementary factors at the firm level correspond to competition policies at the country level. Firms are more likely to invest in skills or organizational restructuring if they are subject to product market competition.[61]

European manufacturers are investing in machines that communicate with one another (internet of things) to escape the increasing competition from low-cost Asian producers. For instance, BuS Elektronik invested in information technology to specialize in custom-designed electronics components produced in lot sizes that are too small to spur the entry of Asian electronics firms. The Daimler Group's Smart automobile plant uses modern information technology to integrate assembly and production lines among a network of seven large suppliers. The interlinked production system allows Daimler to optimize its value chain and to customize its products, with 10,000 variations of its vehicle cockpits. Low-cost factories in emerging countries cannot easily copy this strategy, which requires proprietary data.[62]

The mechanism is illustrated in Schumpeterian growth models predicting that each firm will invest in technologies new to the firm to reduce its costs and escape competition—albeit only temporarily. But these incentives are attenuated when leading firms in the sector have cost advantages that trailing firms cannot overcome. The market leaders have little incentive to invest in technologies new to the firm since they do not face competitive pressures to reduce their costs; the laggard firms are too far away from the frontier to bridge the cost gap and instead use vintage production technologies, focusing on local market niches to survive.[63] Thus fast-growing sectors with a high share of firms using new technologies exhibit specific firm dynamics, echoing high firm churning and neck-and-neck competition market structures, forcing firms to enhance their efficiency by investing in more productive technologies. The positive links among competition, technology adoption, and productivity growth are well documented.[64]

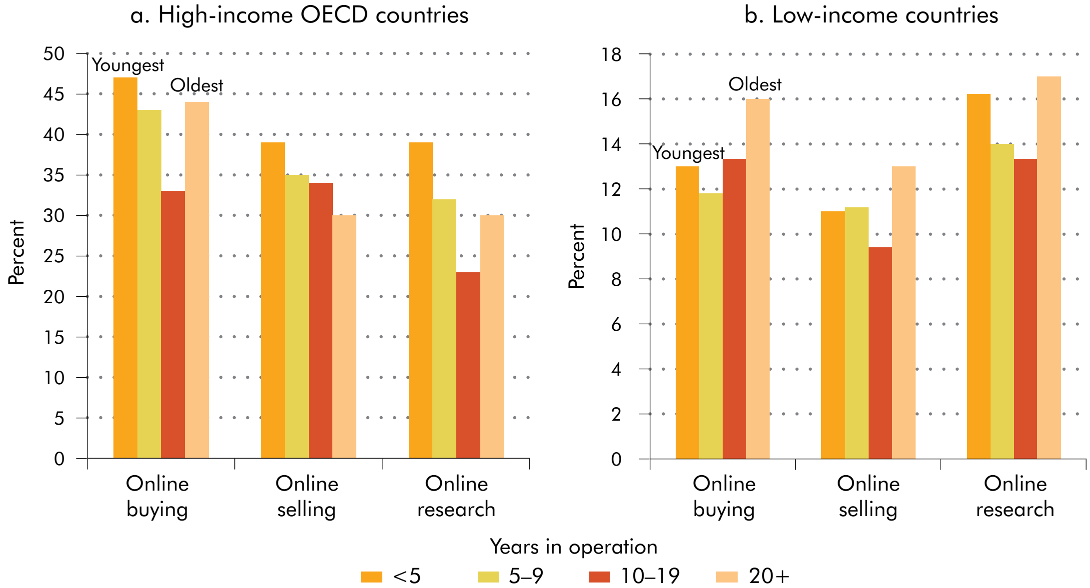
Consistent with the Schumpeterian mechanism, firms in more contested industries use digital technologies (more effectively). The allocation and selection mechanism in more contested markets drives firms to invest in new digital technologies.[65] Competition from China has induced the adoption of new technologies and ICTs in OECD countries, accounting for 15 percent of their technology investment between 2000 and 2007 and contributing to their productivity growth.[66] Arguably, the entry and innovations of Taobao, Alibaba's consumer-to-consumer (C2C) platform, were at least in part encouraged by foreign competition from eBay. Similarly, firms in more contested sectors in Vietnam, which have higher entry and exit rates, are more likely to invest in broadband internet. And younger firms in Mexico use e-commerce more intensively: the share of online sales in total sales is almost twice as high in young firms (less than five years old) than in older firms.[67] In France, automobile dealers enhanced their investments in ICT, such as human resource software and other innovations, when facing more intense product market competition after the liberalization of the automobile distribution system in the European Union in 2002.[68]

In high-income countries, the youngest firms use the internet more intensively, while in low-income countries, the oldest firms do (figure 1.20). In low-income countries, however, startups seem to face barriers to more intensive internet use, which the oldest firms (typically also larger) tend to overcome. In middle-income countries, the results are mixed.

Domestic firms in developing countries use the internet more intensively when they face pressure from foreign competition. The probability that domestic firms (with at least five employees) facing foreign competition use broadband internet increases by 41 percent; that they sell their products online, by 29 percent; and that they purchase inputs online, by 36 percent (figure 1.21). The increase in internet use due to foreign competition is independent of firms' initial productivity.

Among six African countries in 2014, for instance, increased competition incentivized firms to use the internet more intensively, leading to more product and process innovation. Firms that had experienced more competitive pressure, leading to a decline in their market shares over the past three years, invested in more intensive uses of the internet. For example, a 10-percent reduction in the market share increased the probability that these firms used the internet to market their products, on average, by 11 percent, and the probability that they used the internet to manage their inventory by 8 percent.[69] Domestic firms in

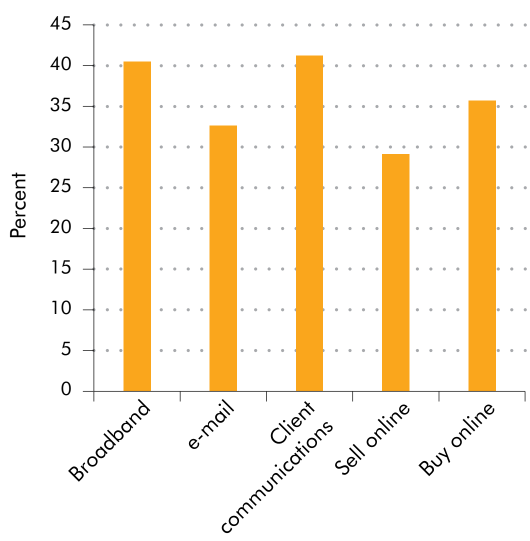
Figure 1.20 Young firms use the internet more intensively in high-income countries—old firms, in low-income countries, 2010–14



Source: Hussain (2015) based on World Bank Enterprise Surveys, various years. Data at http://bit.do/WDR2016-Fig1_20.

Note: OECD = Organisation for Economic Co-operation and Development.

Figure 1.21 Domestic firms use the internet more intensively when they face foreign competition, 2010–14



Source: Hussain (2015) based on World Bank Enterprise Surveys data, 2010–14. Data at http://bit.do/WDR2016-Fig1_21.

Note: The bar chart shows the coefficients of six firm-level cross-section regressions of dummy variables for internet use on a dummy if the firm reports pressure from foreign competition. All coefficients are significant at the 5 percent level. Each regression controls for firm age, firm size, foreign ownership, and sector- and country-specific effects. The data include all firms with at least five employees in more than 80 developing countries. The number of firms in the different regressions varies from 3,400 to 8,200.

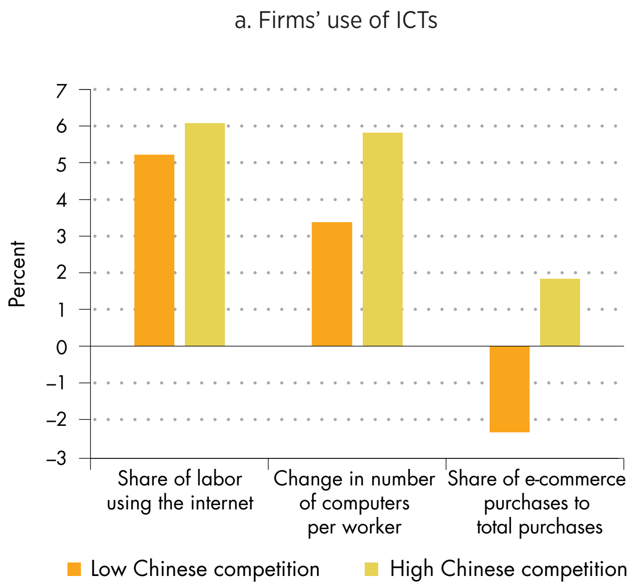
Kenya and Uganda used the internet more intensively in sectors with increasing competition from foreign direct investment (FDI). The (more intensive) internet use due to higher competition had led to more product and process innovation among firms in these six African countries.

Manufacturing firms in Mexico are more likely to invest in digital technologies and use them more productively when they sell products that are directly competing with imports from China. Firms that faced this external shock of higher foreign competition between 2000 and 2008, either in the domestic or the U.S. (export) market, increased their number of computers per employee, their share of labor using the internet, and their share of online purchases in total purchases in the subsequent four years, 2008–12 (see figure 1.22). As a result, the share of labor using the internet in 2012 was 11 percent higher for firms that faced more Chinese competition—and the share of online purchases was 114 percent higher. The more intensive use of digital technologies due to Chinese competition translated into productivity growth among firms in Mexico. By contrast, ICT use had no impact on labor productivity growth among Mexican firms that did not face import competition from China.[70]

Manufacturing firms confronted with an increase in competition in Brazil are more likely to implement

Figure 1.22 Firms in Mexico facing higher import competition from China use more ICTs more productively

percentage-point change, 2008–12



b. Percentage change in productivity associated with 1 standard deviation change in ICT measure

	Low competition	High competition
Computers per worker	9.6	27.2
Share of labor using the internet	6.0	18.0
e-commerce purchases/ total purchases	−9.9	10.2

-- Not statistically significant

Source: Iacovone, Pereira-Lopez, and Schiffbauer 2015. Data at http://bit.do/WDR2016-Fig1_22.

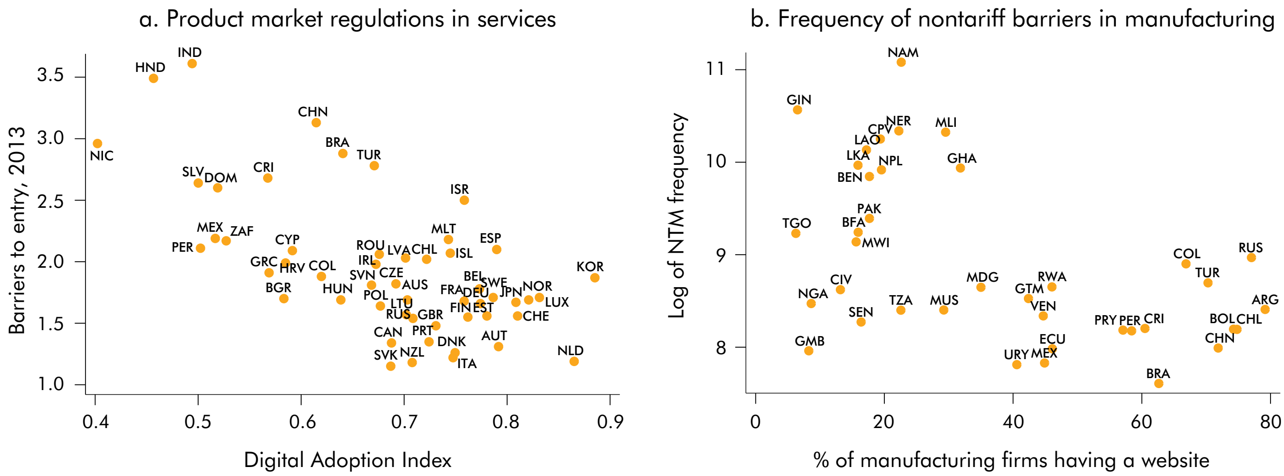
Note: Chinese competition is measured as the change in the share of China in Mexico's imports in the period 2000–08. The two groups depicted in these figures are defined as below the median (low competition) and above the median (high competition). The Mexico ICT survey, ENTIC, represents over 52,000 manufacturing and services firms with at least 10 employees. ICT = information and communication technology.

e-commerce systems. They are also more likely to move to more complete e-commerce systems—providing an online order and integrating payment system on their website—when they face more competitive pressure.[71]

Consistent with these findings, aggregate sector and country data suggest a negative correlation between regulatory barriers to product market competition and firms' investments in digital technologies. More restrictive product market regulations on firm entry in service sectors are associated with lower ICT use (figure 1.23, panel a). The negative relation prevails when comparing restrictions to domestic or foreign entry in individual service sectors with firms' internet use in these sectors across countries. Professional service firms in Europe—for architecture, design, consulting, legal, and accounting—are less likely to sell their services online in countries that have higher barriers to entry in these sectors. Transport service firms are less likely to purchase cloud computing services, such as CRM software, over the internet in European countries that have higher regulatory barriers for foreign firms to enter. Domestic retail firms are less likely to use the internet for online sales if they operate in countries with higher entry barriers for foreign retailers. The same is true for manufacturing firms: higher nontariff barriers to trade are associated with lower ICT use in manufacturing (figure 1.23, panel b).[72]

Firms' internet use varies with barriers to competition across sectors in the same country. The Philippine retail sector has substantial restrictions to domestic and foreign entry and is dominated by a few incumbent firms, while few firms use ICTs. Foreign retailers that aim to establish a commercial presence need to pass prequalification procedures, meet minimum capital requirements, meet limitations to foreign equity participation, and have the majority of the board of directors be Filipinos. Only about 20 percent of retail firms (with at least five employees) sell online in the Philippines.[73] By contrast, the Philippine business process outsourcing sector is characterized by high entry rates and few regulatory barriers to competition. It is intensive in ICT-related services such as software development, animation, contact centers, and transcription. These ICT-specific services experienced high productivity growth in recent years and provided about 1.2 million jobs in 2015. Similarly, Nigeria's retail sector, Indonesia's banking sector, and India's and Bulgaria's ICT sectors are more internet intensive and have fewer regulatory barriers to competition in otherwise difficult business environments.

Figure 1.23 Restrictive product market regulations in services and higher nontariff technical barriers to trade in manufacturing are associated with lower ICT use, 2010–14



Sources: Panel a: Product Market Regulation Index (OECD, various years); Digital Access Index (DAI) (Internet Coaching Library, various years). Panel b: World Integrated Trade Solution (WITS) database (World Bank, various years); World Bank Enterprise Surveys (World Bank, various years). Data at http://bit.do/WDR2016-Fig1_23.

Note: Panel a: The y-axis shows the barriers to entry subindex of the Product Market Regulation (PMR) Index (OECD, various years) for service sectors. The x-axis shows the Digital Adoption Index, as computed for this Report. The PMR index is available for 47 OECD and large developing countries, as well as for eight smaller Latin American countries. Panel b: The y-axis shows the (log) frequency of nontariff barriers (excluding class A, B, and D restrictions) across developing countries. The x-axis shows the share of manufacturing firms that have a website in the corresponding developing countries. ICT = information and communication technology; NTM = nontariff measure; OECD = Organisation for Economic Co-operation and Development.

Regulation to foster competition in the digital economy needs to consider network effects and switching costs, which can lead to new entry barriers in parts of the digital economy. To address these changes in market structures, regulations must prevent anticompetitive behavior and ensure that potential entrepreneurs have fair market access. Regulatory authorities in many countries play a similar role for other network industries, such as electricity or telecommunications. Regulators in several countries have made phone numbers portable across carriers—so that users can keep the same phone number while switching to a new provider—minimizing switching costs and ensuring a level playing field for new entrants. Similar regulatory innovations might be required for social media, digital marketplaces, digital payment systems, and the sharing economy, where users need to be able to change internet platforms with ease and at zero cost.

But regulating the digital economy is far from straightforward. It requires deep understanding of technical characteristics of the corresponding technology. Most internet firms, operating in two-sided markets, can blur price signals in either of the two markets. For instance, sharing economy platforms typically set the rates they charge customers as well as suppliers (drivers or homeowners). Once the platform has a large set of users, it can charge suppliers higher fees, despite having competitive rates for customers. So greater digital use needs to be accompanied by unified standards, full interoperability, and competition across platforms and contracts.

Overall, countries that pursue procompetitive regulations in most sectors grow faster, as firms in these countries invest in digital technologies and use them more effectively. Given the substantial variations in barriers to domestic or foreign competition and entry across countries, the divergence in firms' use of the digital technologies across sectors and countries is not surprising.

The future of markets

Uber, the world's largest taxi company, owns no vehicles. Facebook, the world's most popular media owner, creates no content. Alibaba, the most valuable retailer, has no inventory. And Airbnb, the world's largest accommodation provider, owns no real estate. Something interesting is happening.

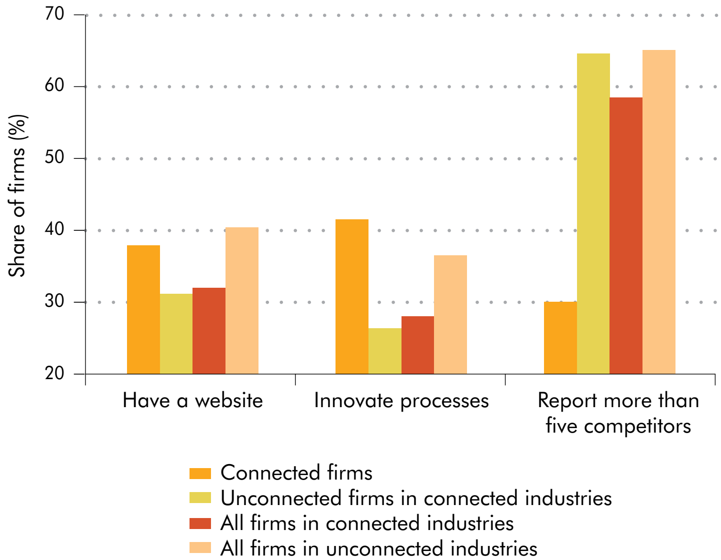
—Tom Goodwin, Havas Media

The internet promotes competition, which encourages more firms to use the internet—a potential virtuous cycle. So, competition is not only a complementary factor but also a mechanism for the internet to increase growth. Internet firms can circumvent regulatory barriers to competition and entry in traditional sectors such as retail, transport, or finance. But this will not happen if vested interests are strong enough to capture regulators and create new barriers to competition and technology adoption.

For instance, some taxi companies try to protect their lucrative businesses by pushing for new regulations that block ride sharing companies. Prices of the ride sharing companies, estimated *before the ride takes place*, can easily be compared, introducing greater transparency—something that taxi regulators attempted for years by requiring taxis to publish their price lists. Cities with tighter market controls like Barcelona, Berlin, and Paris recently saw widespread protests by the taxi industry, as opposed to Dublin, which deregulated its taxi market and lifted restrictions on the number of taxis practically overnight in 2000 (fares remain regulated).[74] In India, taxi associations wrote to the Reserve Bank of India complaining that Uber's credit card transactions violate the country's foreign exchange regulations. Uber collects the fare from a passenger's credit card, transmits it abroad in a foreign currency, and then sends 80 percent of the transaction value back to the driver. The taxi association argues that this violates Indian laws that permit Uber to collect the commission but not the fare in a foreign currency.

In Morocco, the market power of firms owned by influential politically connected businessmen stifles competition, ICT adoption, and innovation among manufacturing firms. Firms that are directly or indirectly owned by the political rulers are larger, have higher market shares, and have higher profits.[75] The larger scale seems to help these firms adopt digital technologies and innovate (figure 1.24). While politically connected firms individually invest more in ICT, their presence seems to discourage other firms from doing so. Politically connected firms appear to dominate their markets: only 30 percent of them report more than five competitors, compared with 65 percent of all other firms; only 11 percent of politically connected firms report price competition in domestic markets, compared with 37 percent of all other firms. There is no difference between politically connected and unconnected firms for price competition in foreign (export) markets. The dominance of politically connected firms and the resulting lack of competition seem to discourage all other firms in their industry from adopting digital technologies or innovating, leading to inferior aggregate technology adoption: only 32 percent of all firms in industries with at least one politically connected firm have a website, compared with 40 percent in industries without politically connected firms.[76] Only 28 percent of all firms innovate in politically connected industries, compared with 37 percent in industries without politically connected firms (figure 1.24).

Figure 1.24 The dominance of a few politically connected firms stifles competition and innovation in Morocco, 2004 and 2007



Source: Saadi 2015. Data at http://bit.do/WDR2016-Fig1_24.

Note: The analysis is based on 48 politically connected and 620 unconnected manufacturing firms with at least five employees in 2004 and 2007. See Saadi (2015) for more details.

Economic activities with a high potential growth impact from digital technologies are often protected from foreign or domestic competition in developing countries. The potential impact of the internet on firm productivity is often highest for economic activities that typically have higher barriers to competition (table 1.3). These sectors include utilities that are often natural monopolies, which are more difficult to regulate. But they also include banking, insurance, transport, retail trade, and some professional services, which are often protected by regulations from more foreign or domestic competition in developing countries (see figure 1.23).

In sum, developing countries with an institutional environment that safeguards competition and easy market entry will more likely harness the full growth opportunities of digital technologies and catch up faster with high-income countries. But countries will more likely remain poor if the institutional environment allows firms to obtain profits by lobbying for protection rather than investing in new digital technologies.[77]

Table 1.3 Economic activities with high potential for firms to use digital technologies more intensively are often protected from foreign or domestic competition in developing countries, reducing productivity growth

	Sectors or activities with barriers to competition		
Potential impact	**Lowest**	**Medium**	**Highest**
High	—	Banking, insurance, retail and wholesale trade	Transport
Medium	Manufacturing	Agriculture, hotels and restaurants, mining, technical services	Education, health care, real estate, utilities
Low	—	Legal services	Construction

Source: WDR 2016 team.

Note: The approximate grouping of sectors for the potential impact of digital technology is determined by scalability and contract complexity of most products in the sector, as defined in table 1.1. Digital technologies have a high potential in sectors that are more scalable and less complex (upper left cell in table 1.1), a medium impact for sectors that are more scalable but more complex or less scalable but less complex, and a low impact for sectors that are less scalable and more complex (lower right cell in table 1.1). The approximate grouping of sectors for the degree of competition is based on sectors' tradability, their average barriers to foreign or domestic entry across countries (for example, the Product Market Regulation Index [OECD, various years] and the Services Trade Restrictions Index), and their fixed costs (natural monopolies or land intensiveness). — = not available.

Notes

1. These channels can affect growth through more than one mechanism. For instance, the internet increases trade not only by allowing more and smaller firms to export (inclusion) but also by allowing existing exporters to trade more intensively, exploiting economies of scale (efficiency).
2. Nguyen and Schiffbauer 2015.
3. The results are based on ICT surveys linked to census data of firms in manufacturing and service sectors. The data cover more than 300,000 firms in Vietnam in 2011 (Nguyen and Schiffbauer 2015); 8,000 firms with at least 10 employees in Turkey in 2011 (Atiyas and Bakis 2015); more than 52,000 firms in Mexico in 2009 (Iacovone, Pereira-Lopez, and Schiffbauer 2015); and more than 3,000 manufacturing firms in Brazil (Cirera, Lage, and de Oliveria 2015).
4. See, for example, Cardona, Kretschmer, and Strobel 2013; Bartelsman, Hagsten, and Polder 2013.
5. There are two exceptions: firms in the second-lowest productivity quintile have the largest share of broadband users in low-income countries, and firms in the third-lowest quintile have the largest share of broadband users in upper-middle-income countries.
6. Cirera, Lage, and Sabetti 2015. Note that firm labor productivity is higher due either to higher TFP or to higher capital intensities.
7. See, for example, Haller and Siedschlag 2011.
8. Atiyas and Bakis 2015.
9. The statistics are based on census data including all manufacturing and service firms in Vietnam between 2007 and 2012 (no size restrictions). In Mexico and Turkey, the statistics are based on a representative sample for all manufacturing and service firms with at least 10 employees.
10. The results here are somewhat higher than the ones in Jorgenson (2011), who finds that the accumulation of ICT capital raised aggregate growth by 13 percent a year on average for more than 100 countries from 1995 to 2008. Moreover, Manyika and others (2011) estimate that the average contribution of the internet (alone) to economic growth was 0.3 percentage points among seven high-income countries between 2004 and 2009, and 0.4 percentage points for five large developing countries (Brazil, China, India, the Republic of Korea, and the Russian Federation). These results should be regarded with caution, however, since the growth contribution of the internet is effectively equated with the contribution of TFP.
11. Melitz 2003.
12. The internet reduces information frictions by providing a tool for firms to easily find information about new markets and advertise their products to multiple buyers. In addition, the internet can reinforce business and social networks and reduce communication costs with potential customers (Rauch 1999; Rauch and Trindade 2002; Fink, Mattoo, and Neagu 2005).
13. Freund and Weinhold (2004) examine the growth of bilateral merchandise exports of 56 countries and (2002) consider the growth of U.S. imports and exports of services. Both studies use data from 1995 to 1999.
14. There are two common measurements of internet usage in these studies. Freund and Weinhold (2002, 2004) and Clarke and Wallsten (2006) measure internet usage by the number of web hosts, while Osnago and Tan (2015) use the percentage of individuals using the internet in a country.
15. Osnago and Tan (2015) estimate a panel gravity equation using aggregate bilateral trade flows from 2001 to 2012 for all countries with country-pair and year

fixed effects. They determine whether a country has high internet usage when it has an internet usage above the median for all countries, which changes yearly.

16. The results are based on Osnago and Tan (2015).
17. eBay 2013.
18. Chen and Xu (2015) compare transaction-level data from AliExpress (a branch of Alibaba) and Chinese customs data across seven months. The online trade data are transaction-level data based on AliExpress from January to July 2014, and the offline trade data are Chinese customs data from January to July 2006.
19. Chen and Xu 2015.
20. The average number of export destinations is relatively low since the study focuses on only nine products that are narrowly defined at the 10-digit level (harmonized classification system). Thus, the average firm is only exporting about two different specialized products, for instance, silk and pure cotton T-shirts.
21. As a comparison, large firms selling on eBay reach an average of 30 export destinations (eBay 2013); large firms are defined as having an annual export of more than US$10,000 in 2012.
22. See http://www.theanou.com/.
23. Andjelkovic 2015.
24. Tan 2015; Osnago and Tan 2015. Tan (2015) uses the World Bank Exporter Dynamics Database (World Bank, various years) and estimates a panel regression to examine the effect of the internet usage of 4.5 million firms in 47 developing countries between 2002 and 2012. A product is defined as a harmonized system (HS) six-digit category.
25. This measure of physical infrastructure predicts firms' internet use; it is strongly positively correlated with the number of internet users by province over time (correlation coefficient of 0.55). Therefore, the length of the fiber-optic cables per population is also a good proxy for the number of "last mile" connections to firms or households in a province.
26. The number of exporting firms and firms' export share follow a similar pattern across provinces over time.
27. Fernandes and others (2015) use changes in the number of internet users per capita, Chinese internet domains per capita, and the length of fiber-optic cables per population to measure the rollout of broadband infrastructure across Chinese provinces between 1999 and 2007. The analysis is based on census data for manufacturing firms. The ICT intensity per industry is measured by the ICT capital services share in total capital services based on World KLEMS two-digit sector-level data for the United States, two-digit sector-level data on telecommunication expenses in China, and four-digit sector-level data from a Vietnamese firm census. All empirical specifications include firm fixed effects and *year x province* fixed effects controlling for time-invariant differences across firms and changes in any other export determinants across provinces over time.
28. Baldwin (2011) describes the reduction of transportation costs from the late 1800s as the first unbundling, where consumption and production can be geographically separated.
29. This relationship has been confirmed in Canada (Baldwin and Gu 2008), Germany (Rasel 2012), Ireland (Murphy and Siedschlag 2013), Italy (Benfratello, Razzolini, and Sembenelli 2009), the United Kingdom (Abramovsky and Griffith 2006), and globally based on a large dataset of multinational firms and their subsidiaries (Alfaro and Chen 2015).
30. Cristea (2014) also finds that the negative relationship between the headquarter services exports and communication costs weakens with the education of the foreign workers.
31. Fort 2014.
32. Alfaro and Chen (2015) examine the patterns of entry of multinational firms into 70 countries from 2005 to 2007. The data are from the Harvard Business School's Orbis Database (http://www.library.hbs.edu/go/orbis.html) and cover 1.2 million manufacturing companies.
33. Computer and information services exports include computer services such as hardware- and software-related services, news agency services, and database services.
34. Cardona, Kretschmer, and Strobel (2013) provide a survey of the recent microeconomic studies estimating the relationship between the use of digital technologies and firm productivity growth.
35. See UNCTAD 2013 and Ogodo 2009.
36. McKinsey Global Institute 2014; *Economist* 2014.
37. Chick, Huchzermeier, and Netessine 2014.
38. Chick, Huchzermeier, and Netessine 2014.
39. McKinsey Global Institute 2014.
40. The analysis is based on an annual panel of firm census data from 2007 to 2012 with more than 300,000 observations each year. TFP is estimated following the methodology of Olley and Pakes (1996). Each regression controls for two-digit sector dummies, year dummies, and firm characteristics (firm size, age, and ownership as well as export status). See Nguyen and Schiffbauer (2015) for details.
41. Brown and Goolsbee 2002. Their availability raised price dispersion initially and then reduced it as internet use became more widespread, which is consistent with the theory of search costs by Stigler (1961) and Stahl (1989).
42. The results are based on a regression of the average entry density on a dummy that is one in the years of or after the reform, controlling for year-specific effects.
43. The positive link between the use of new technology and competition is well documented. For instance,

Collard-Wexler and De Loecker (2015) show that two-thirds of the higher productivity in the U.S. steel sector after the introduction of a major new technology, the minimill, originated primarily from an increased competition effect and only one-third from a technology replacement effect. In particular, the minimill expansion drove a productivity resurgence at the surviving vertically integrated producers and thus for industry as a whole.

44. Mbiti and Weil (2011) find this effect based on firm-level data comparing competing money transfer services.
45. Wei and Mozur 2014.
46. Golovin 2014.
47. Andjelkovic 2015.
48. Van Welsum 2015.
49. Cirera, Lage, and Sabetti 2015.
50. Comin and Mestieri 2013.
51. According to data from the market-research firm IDC.
52. Rochet and Tirole 2003.
53. A two-sided market is one in which (1) two sets of agents interact through an intermediary platform and (2) the decisions of each set of agents affect the outcomes of the other set of agents, typically through an externality (Rysman 2009). For instance, in an e-commerce platform like Amazon, the two agents are the consumers and the online sellers whereby consumers benefit from more online sellers using the platform and vice versa.
54. Nunn (2007) constructed a measure of contract intensity for tradable goods. Contract-intensive goods include packaging machinery, musical instruments, and alcoholic beverages. Goods with low contract intensity include wearing apparel, frozen food, plastics and rubber, base metals, or fertilizers.
55. The correlation coefficient between the contract-intensity four-digit sectors in Vietnam from 2007 to 2011 and the share of firms that use the internet (have a website) in these sectors is 0.44 (0.28); see Nguyen and Schiffbauer 2015.
56. Bloom, Sadun, and Van Reenen (2012) argue that digital technologies enhance managers' information set, improving their ability to monitor staff and allowing them to delegate decisions to subordinate management layers. They show that the impact of good management practices on firm productivity is larger in ICT-intensive sectors.
57. Bresnahan, Brynjolfsson, and Hitt 2002; Brynjolfsson and Hitt 2003; Crespi, Criscuolo, and Haskel 2007; Bartel and others 2009; Bloom, Sadun, and Van Reenen 2012.
58. See Commander, Harrison, and Menezes-Filho (2011) for Brazil and India, and Nguyen and Schiffbauer (2015) for Vietnam.
59. Riker (2015) shows that internet access increases the probability of product entry into the United States, and the probability is higher for countries with better logistics.
60. UNCTAD 2015.
61. Bloom, Sadun, and Van Reenen 2012; Inklaar, Timmer, and van Ark 2008.
62. Chick, Huchzermeier, and Netessine 2014.
63. See Aghion and others 2001. The theoretical framework is also closely related to Parente and Prescott (1999). Aghion and others (2001) also discuss whether perfect competition can reduce the incentives for any innovation by reducing the discounted present value of associated rents, leading to an inverted U-shaped relation between competition and growth. They provide evidence, however, that the negative part in the competition-growth nexus is less empirically relevant (see also Aghion and others 2006, 2008, 2009).
64. For instance, Aghion and others (2006, 2008, 2009) find that more product market competition and entry deregulation lead to higher productivity growth. Buccirossi and others (2013) show that improvements in competition policy, measuring restrictions to domestic and foreign entry and restrictions to antitrust, led to higher TFP growth among 22 industries in 12 OECD countries. The effect was strongest for antitrust activities.
65. Bartelsman, Hagsten, and Polder 2013.
66. Bloom, Draca, and Van Reenen 2011.
67. The findings are consistent for the other available measures of ICT, such as the share of firms that have a website or use e-commerce in Vietnam (Nguyen and Schiffbauer 2015), and the average share of a firm's workforce using the internet or the share of firms' e-commerce purchasing over total purchases in Mexico (Iacovone, Pereira-Lopez, and Schiffbauer 2015).
68. Kretschmer, Miravete, and Pernías 2002.
69. Cirera, Lage, and Sabetti 2015. The results are based on more than 2,300 firms in these six African countries in 2014.
70. The effect is based on a regression of (log) labor productivity from 2008 to 2012 on the ICT variables, the product-level degree of import competition from China from 2000 to 2008 (in the Mexican or U.S. markets), and the interaction term between these two variables. Each regression controls for firm fixed effects and changes from 2008 to 2012 in other firm characteristics (firm size, age, location, exports, foreign or state ownership, and share of skilled labor). See Iacovone, Pereira-Lopez, and Schiffbauer 2015. The results are robust when using the interaction term between household internet use at the province level and sectors' ICT intensity based on U.S. data as an instrumental variable controlling for the endogeneity of the ICT variables.

71. Cirera, Lage, and de Oliveria 2015. An increase in competition is measured by a change in firms' market share in previous years. The results are based on a multinomial logit regression from 2009 to 2012 where the dependent variable indicates different stages of the e-commerce system; the most advanced e-commerce system also allows for online payments. The regressions control for firm characteristics such as firm size, age, export status, and ownership and sector-specific effects.
72. Countries with available data that are not members of the World Trade Organization (Afghanistan, Kazakhstan, Lebanon, and Liberia) are excluded because they do not face restrictions on using tariff rates as an alternative mode to restrict import competition.
73. See World Bank Enterprise Surveys (http://www.enterprisesurveys.org/); the World Bank's Services Trade Restrictions Index (Borchert, Gootiiz, and Mattoo 2013).
74. See Golovin 2014. To deal with the problem at the time, Ireland set up a "hardship fund" with payments of up to €15,000 to alleviate the financial hardships suffered by license holders due to the devaluation of their assets, although the general consensus was that the government was under no obligation to compensate the taxi industry.
75. The analysis is based on 48 politically connected and 620 nonconnected manufacturing firms with at least five employees in the World Bank Enterprise Surveys data in 2004 and 2007. The 48 politically connected firms operate in almost all of the 22 two-digit manufacturing industries. But within these, they operate in fewer than half of the more than 100 four-digit subsectors in total. See Saadi (2015) for more details.
76. Almost all firms in connected and nonconnected industries use e-mail.
77. See, among others, Parente and Prescott (1999) or Acemoglu, Johnson, and Robinson (2005).

References

Abramovsky, Laura, and Rachel Griffith. 2006. "Outsourcing and Offshoring of Business Services: How Important is ICT?" *Journal of the European Economic Association* 4 (2): 594–601.

Acemoglu, Daron, David Autor, David Dorn, Gordon Hanson, and Brenadan Price. 2014. "Return of the Solow Paradox." *American Economic Review Papers and Proceedings* 104 (5): 394–99.

Acemoglu, Daron, Simon Johnson, and James Robinson. 2005. "Institutions as a Fundamental Cause of Long-Run Growth." In *Handbook of Economic Growth* 1, edited by Philippe Aghion and Steven N. Durlauf, 385–472. Amsterdam: Elsevier.

Aghion, Phillipe, R. Blundell, R. Griffith, P. Howitt, and S. Prantl. 2009. "The Effects of Entry on Incumbent Innovation and Productivity." *Review of Economics and Statistics* 91 (1): 20–32.

Aghion, Phillipe, Robin Burgess, Stephen J. Redding, and Fabrizio Zilibotti. 2006. "Entry Liberalization and Inequality in Industrial Performance." *Journal of the European Economic Association* 3 (2/3): 291–302.

———. 2008. "The Unequal Effects of Liberalization: Evidence from Dismantling the License Raj in India." *American Economic Review* 98 (4): 1397–1412.

Aghion, Phillipe, Christopher Harris, Peter Howitt, and John Vickers. 2001. "Competition, Imitation and Growth with Step-by-Step Innovation." *Review of Economic Studies* 68 (3): 467–92.

Akerman, Anders, Ingvil Gaarder, and Magne Mogstad. 2015. "The Skill Complementarity of Broadband Internet." NBER Working Paper 20826, National Bureau of Economic Research, Cambridge, MA.

Alfaro, Laura, and Maggie Chen. 2015. "ICT and Multinational Activity." Background paper for the *World Development Report 2016,* World Bank, Washington, DC.

Anderson, Chris. 2006. *The Long Tail: Why the Future of Business Is Selling Less of More.* New York: Hyperion.

Andjelkovic, Maja. 2015. "What Is the Digital Economy and Why Does It Matter?" Background paper for the *World Development Report 2016*, World Bank, Washington, DC.

Atiyas, Izak, and Ozan Bakis. 2015. "ICT, Internet Use and Organizational Characteristics of Turkish Firms." Background paper for the *World Development Report 2016,* World Bank, Washington, DC.

Baldwin, John Russel, and Wulong Gu. 2008. "Outsourcing and Offshoring in Canada." Statistics Canada. http://www.statcan.gc.ca/start-debut-eng.html.

Baldwin, Richard. 2011. "Trade and Industrialization after Globalization's Second Unbundling: How Building and Joining a Supply Chain Are Different and Why It Matters." NBER Working Paper 17716, National Bureau of Economic Research, Cambridge, MA.

Bartel, Ann P., Casey Ichniowski, Kathryn L. Shaw, and Ricardo Correa. 2009. "International Differences in the Adoption and Impact of New Information Technologies and New HR Practices: The Valve-Making Industry in the United States and United Kingdom." In *International Differences in the Business Practices and Productivity of Firms*, edited by Richard B. Freeman and Kathryn L. Shaw, 55–78. Chicago: University of Chicago Press.

Bartelsman, E. J., E. Hagsten, and M. Polder. 2013. "Cross-Country Analysis of ICT Impact Using Firm-Level Data: The Micro Moments Database and Research Infrastructure." http://www.scb.se/Grupp/OmSCB/Internationellt/Dokument/esslait-mmd-final.pdf.

Benfratello, Luigi, Tiziano Razzolini, and Alessandro Sembenelli. 2009. "Does ICT Investment Spur or Hamper Offshoring? Empirical Evidence from Microdata." Development Working Paper 276, University of Milan, Centro Studi Luca d'Agliano, Milan.

Bertschek, Irene, Daniel Cerquerab, and Gordon Kleinc. 2013. "More Bits—More Bucks? Measuring the Impact of Broadband Internet on Firm Performance." *Information Economics and Policy* 25 (3): 190–203.

Bloom, Nicholas, Mirko Draca, and John Van Reenen. 2011. "Trade Induced Technical Change? The Impact of Chinese Imports on Innovation, IT and Productivity." NBER Working Paper 16717, National Bureau of Economic Research, Cambridge, MA.

Bloom, Nicholas, Raffaella Sadun, and John Van Reenen. 2012. "Americans Do IT Better: US Multinationals and the Productivity Miracle." *American Economic Review* 102 (1): 167–201.

Blum, Bernardo S., and Avi Goldfarb. 2006. "Does the Internet Defy the Law of Gravity?" *Journal of International Economics* 70 (2): 384–405.

Borchert, I., B. Gootiiz, and A. Mattoo. 2013. "Policy Barriers to International Trade in Services: Evidence from a New Database." *World Bank Economic Review*. http://wber.oxfordjournals.org/content/early/2013/07/14/wber.lht017.abstract.

Bresnahan, Timothy, Erik Brynjolfsson, and Lorin M. Hitt. 2002. "Information Technology, Workplace Organization, and the Demand for Skilled Labor: Firm-Level Evidence." *Quarterly Journal of Economics* 117 (1): 339–76.

Brown, Jeffrey R., and Austan Goolsbee. 2002. "Does the Internet Make Markets More Competitive? Evidence from the Life Insurance Industry." *Journal of Political Economy* 110 (3): 481–507.

Brynjolfsson, Erik, and Lorin M. Hitt. 2003. "Computing Productivity: Firm-Level Evidence." *Review of Economics and Statistics* 85 (4): 793–808.

Buccirossi, Paolo, Lorenzo Ciari, Tomaso Duso, Giancarlo Spagnolo, and Cristiana Vitale. 2013. "Competition Policy and Productivity Growth: An Empirical Assessment." *Review of Economics and Statistics* 95 (4): 1324–36.

Byrne, David M., Stephen D. Oliner, and Daniel E. Sichel. 2013. "Is the Information Technology Revolution Over?" *International Productivity Monitor* 25 (Spring): 20–36.

Cai, J., and N. Li. 2015. "The Composition of Knowledge and Long-Run Growth in a Path-Dependent World." *2013 Meeting Papers 336*. Society for Economic Dynamics. http://www.freit.org/WorkingPapers/Papers/Development/FREIT848.pdf.

Cairncross, Frances. 2001. *The Death of Distance: How the Communications Revolution Is Changing Our Lives.* Cambridge, MA: Harvard Business Press.

Cardona, M., Tobias Kretschmer, and Thomas Strobel. 2013. "ICT and Productivity: Conclusions from the Empirical Literature." *Information Economics and Policy* 25 (3): 109–25.

Chen, Maggie, and Min Xu. 2015. "Online International Trade in China." Background paper for the *World Development Report 2016*, World Bank, Washington, DC.

Chen, Yan, Grace YoungJoo Jeon, and Yong-Mi Kim. 2014. "A Day without a Search Engine: An Experimental Study of Online and Offline Searches." *Experimental Economics* 17 (4): 512–36.

Chick, Stephen, Arnd Huchzermeier, and Serguei Netessine. 2014. "Europe's Solution Factories." *Harvard Business Review* (April). https://hbr.org/2014/04/europes-solution-factories.

Cirera, Xavier, Filipe Lage, and Joao Maria de Oliveria. 2015. "E-Commerce and Productivity in Brazilian Firms." Background paper for the *World Development Report 2016*, World Bank, Washington, DC.

Cirera, Xavier, Filipe Lage, and Leo Sabetti. 2015. "ICT Adoption, Innovation and Productivity in Africa." Background paper for the *World Development Report 2016*, World Bank, Washington, DC.

Clarke, George R. G., and Scott J. Wallsten. 2006. "Has the Internet Increased Trade? Developed and Developing Country Evidence." *Economic Inquiry* 44 (3): 465–84.

Collard-Wexler, Allan, and Jan De Loecker. 2015. "Reallocation and Technology: Evidence from the U.S. Steel Industry." *American Economic Review* 105 (1): 131–71.

Colombo, Massimo G., Annalisa Croce, and Luca Grilli. 2013. "ICT Services and Small Businesses Productivity Gains: An Analysis of the Adoption of Broadband Internet Technology." *Information Economics and Policy* 25 (3): 171–89.

Comin, Diego, and Martí Mestieri. 2013. "If Technology Has Arrived Everywhere, Why Has Income Diverged?" INET Research Note 26, Institute for New Economic Thinking, New York.

Commander, Simon, Rupert Harrison, and Naercio Menezes-Filho. 2011. "ICT and Productivity in Developing Countries: New Firm-Level Evidence from Brazil and India." *Review of Economics and Statistics* 93 (2): 528–41.

Conference Board. 2015. "Productivity Brief 2015: Global Productivity Growth Stuck in the Slow Lane with No Signs of Recovery in Sight." Conference Board, New York.

Corrado, Carol, Jonathan Haskel, Cecilia Jona-Lasinio, and Massimiliano Iommi. 2013. "Innovation and Intangible Investment in Europe, Japan and the US." *Oxford Review of Economic Policy* 29 (2): 261–86.

Cowgill, Bo, and Cosmina Dorobantu. 2014. "Worldwide Gravity in Online Commerce." http://www.columbia.edu/~bc2656/papers/WWCurrent.pdf.

Crafts, Nicholas. 2015. "The Economic Impact of ICT: A Historical Perspective." Background paper for the *World Development Report 2016*, World Bank, Washington, DC.

Crespi, Gustavo, Chiara Criscuolo, and Jonathan Haskel. 2007. "Information Technology, Organizational Change and Productivity Growth: Evidence from UK Firms." CEP Discussion Paper 783, Centre for

Economic Performance, London School of Economics and Political Science.

Cristea, Anca D. 2014. "The Effect of Communication Costs on Trade in Headquarter Services." January 30. http://pages.uoregon.edu/cristea/Research_files/infofdi.pdf.

Czernich, Nina, Oliver Falck, Tobias Kretschmer, and Ludger Woessmann. 2009. "Broadband Infrastructure and Economic Growth." CESifo Working Paper 2861, Center for Economic Studies and Ifo Institute, Leibniz Universität, Hannover, Germany.

David, Paul A. 1990. "The Dynamo and the Computer: An Historical Perspective on the Modern Productivity Paradox." *American Economic Review* 80 (2): 355–61.

Draca, Mirco, Raffaela Sadun, and John Van Reenen. 2007. "Productivity and ICTs: A Review of the Evidence." In *The Oxford Handbook of Information and Communication Technologies*, edited by Robin Mansell, D. Q. Chrisanthi Avgerou, and R. Silvestone, 100–47. New York: Oxford University Press.

Dutz, Mark, Sérgio Kannebley Jr., Maira Scarpelli, and Siddharth Sharma. 2012. "Measuring Intangible Assets in an Emerging Market Economy: An Application to Brazil." Policy Research Working Paper 6142, World Bank, Washington, DC.

eBay. 2013. "Commerce 3.0 for Development: The Promise of the Global Empowerment Network." eBay report based on an empirical study conducted by Sidley Austin LLP. http://www.ebaymainstreet.com/news-events/commerce-30-development-promise-global-empowerment-network.

EC (European Commission). Various years. Eurostat (database), Brussels, http://ec.europa.eu/eurostat/data/database.

Economist. 2014. "Defending the Digital Frontier: A Special Report on Cybersecurity." http://www.economist.com/news/special-report/21606416-companies-markets-and-countries-are-increasingly-under-attack-cyber-criminals.

———. 2015a. "Hyperconnected Organization." http://www.economistinsights.com/technology-innovation/analysis/hyperconnected-organisations/fullreport.

———. 2015b. "The Truly Personal Computer: The Smartphone Is the Defining Technology of the Age." http://www.economist.com/news/briefing/21645131-smartphone-defining-technology-age-truly-personal-computer.

Ellison, Glenn, and Sara Fisher Ellison. 2014. "Match Quality, Search, and the Internet Market for Used Books." Massachusetts Institute of Technology. http://economics.mit.edu/files/10351.

Evans, David. 2015. "An Empirical Examination of Why Mobile Money Schemes Ignite in Some Developing Countries but Flounder in Most." Research Paper 723, University of Chicago Coase-Sandor Institute for Law and Economics, Chicago.

Fernandes, Ana, Aaditya Mattoo, Huy Nguyen, and Marc Schiffbauer. 2015. "The Impact of Broadband on Chinese Exports in the Pre-Alibaba Era." Background paper for the *World Development Report 2016*, World Bank, Washington, DC.

Fink, Carsten, Aaditya Mattoo, and Ileana Cristina Neagu. 2005. "Assessing the Impact of Communication Costs on International Trade." *Journal of International Economics* 67 (2): 428–45.

Fogel, R. W. 1965. "The Reunification of Economic History with Economic Theory." *American Economic Review* 55 (1/2): 92–98.

Fort, Teresa C. 2014. "Technology and Production Fragmentation: Domestic versus Foreign Sourcing." Working paper, Tuck School of Business at Dartmouth, Hanover, NH. http://faculty.tuck.dartmouth.edu/images/uploads/faculty/teresa-fort/Fort_Fragmentation_March2014.pdf.

Freund, Caroline, and Diana Weinhold. 2002. "The Internet and International Trade in Services." *American Economic Review* 92 (2): 236–40.

———. 2004. "The Effect of the Internet on International Trade." *Journal of International Economics* 62: 171–89.

Golovin, Sergiy. 2014. "The Economics of Uber." *Bruegel* (blog), September 30. http://www.bruegel.org/nc/blog/detail/article/1445-the-economics-of-uber/.

Goolsbee, Austan, and Peter J. Klenow. 2006. "Valuing Consumer Products by the Time Spent Using Them: An Application to the Internet." *American Economic Review Papers and Proceedings* 96: 108–13.

Gordon, Robert J. 2010. "Revisiting U.S. Productivity Growth over the Past Century with a View of the Future." NBER Working Paper 15834, National Bureau of Economic Research, Cambridge, MA.

———. 2014. "The Demise of U.S. Economic Growth: Restatement, Rebuttal, and Reflections." NBER Working Paper 19895, National Bureau of Economic Research, Cambridge, MA.

Grimes, Arthur, Cleo Ren, and Philip Stevens. 2012. "The Need for Speed: Impacts of Internet Connectivity on Firm Productivity." *Journal of Productivity Analysis* 37 (2): 187–201.

Haller, Stefanie, and Sean Lyons. 2015. "Broadband Adoption and Firm Productivity: Evidence from Irish Manufacturing Firms." *Telecommunications Policy* 39: 1–13.

Haller, Stefanie, and Iulia Siedschlag. 2011. "Determinants of ICT Adoption: Evidence from Firm-Level Data." *Applied Economics* 43 (26): 3775–88.

Hao, Janet, Charles R. Hulten, and Kirsten Jaeger. 2013. "The Measurement of India's Intangible Capital." Conference Board, New York.

Hauk, William R., and Romain Wiczarg. 2009. "A Monte Carlo Study of Growth Regressions." *Journal of Economic Growth* 14: 103–47.

Hortaçsu, Ali F., F. Asís Martínez-Jerez, and Jason Douglas. 2009. "The Geography of Trade in Online Transactions:

Evidence from eBay and Mercado Libre." *American Economic Journal: Microeconomics* 1: 53–74.

Hulten, Charles R., and Janet Hao. 2011. "The Role of Intangible Capital in the Transformation and Growth of the Chinese Economy." Unpublished manuscript, University of Maryland.

Hussain, Sahar. 2015. "When Do Firms in Developing Countries Adopt New Digital Technologies?" Background paper for the *World Development Report 2016,* World Bank, Washington, DC.

Iacovone, Leonardo, Mariana Pereira-Lopez, and Marc Schiffbauer. 2015. "The Complementarity between ICT Use and Competition in Mexico." Background paper for the *World Development Report 2016,* World Bank, Washington, DC.

Inklaar, R., M. P. Timmer, and B. van Ark. 2008. "Market Services Productivity across Europe and the U.S." *Economic Policy* 23 (53): 139–94.

Internet Coaching Library. Various years. DAI (Digital Access Index). Miniwatts Marketing Group, Bogota. http://www.internetworldstats.com/list3.htm.

Jorgenson, Dale W. 2001. "Information Technology and the U.S. Economy." *American Economic Review* 91 (1): 1–33.

———. 2011. "Innovation and Productivity Growth." *American Journal of Agricultural Economics* 93 (2): 276–96.

Keller, Wolfgang. 2002. "Geographic Localization of International Technology Diffusion." *American Economic Review* 92: 120–42.

Keller, Wolfgang, and Stephen R. Yeaple. 2013. "The Gravity of Knowledge." *American Economic Review* 103 (4): 1414–44.

Koutroumpis, Pantelis. 2009. "The Economic Impact of Broadband on Growth: A Simultaneous Approach." *Telecommunications Policy* 33 (9): 471–85.

Kretschmer, Tobias, Eugenio J. Miravete, and José C. Pernías. 2002. "Competitive Pressure and the Adoption of Complementary Innovations." *American Economic Review* 102 (4): 1540–70.

Lamla, Michael, and Marc Schiffbauer. 2015. "Spillovers from FDI in ICT in Jordan." Background paper for the *World Development Report 2016,* World Bank, Washington, DC.

Leamer, Edward E., and Michael Storper. 2001. "The Economic Geography of the Internet Age." NBER Working Paper 8450, National Bureau of Economic Research, Cambridge, MA.

Lendle, Andrea, Marcelo Olarreaga, Simon Schropp, and Pierre-Louis Vezina. 2012. "There Goes Gravity: How eBay Reduces Trade Costs." Policy Research Working Paper 6253, World Bank, Washington, DC.

Manyika, James, Matthieu Pélissié du Rausas, Eric Hazan, Jacques Bughin, Michael Chui, and Rémi Said. 2011. "Internet Matters: The Net's Sweeping Impact on Growth, Jobs and Prosperity." McKinsey Global Institute report, McKinsey & Company. http://www.mckinsey.com/insights/high_tech_telecoms_internet/internet_matters.

Mbiti, I., and D. N. Weil. 2011. "Mobile Banking: The Impact of M-Pesa in Kenya." NBER Working Paper 17129, National Bureau of Economic Research, Cambridge, MA.

McKinsey Global Institute. 2014. "Offline and Falling Behind: Barriers to Internet Adoption." McKinsey & Company. http://www.mckinsey.com/insights/high_tech_telecoms_internet/offline_and_falling_behind_barriers_to_internet_adoption.

Melitz, Marc J. 2003. "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity." *Econometrica* 71 (6): 1695–1725.

Minges, Michael. 2015. "Exploring the Relationship between Broadband and Economic Growth." Background paper for the *World Development Report 2016*, World Bank, Washington, DC.

Murphy, Gavin, and Iulia Siedschlag. 2013. "Determinants of Offshoring: Empirical Evidence from Ireland." SERVICEGAP Discussion Paper 38, University of Birmingham, Birmingham, U.K.

Nguyen, Huy, and Marc Schiffbauer. 2015. "Internet, Reorganization and Firm Productivity in Vietnam." Background paper for the *World Development Report 2016,* World Bank, Washington, DC.

Niebel, T. 2014. "ICT and Economic Growth: Comparing Developing, Emerging and Developed Countries." ZEW Discussion Paper 14–117, ZEW Centre for European Economic Research, Mannheim, Germany.

Nunn, Nathan. 2007. "Relationship-Specificity, Incomplete Contracts, and the Pattern of Trade." *Quarterly Journal of Economics* 122 (2): 569–600.

OECD (Organisation for Economic Co-operation and Development). Various years. Product Market Regulation Index. OECD, Paris, http://www.oecd.org/eco/growth/indicatorsofproductmarketregulationhomepage.htm.

———. 2015. "ICT Value Added (Indicator)." doi: 10.1787/4bc7753c-en.

Ogodo, O. 2009. "Africans 'Losing Out' in North-South Collaborations." *Science and Development Network*. http://www.scidev.net.

Olley, G. S., and A. Pakes. 1996. "The Dynamics of Productivity in the Telecommunications Equipment Industry." *Econometrica* 64: 1263–97.

Osnago, Alberto, and Shawn W. Tan. 2015. "The Effects of the Internet on Trade Flows and Patterns." Background paper for the *World Development Report 2016*, World Bank, Washington, DC.

Ou, Carol Xiaojuan, and Robert M. Davidson. 2009. "Why eBay Lost to TaoBao in China: The Global Advantage." *Communications of the ACM* 52: 145–48.

Parente, Stephen L., and Edward C. Prescott. 1999. "Monopoly Rights: A Barrier to Riches." *American Economic Review* 89 (5): 1216–33.

Qiang, Christine Zhen-Wei, Carlo M. Rossotto, and Kaoru Kimura. 2009. "Economic Impacts of Broadband." In *Information and Communications for Development 2009: Extending Reach and Increasing Impact,* chap. 3.

Washington, DC: World Bank. http://siteresources.worldbank.org/EXTIC4D/Resources/IC4D_Broadband_35_50.pdf.

Rasel, Fabienne. 2012. "Offshoring and ICT: Evidence for German Manufacturing and Service Firms." ZEW Discussion Paper 12-087, ZEW Centre for European Economic Research, Mannheim, Germany.

Rauch, James E. 1999. "Networks versus Markets in International Trade." *Journal of International Economics* 48 (1): 7–35.

Rauch, James E., and Vitor Trindade. 2002. "Ethnic Chinese Networks in International Trade." *Review of Economics and Statistics* 84 (1): 116–30.

Riker, David. 2015. "The Internet and Product-Level Entry into the U.S. Market." Research Note 2015-05B, U.S. International Trade Commission, Washington, DC.

Rochet, Jean-Charles, and Jean Tirole. 2003. "Platform Competition in Two-Sided Markets." *Journal of the European Economic Association* 1 (4): 990–1029.

Rysman, Marc. 2009. "The Economics of Two-Sided Markets." *Journal of Economic Perspectives* 23 (3): 125–43.

Saadi, Mohammed Said. 2015. "Innovation, Political Connectedness, and Competition." Background paper for the *World Development Report 2016*, World Bank, Washington, DC.

Schiffbauer, Marc, Roberta Serafini, and Rolf Strauch. 2011. "The Impact of ICT and Human Capital on TFP: Implications for Recent EMU and US Growth Differences." Working paper, European Central Bank, Frankfurt, Germany.

Stahl, Dale O. 1989. "Oligopolistic Pricing with Sequential Consumer Search." *American Economic Review* 79: 700–12.

Stigler, George J. 1961. "The Economics of Information." *Journal of Political Economy* 69: 213–25.

Syverson, Chad. 2013. "Will History Repeat Itself? Comments on 'Is the Information Technology Revolution Over?'" *International Productivity Monitor* 25 (Spring): 37–40.

Tan, Shawn W. 2015. "The Effects of the Internet on Firm Export Behavior." Background paper for the *World Development Report 2016*, World Bank, Washington, DC.

UNCTAD (United Nations Conference on Trade and Development). 2013. *Information Economy Report 2013: The Cloud Economy and Developing Countries*. Geneva: United Nations. http://unctad.org/en/PublicationsLibrary/ier2013_en.pdf.

———. 2015. *Information Economy Report 2015: Unlocking the Potential of E-Commerce for Developing Countries*. Geneva: United Nations. http://unctad.org/en/PublicationsLibrary/ier2015_en.pdf.

Van Welsum, Desiree. 2015. "Sharing Is Caring? Not Quite: Some Observations about the Sharing Economy." Background paper for the *World Development Report 2016*, World Bank, Washington, DC.

Varian, Hal. 2011. "Economic Value of Google." Paper presented at The Data Frame: The Web 2.0 Summit 2011 Conference, San Francisco, October 17–19. http://www.web2summit.com/web2011.

Venables, A. J. 2001. "Geography and International Inequalities: The Impact of New Technologies." *Journal of Industry, Competition and Trade* 1 (2): 135–59.

Von Tunzelmann, G. N. 1978. *Steam Power and British Industrialization to 1860*. Oxford: Oxford University Press.

Waldfogel, Joel. 2013. "Digitization and the Quality of New Media Products: The Case of Music." Unpublished manuscript, University of Minnesota.

Wei, Lingling, and Paul Mozur. 2014. "China's Central Bank Leads Effort to Regulate Internet Finance." *Wall Street Journal*, February 11. http://www.wsj.com/articles/SB10001424052702303874504579376111028523376.

World Bank. Various years. Doing Business (database). World Bank, Washington, DC, http://www.doingbusiness.org/.

———. Various years. Enterprise Surveys database. World Bank, Washington, DC, http://www.enterprisesurveys.org/.

———. Various years. Entrepreneurship Database. World Bank, Washington, DC, http://econ.worldbank.org/WBSITE/EXTERNAL/EXTDEC/EXTRESEARCH/EXTPROGRAMS/EXTFINRES/0,,contentMDK:21454009~pagePK:64168182~piPK:64168060~theSitePK:478060,00.html.

———. Various years. Exporter Dynamics Database. World Bank, Washington, DC, http://econ.worldbank.org/WBSITE/EXTERNAL/EXTDEC/EXTRESEARCH/EXTPROGRAMS/EXTTRADERESEARCH/0,,contentMDK:23192718~pagePK:64168182~piPK:64168060~theSitePK:544849,00.html.

———. Various years. WITS (World Integrated Trade Solution) (database). World Bank, Washington, DC, http://wits.worldbank.org/.

———. 2015. *Measuring the Urban Tech Sector*. Unpublished manuscript. Washington, DC: World Bank.

Wulf, Julie. 2010. "Alibaba Group." Harvard Business School Case Study 710-436, Harvard Business School, Cambridge, MA. http://www.hbs.edu/faculty/Pages/item.aspx?num=38507.

SECTOR FOCUS 1

Agriculture

Across the developing world, agriculture sustains the majority of rural livelihoods. Ever since people have grown crops, raised livestock, and caught fish, they have sought information from one another. What is the most effective planting strategy on steep slopes? Where can we buy improved seeds? Who is paying the highest price at the market? Over time, weather patterns and soil conditions change. Epidemics of pests and diseases come and go. Updated information allows farmers to cope with and benefit from these changes.

Providing such knowledge can be challenging. Agriculture is location-specific, and farmers need accurate local weather forecasts, advice on agricultural practices and input use, and real-time information about prices and market logistics. Harnessing the rapid growth of the internet and associated digital technologies such as mobile phones is critical to helping farmers obtain the information they need and to promoting transformative agricultural development. Interest is especially keen in increasing access to extension services, improving marketing of outputs, and arranging logistics. The body of rigorous, quantitative evidence on the ways in which digital innovations can help improve the lives of rural people is growing steadily.

Enhancing on-farm productivity

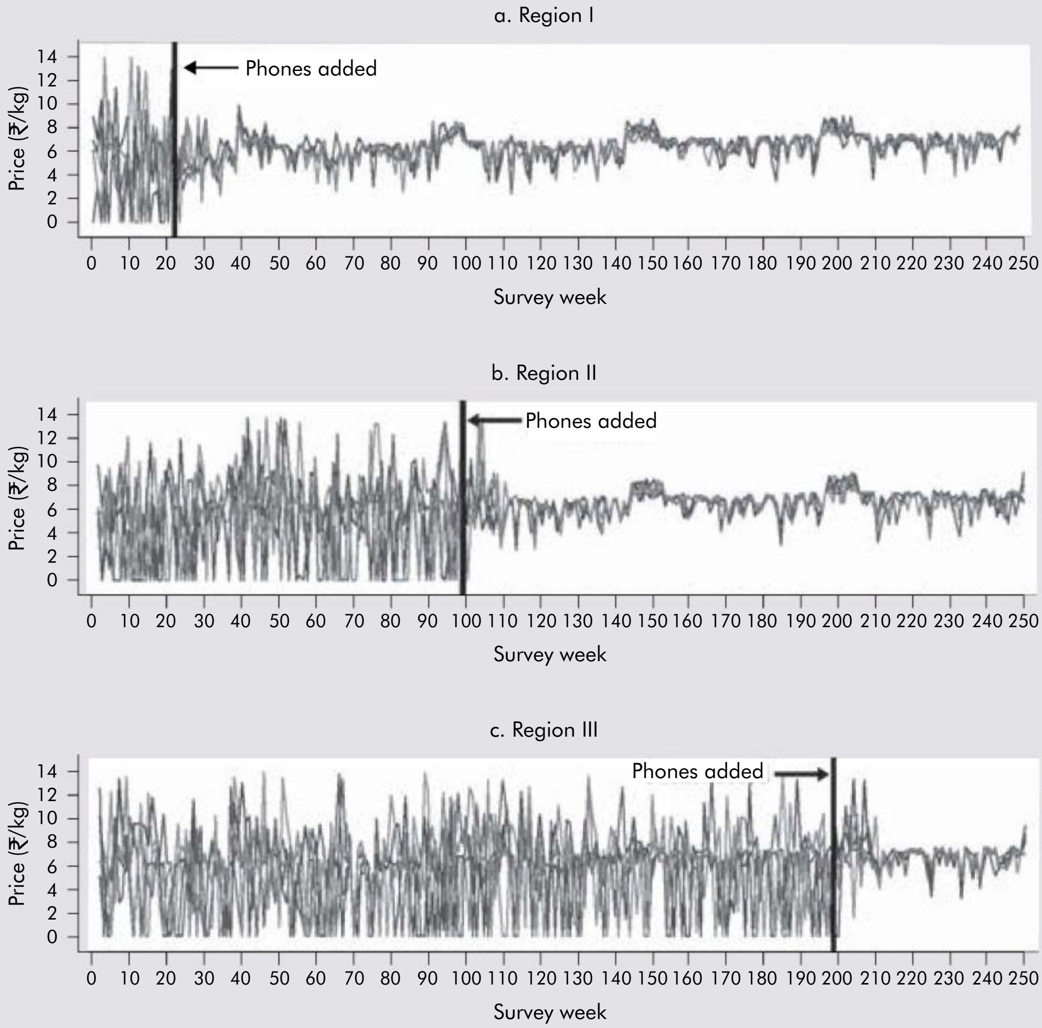
Agricultural productivity varies dramatically around the world. While credit constraints, missing insurance markets, and poor infrastructure account for some of this disparity, suboptimal agricultural practices and poor management are also to blame. New production technologies such as improved seed varieties, nutrient management, and pest control methods are not necessarily reaching farmers. Public extension agents can overcome information barriers related to new agricultural practices and technologies, but such extension programs have been burdened by limited scale, sustainability, and impact.

Digital technologies help overcome these constraints. They are reviving agricultural extension and advisory services around the world. In cooperation with agricultural research and extension services, organizations such as Digital Green, the Grameen Foundation, and TechnoServe deliver timely, relevant, and actionable information and advice to farmers in South Asia, Latin America, and Sub-Saharan Africa, respectively, at a dramatically lower cost than traditional services can. Rather than always visiting a farmer, extension agents use a combination of phone calls, text, videos, and internet to reduce transaction costs and increase the frequency of interaction with farmers. Governments, in partnership with mobile operators, use phones to coordinate distribution of seeds and subsidized fertilizers in remote areas through e-vouchers, as in Nigeria's large-scale e-wallet initiative (spotlight 2, "Digital finance"). Technology firms such as Climate Corp, based in Silicon Valley, are pioneering the provision of agrometeorological services for early warning of weather and climate risks. A number of innovations aim for real-time and accurate weather monitoring using remote sensing and technologies enabled with geographic information systems (GIS) for climate-resilient agriculture.

This sector focus was contributed by Aparajita Goyal.

Figure F1.1 **Introducing mobile phone service reduces price dispersion in local markets**

Sardine prices in three coastal markets in Kerala, India



Source: Jensen 2007, © Oxford University Press. Reproduced with permission from Oxford University Press; further permission required for reuse.

Note: kg = kilogram; ₹ = Indian rupee.

Facilitating market transparency

Agricultural product markets in many developing countries are poorly integrated. High search costs have tended to lower competition and create an inefficient allocation of goods across markets. When the internet took off in the mid-1990s, it was often claimed that it would improve price transparency, cut out middlemen, and make markets more efficient. Indeed, rapid adoption of digital technologies has dramatically reduced the search costs incurred by farmers and traders, and hence overcome an important constraint in the context of limited infrastructure. As Robert Jensen's classic 2007 study of sardine fishermen and wholesalers in Kerala, India, found, the introduction of mobile phone service dramatically reduced price dispersion and waste in the sardine catch, increasing welfare for producers and consumers (figure F1.1). Similar effects have been shown for communication platforms such as Esoko in Ghana, e-Choupal in India, and telecenters in Peru, as well as studies on grain traders in Niger and farmers in the Philippines.[1]

Enabling efficient logistics and improving quality control

Digital technologies also improve the management of agricultural supply chains. With globalized food systems, ensuring food safety has become more complex. These trends have catalyzed innovations to trace the food supply from producer to consumer—which is important for developing countries that want to reach new export markets. Smallholder farms can turn to cooperatives and aggregators, who use digital tools to improve collection, transportation, and quality control. By opening up new specialized market opportunities, the internet has improved consumer protection and farmers' livelihoods.

Lessons for adapting digital technologies for agriculture

Why do many of these innovations fail to scale up and achieve wider acceptance? One reason is market fragmentation—even though market consolidation will, over time, enhance growth prospects. Another reason is the lack of financially sustainable business models that will attract private sector investments in innovative solutions for small-scale agriculture. There is great potential for the internet and related technologies to improve rural economies, but several lessons need to be kept in mind.

First, agriculture is becoming increasingly knowledge-intensive and high-tech. Some of the world's newest industries have started to put money and tech talent into farming—the world's oldest industry. Digital soil maps, remote sensing, and global positioning system (GPS) guidance are critical tools for modern farmers. "Big data" for precision agriculture increases yields and efficiency. These high-tech tools mostly benefit big farms that can make large investments in technology. But there are also many innovative ways in which illiterate and otherwise disadvantaged people use digital technologies, such as basic mobile phones. Greater efforts to *close the digital divide* in rural areas can have great payoffs.

Second, basic price and market information systems can improve efficiency and welfare. The evidence, although strong, is still limited to certain countries and certain contexts. A number of recent studies have cast doubt on the overall novelty of information provided to the farmer and the degree of competition in many markets. One explanation of weak effects is low take-up of fee-based price information services. But even when farmers are seemingly better informed, they may not necessarily be able to act on that information because of the inaccessibility of alternative markets and the complex interlinked relationships between buyers and sellers in low-income developing economies. Rather than assuming that an information and communication technology (ICT) approach will always be cost-effective and yield a better outcome, a more nuanced *understanding of the underlying institutional environment and constraints* is warranted.

Third, technology-enabled interventions are no panacea in themselves, and need to be backed by *complementary investments in physical infrastructure*, including electricity and literacy. The versatility and near-constant innovation that characterize digital technologies can sometimes be a distraction that can cause interventions to focus more on the technology than on the demands and priorities of the intended beneficiaries and the trade-offs imposed by resource-constrained environments.

Finally, information technology (IT) policy and the *broader regulatory environment* in a country should be discussed jointly. Whereas the expansion of mobile phone access has been rapid and commercially self-sustaining even among many of the poor, the same is not true of the internet. In the long run, the internet can have an even greater impact on rural growth; much depends on finding sustainable business models to encourage its spread in the poorest parts of the world.

Note

1. Nakasone, Torero, and Minten 2014.

References

Jensen, Robert. 2007. "The Digital Provide: Information (Technology), Market Performance, and Welfare in the South Indian Fisheries Sector." *Quarterly Journal of Economics* 122 (3): 879–924.

Nakasone, E., M. Torero, and B. Minten. 2014. "The Power of Information: The ICT Revolution in Agricultural Development." *Annual Review of Resource Economics*. doi: 10.1146/annurev-resource-100913-012714.

SPOTLIGHT 2

ENABLING DIGITAL DEVELOPMENT

Digital finance

Until a few years ago, agricultural productivity in Nigeria was declining, even though government spending had increased.[1] Since then, agriculture has become a driver of economic growth. One reason has been an innovative mobile wallet system initiated jointly by the public and private sectors and run by Cellulant, a mobile services company. Nigeria's smallholder farmers depend on subsidized fertilizer, but this crucial resource too often did not reach beneficiaries. The 2012 Growth Enhancement Support Scheme introduced mobile technology to transfer fertilizer subsidies directly to farmers, taking the government out of the business of procuring and distributing fertilizer. The support scheme now helps up to twice as many farmers, at one-sixth the cost. The transfer system relies on a database of more than 10.5 million farmers, who, as registered recipients of the subsidies, now have a better chance of gaining access to formal or regulated financial services. Based on this initial success, the system is expanding, aided by a digital identification system and biometric signatures, taking financial services far into Nigeria's rural hinterland.

This example and many similar experiences covered throughout this Report illustrate the large impact of the internet and related digital technologies on the financial sector.[2] Digital finance has promoted financial inclusion, providing access to financial services to many of the 80 percent of poor adults estimated to be excluded from the regulated financial sector.[3] It has boosted efficiency, as the cost of financial transactions has dropped and speed and convenience have increased. And it has led to major innovations in the financial sector, many of which have emerged in developing countries (box S2.1). The benefits pervade almost all areas discussed in this Report. Digital finance makes businesses more productive, allows individuals to take advantage of opportunities in the digital world, and helps streamline public sector service delivery.

Like all great opportunities, digital finance also comes with risks. What makes online financial systems easy to use for customers also makes them susceptible to cybercrime. The entry of nontraditional players poses new challenges for policy, regulation, and supervision. And the ease of transferring funds across the globe—often anonymously, using means such as cryptocurrencies—might increase illicit financial flows.

Benefits of digital finance

Digital finance promotes financial inclusion

More than 2 billion people have no access to any financial services. Overall, only about 59 percent of men and 50 percent of women in developing countries have an account at a regulated financial institution. Women, the poor, and small businesses often rely on informal financial services, even when they receive public transfers or remittances.

Digital payment systems help overcome barriers to accessing financial services. Mobile money schemes, in particular, allow people who own a phone but do not have a bank account to make and receive payments. In the right environment, these systems can take off and reach massive size rapidly (figure S2.1). Digital payments can reduce costs to recipients.[4] For instance, farmers in Niger realized time savings for

WDR 2016 team based on Bossone (2015) and Tropina (2015).

Box S2.1 Innovations in digital payments

There are four major innovations in digital payments.

Wrappers create a digital interface with traditional payment systems such as credit cards or bank accounts. Many are offered by nontraditional providers, including internet intermediaries such as Google Wallet and Apple Pay.

Mobile money systems store money in the national currency as credit on smart cards or a system provider's books, and enable payments online or through mobile phones. A well-known example is M-Pesa, run by Safaricom. These systems can offer lower fees and easier use than traditional payment systems, even for those without a bank account.

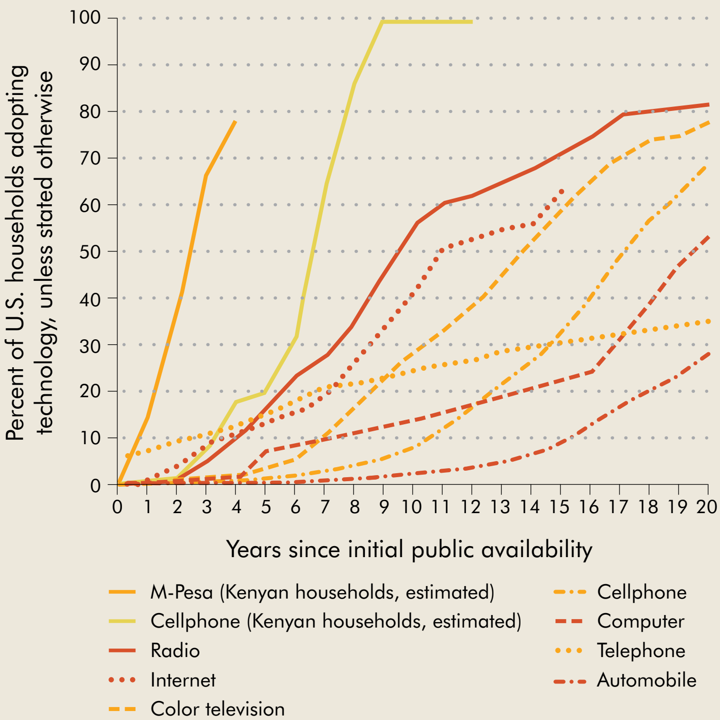
Credits and local digital currencies are alternative units of account (not in national currency) designed to promote spending in a local economy or as a means of exchange in computer games.

Digital currencies are both a new decentralized payment scheme and a new currency. Such schemes record transactions in a publicly visible ledger. Most digital currencies, including Bitcoin, are cryptocurrencies because they use cryptographic techniques to ensure secure validation of transactions.

To get a sense of the magnitude of digital payment flows, consider this: In 2014, the volume of Bitcoin transactions worldwide was about US$23 billion; for mobile payments on M-Pesa in Kenya, it was about US$24 billion; for the online payment platform PayPal, it was US$228 billion; and for the credit card issuer Visa, it was US$4.7 trillion.

Sources: Bank of England 2014; https://blockchain.info; company reports.

Figure S2.1 Kenya's M-Pesa payment system reached 80 percent of households within four years



Source: Suri, Jack, and Stoker 2012. Adapted with permission from the National Academy of Sciences; further permission required for reuse.

Note: Shares of households in the United States, except for Kenyan M-Pesa and cellphone users.

SPOTLIGHT 2

each payment equivalent to an amount that would feed a family of five for a week. Digital payments increase control, since senders of remittances can have a greater influence on how recipients use the money, including for savings. Digital finance can increase the incentive to save, through automatic deposits, text reminders, or default options. Texted reminders increased savings in Bolivia, Peru, and the Philippines by up to 16 percent.[5] Digital payments improve risk management by making it easier to receive support from social networks that can act as safety nets. M-Pesa users were better able to absorb income shocks compared to nonusers.[6] Digital payments speed up delivery, which is especially important in case of emergencies such as natural disasters. And they increase security compared to traveling with large amounts of cash, as is commonly necessary in low- and middle-income countries.

Digital finance can increase women's economic participation. In part, this is because digital payments can more easily be concealed by the recipient than cash, at least temporarily, which helps shift economic decision making in favor of women. Access to savings instruments also increases female empowerment and the consumption and productive investment of female entrepreneurs. There is a significantly positive relationship between female labor force participation and female bank account ownership.[7]

Information asymmetries—when one party to a transaction knows much more than the other—are pervasive in the financial sector. In credit markets, especially those for informal enterprises and low-income borrowers, the lender usually has limited information about a potential borrower's ability to repay a loan, thus impeding lending. Digital technologies help estimate credit scores from digital footprints. Alifinance, a subsidiary of the Chinese e-commerce firm Alibaba that is now part of Ant Financial, provides loans to vendors on its e-commerce platform. Many vendors have small operations and face difficulties obtaining loans in the traditional financial system. Alifinance's credit scoring model is based on at least three months of a vendor's online activity and makes loan decisions automatically and almost instantly. Loans are Y 20,000 to Y 30,000 (US$3,500 to US$5,000), on average, with flexible repayment terms. Microlending elsewhere that serves small farmers or small businesses functions similarly, often using mobile phone payment records to assess credit risk. M-Shwari, operated by the Commercial Bank of Africa and Safaricom, is a bank account linked to Kenya's M-Pesa payment system. It pays interest on deposits and provides short-term loans with approval often in a matter of seconds based on M-Pesa usage history. Between November 2012 and early 2015, the system issued 21 million loans to 2.8 million unique borrowers, with an average loan amount of US$15.

Digital finance can increase efficiency

The internet reduces the cost of many financial transactions by allowing their unbundling into separate components that can be automated or provided by specialized entities. A retail payment consists of pre-transaction, authorization, clearing, settlement, and post-transaction, each one again involving several steps. Specialized providers can execute individual steps, yielding economies of scale that translate into savings. Such service providers are becoming more widespread in developing and emerging markets.

Governments can also lower the cost of financial transactions. Electronic payment cards reduced costs of social transfers in Brazil's conditional cash transfer program, Bolsa Familia, from almost 15 percent to under 3 percent of total payments.[8] McKinsey estimated in 2010 that digital payments could save the government of India US$22 billion per year.[9] A large part of these savings comes from lower leakages and reduced fraud. Electronic payments create a clear digital record and can be traced, so the likelihood of funds not reaching the beneficiary or of duplicate payments or payments to "ghost" recipients who do not exist will be lower. Evidence from India also shows that using smart cards rather than cash for social security payments halved the incidence of demands for bribes.

Digital finance spurs financial innovation

The financial sector is transaction-intensive and has always been at the forefront of adopting new technology. Automation has led to a significant reduction in financial transaction costs. This has spawned innovations, such as automated credit scoring using advanced analytics and massive amounts of data. Automating processes allows new, so-called fin-tech firms to offer services often at lower costs than traditional providers, including money transfer across borders (Xoom, TransferWise) or short-term loans (Wonga, ZestFinance). Part of the Alibaba Group in China, Yu'E Bao—or "leftover treasure" in Mandarin—is a fixed-income investment fund into which customers can easily transfer balances from their Alipay digital payment accounts. Established in 2013, by the end of 2014, the fund had 185 million users and about US$93 billion in assets. Peer-to-peer lending platforms operate without traditional financial intermediaries, instead matching potential lenders and borrowers directly.

The emergence of digital currencies has been another innovation made possible by the internet. Bitcoin, the most well-known, was created in 2009. Its value in terms of national currencies has fluctuated widely, its acceptance as a means of exchange has been limited, and there have been widely publicized instances of fraud. But a recent analysis by the Bank of England suggests that the key innovation of such currencies is the distributed ledger that removes the need for accounting and settlement by intermediaries such as banks.[10] This model could also work for other financial assets such as loans, stocks, or bonds, although it is unlikely to spread widely anytime soon.

Managing risks

The rapid development of whole new segments of finance has raised policy questions. How should these new areas of finance be regulated and supervised, for instance to ensure consumer protection? Do they pose significant risks to financial stability? And do they make it easier to commit financial fraud or illicit flows of funds?

One characteristic of digital finance has been the rise of nontraditional providers of financial services such as money transfers, savings, and lending. Some of these are new companies such as peer-to-peer lending firms like Kickstarter or LendingTree. Others are nonfinancial institutions setting up a finance arm (or "nonbank"), such as e-commerce sites like eBay (owner of PayPal) and Alibaba; internet intermediaries like Google; electronics and software developers like Apple; and telecom operators like Safaricom. This raises several concerns.

One concern is that traditional financial regulation does not always cover these companies or they are held to a different standard, such as reduced oversight, even though they can scale up quickly. These problems are somewhat similar to the "shadow banking problem" that preceded the global financial crisis, and regulators are exploring ways to shift from regulating entities to regulating activities. Traditional financial institutions, in contrast, use regulatory arguments to keep out innovative providers of digital financial services that could greatly benefit consumers and firms. This has obstructed the growth of online payment systems in Central America, for example. Light regulation fosters innovation. M-Pesa could not have grown as quickly had Kenya's central bank erected strict regulatory hurdles.

Second, digital finance is bringing large numbers of people into the financial system for the first time. This requires strong consumer education and consumer protection, including promoting financial literacy and fraud prevention, dispute resolution mechanisms, and data privacy.

A third concern is that financial innovations could pose a systemic risk to a country's banking sector, including credit, liquidity, operational, and consumer risk. Prudential regulation of digital finance reduces this risk, but may involve high compliance costs that raise barriers to entry, and thus to competition. Concerns about risks to the banking system were raised about Bitcoin, but analysis by the Bank of England, for instance, suggests that digital currencies play too small a role to threaten financial stability. A greater concern may be that financial innovations create distortions in financial markets that could have larger implications. For example, if automation and "big data" approaches make it much easier to issue consumer credit but not commercial credit, financial institutions might overallocate to the former, potentially creating a credit bubble and reducing credit availability for investments that increase productivity.

Finally, there are concerns about increased fraud in the financial system.[11] With the rise of electronic banking, cyberattacks on financial institutions and on other sectors processing electronic financial transactions have also increased. Massive theft of credit card information from retailers has highlighted the stakes involved. Larger financial institutions have the resources and know-how to continuously upgrade online and mobile security through tools such as encryption or strong authentication. In fact, banks have been at the forefront of developing secure transaction processes. But smaller and nonfinancial institutions may be more at risk. Apart from monetary losses, a large risk is also a loss of trust in digital financial systems that may hinder further innovation in the sector.

Besides fraud and theft, digital finance could facilitate financial flows for illegal or illicit purposes.[12] Such transfers could be money laundering ("cyberlaundering"), when illegally obtained funds are turned into seemingly legal assets through a process of deposit, layering, and integration with legitimate funds. They could represent payments for illegal goods or services such as drugs. Or they could be illicit financial flows—often from developing countries to capital markets in industrialized countries—that represent the proceeds from tax evasion, corruption, or bypassing of capital controls. Some flows may be to circumvent arbitrary regulations by unaccountable governments, but often they are the result of illegal activity that deprives a

SPOTLIGHT 2

Box S2.2 Technology can help unveil illicit money flows

Global communication networks have made it easier to move illicit money around the world and to shelter assets from domestic tax authorities. But recent high-profile cases also show how a combination of human intervention and technology increases the chances of detection. In each case, large datasets were leaked by insiders to tax officials or watchdog groups such as the International Consortium of Investigative Journalists (ICIJ). One case in 2014, Offshore Leaks, yielded 260 gigabytes of accounts data in offshore tax havens, including the British Virgin Islands and Cook Islands. Collaborating with media outlets, experts from Costa Rica, Germany, Malta, and the United Kingdom developed automated software tools for organizing and searching this massive dataset. The largest number of addresses tied to these offshore accounts were from a number of large emerging economies. Besides Offshore Leaks, Swiss Leaks yielded data about secret bank accounts in Switzerland, and Lux Leaks documented strategies that international corporations use to avoid taxes in countries where they make profits, notably by channeling them through Luxembourg. While many clients are from developing countries, they get help from western accountants, and much of the money ends up in industrialized countries or their offshore territories. Increased transparency, thanks to technology's ability to sift through large leaked datasets, is encouraging reforms that will make it harder to hide assets in foreign jurisdictions.

Sources: http://www.icij.org; press reports.

country of financial resources that, in aggregate, are thought to exceed the value of development aid.[13]

The anonymity, speed, ease of transaction, and global reach of digital finance make illegal and illicit transfers easier, including through the ability to split large transactions into small tranches. Internet sites such as online casinos and digital currencies that offer a high degree of anonymity aid such activity. One study found that online casinos offered customers a choice of 235 payment options.[14] And Bitcoin has been used to circumvent capital controls. Because these flows as well as cybercrime generally cross borders, it is not always clear which jurisdiction is responsible.

Although the internet might make illegal money transfers easier, it can also help address the problem. In contrast to cash, electronic transfers leave a trail that can aid law enforcement. Digital technologies could also help establish registries of beneficial ownership of financial and commercial holdings and transaction monitoring systems, a current priority of the G-20. This could reduce tax evasion and cyberlaundering—although the barriers to developing such directories tend to be due more to resistance by tax havens than to technical reasons, and reforms have mostly been prompted by high-profile disclosures (box S2.2). More generally, technology as a tool for tackling the problem of illicit financial flows can complement, but not substitute for, proper legal frameworks, international cooperation, and public-private collaboration. As with international reporting obligations aimed at preventing financing of illegal activities or terrorism, a greater regulatory burden and reporting requirements can tax the resources of smaller countries, which may require assistance to comply.

Digital finance is developing rapidly, and constant changes will challenge the ability of regulators to catch up. Both too much and too little intervention by policy makers entails risks. Even in light of new types of financial crime online, however, the opportunities of digital finance for inclusion, efficiency, and innovation will likely outweigh the risks.

Notes

1. Case study from Grossman and Tarazi 2014.
2. See Bossone 2015.
3. World Bank 2014.
4. World Bank 2014.
5. World Bank 2014.
6. World Bank 2014.
7. Data from the World Bank Findex database, which covers 148 countries.
8. World Bank 2014.
9. McKinsey, as cited in World Bank 2014.
10. Bank of England 2014.
11. Chatain and others 2011.
12. Council of Europe 2012; Tropina 2015.
13. Tropina 2015.
14. Tropina 2015.

References

Bank of England. 2014. "Innovations in Payment Technologies and the Emergence of Digital Currencies." *Quarterly Bulletin 2014 Q3*.

Bossone, Biagio. 2015. "Internet, Finance and Development." Background paper for the *World Development Report 2016*. World Bank, Washington, DC.

Chatain, P. L., A. Zerzan, W. Noor, N. Dannaoui, and L. De Koker. 2011. *Protecting Mobile Money against Financial Crimes: Global Policy Challenges and Solutions*. Washington, DC: World Bank.

Council of Europe. 2012. "Criminal Money Flows on the Internet: Methods, Trends and Multi-Stakeholder Counteraction." http://www.coe.int/t/dghl/monitoring/moneyval/.

Grossman, Jeremiah, and Michael Tarazi. 2014. *Serving Smallholder Farmers: Recent Developments in Digital Finance*. Washington, DC: CGAP (Consultative Group to Assist the Poor).

Suri, Tavneet, William Jack, and Thomas M. Stoker. 2012. "Documenting the Birth of a Financial Economy." *Proceedings of the National Academy of Sciences* 109 (26): 10257–62.

Tropina, Tatiana. 2015. "Do Digital Technologies Facilitate Illicit Financial Flows?" Background paper for the *World Development Report 2016*. World Bank, Washington, DC.

World Bank. Various years. Findex (database). World Bank, Washington, DC, http://www.worldbank.org/en/programs/globalfindex.

———. 2014. *The Opportunities of Digitizing Payments.* Report prepared by the World Bank Development Research Group for the G20 Australian presidency. Washington, DC: World Bank.

CHAPTER 2

Expanding opportunities

Digital technologies can improve overall welfare and reduce poverty, but without complementary investments, they can also worsen inequality. In Africa alone, 11 million youth are expected to enter the labor market every year for the next decade.[1] Born in the internet era, they live in a world full of new and exciting opportunities.[2] Farmers use mobile phones to get price information and technical advice. Women facing barriers to work outside their homes can work online and better balance work and family. And many have found earning opportunities through online work and the on-demand economy. But these new opportunities come hand in hand with fundamental and rapid changes in the world of work, as digital technologies increase the demand for advanced skills, and many skills quickly become obsolete. From a technological standpoint, fewer than half of today's schoolchildren in China, Croatia, or Thailand can expect to find a job in an occupation that exists today.[3] But more than jobs disappearing, they will be transformed. The challenge for policy makers is to ensure that *all* current and future workers can seize the growing economic opportunities that accompany the spread of digital technologies. The risk is that rapid technological change will end up increasing inequality and leaving many behind—blunting the digital dividends.

The potential gains from technological progress for workers and consumers in developing countries are indeed large. Digital technologies can create jobs and increase earnings in the small information and communication technology (ICT) sector—and much more in the sectors that use ICT. They also increase worker productivity by augmenting human capital and—especially critical for the poor—connecting people to work and markets. And they can benefit consumers by lowering prices and expanding the variety of goods and services available, thus producing consumer surplus. Most of these consumer gains come from lower marginal production and distribution costs when firms innovate and automate processes, or from fully digital goods and services that allow firms to exploit economies of scale (figure 2.1 and spotlight 1).

But not everyone stands to benefit automatically. Only by improving internet access and basic literacy and updating skill and training systems will the benefits be realized and broadly shared. For the world's poor, the key is to leverage digital technologies to improve the productivity of household enterprises, subsistence family farmers, and the informal sector. Yet for every person connected to the internet in developing countries, almost three are not; among the poor, more than six are not; and many also lack access to such complementary infrastructure as electricity or roads. Even if connected, many cannot read or use the information the internet provides. For workers in more organized labor markets, conditions are changing rapidly. New jobs require different skills from old jobs, and many new jobs are informal or nonwage, without benefits or worker protections. Greater computer power and internet connectivity make some skills obsolete by substituting for work that is codifiable and routine, and thus can be automated. The remaining tasks require complex skills that complement technology, such as creativity, critical thinking, and problem solving. These skills remain hard for technology to emulate, but also for education and training systems to provide, leaving many workers unprepared for the modern world of work.

Thus while digital technologies can raise productivity and enhance overall welfare, associated labor market disruptions can be painful and can result in higher inequality. High-skilled workers are the biggest winners when paired with digital technologies. Globally, returns to education remain high, at 10 percent per year, and are even higher for those using technology at work. The poor, with no access to technology and lacking skills, see few of the direct downsides from technological adoption but also only partial benefits.

But it is the middle class that can be hollowed out as jobs held by this segment—often medium skilled—are transformed, partly driven by technological change. Machine operators and clerical support workers, for example, perform many "routine" tasks that are easily automated. Since 1995, the share of routine employment in total employment has fallen by 8 and 12 percentage points in developing and developed countries, respectively.[4] Such medium-skilled jobs, critical to the growth of the middle class and held disproportionately by the bottom 40 percent of the welfare distribution, give way either to high-skilled jobs that only a small share of workers qualify for, or to low-skilled jobs that face increasing competition and most likely declining wages.

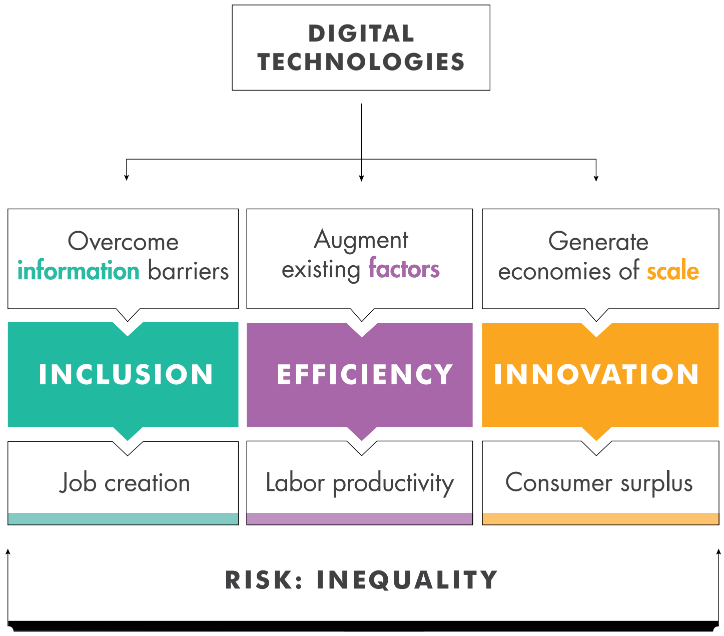
So the race is on between skills and technology, and the outcome will determine whether the dividends from digital technologies are realized and the benefits widely shared. It is important to bridge the digital divides both in access and in capabilities. This second divide separates the digitally savvy, who can make productive use of digital technologies and have skills that complement them—and the digitally poor, who remain unconnected and unskilled. Providing current and future workers with the cognitive, technical, and socioemotional skills that are augmented by technology—and not replaced by it—is a priority. Given the fast pace of technological change—with more intense job creation, destruction, and reallocation to be expected—labor regulations, taxation, and social protection systems will have to support labor mobility and adapt to the changing nature of work. This is the analog foundation for workers to succeed in a digital world.

Connected people

The world is more connected than ever. On average, 8 in 10 people in the developing world own a mobile phone (map 2.1). Digital technologies, often low-end phones, connect the more than 60 percent of the world's people who did not have a landline phone as late as 2000. More people have access to a mobile phone than to secondary schooling, clean water, or sanitation.[5] Internet adoption lags behind mobile phone access, but has tripled since 2005. In developing countries today, 28 percent of the population reports access to the internet at home, and in advanced economies, 80 percent.[6, 7]

Mobile phones are driving this interconnectedness, especially among the poor. All regions are converging in mobile phone use, but South Asia and Sub-Saharan Africa lag far behind in internet access

Figure 2.1 A framework for the internet and economic opportunities



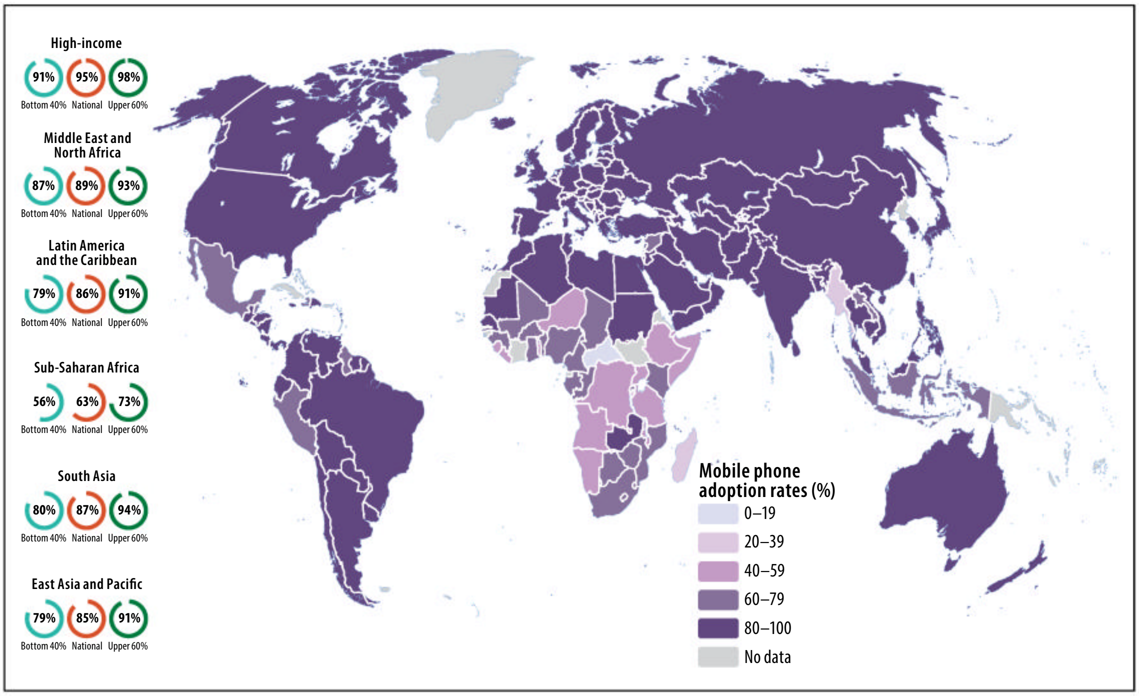
Source: WDR 2016 team.

(figure 2.2). A technology diffuses rapidly when it is low in cost, easy to use, has high potential benefits, and fits well with the local context. Low-cost mobile phones—which can be shared, prepaid, billed in prices per second, and do not require much literacy or numeracy for basic use—fit this description, and are the technology of choice among the poor.[8] In Cameroon, Ethiopia, Rwanda, Tanzania, and Uganda, more than four in five mobile phone owners have simple phones, not capable of browsing the internet.[9] Personal computers and the internet, by contrast, require literacy and often foreign language (especially English) skills. Computers with internet capabilities in the Warana subdistrict in Maharashtra, India, for instance, went largely unused except for transmitting market information to farmers—a function later substituted by mobile phones, which were cheaper and easier to use.[10]

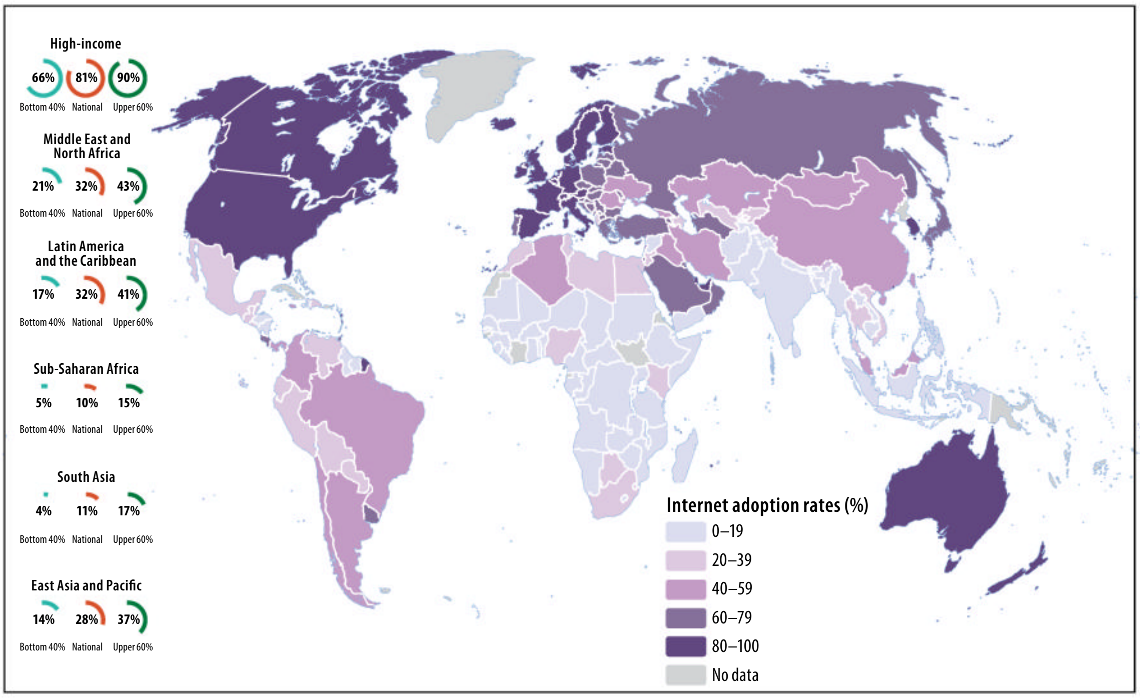
Communications, entertainment, and searching for information are the most common uses for mobile phones and the internet. In African countries, social networking, sending and receiving e-mails, instant messaging, and checking facts and definitions are the most common uses of the internet (figure 2.3). This is similar in Argentina, Brazil, Colombia, Mexico, Uruguay, and the European Union countries, especially with social networking (between 50 and 80 percent of all internet users).[11] The use of digital technologies

Map 2.1 Mobile phones are the main source of connectivity in the developing world, but large gaps in internet access remain

a. Mobile phone adoption rates, circa 2014



b. Internet adoption rates, circa 2014



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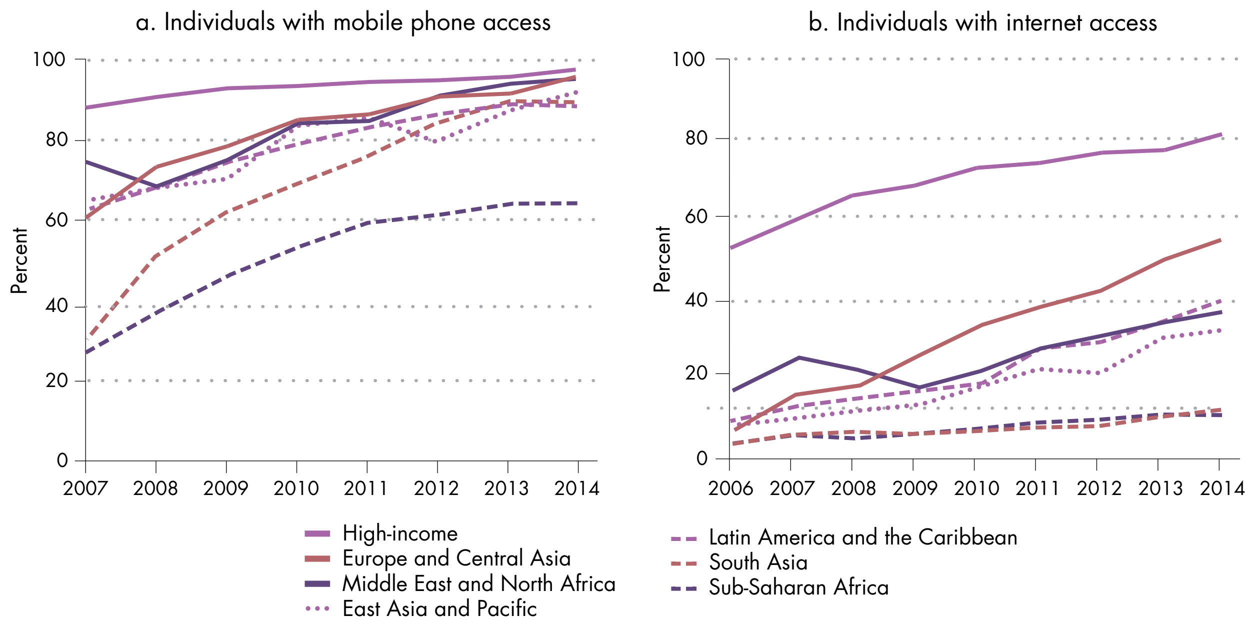
Source: WDR 2016 team, based on Gallup World Poll, various years. Data at http://bit.do/WDR2016-Map2_1.

Note: Adoption rates refer to the percentage of individuals who report owning a mobile phone (panel a) and having internet access at home (panel b).

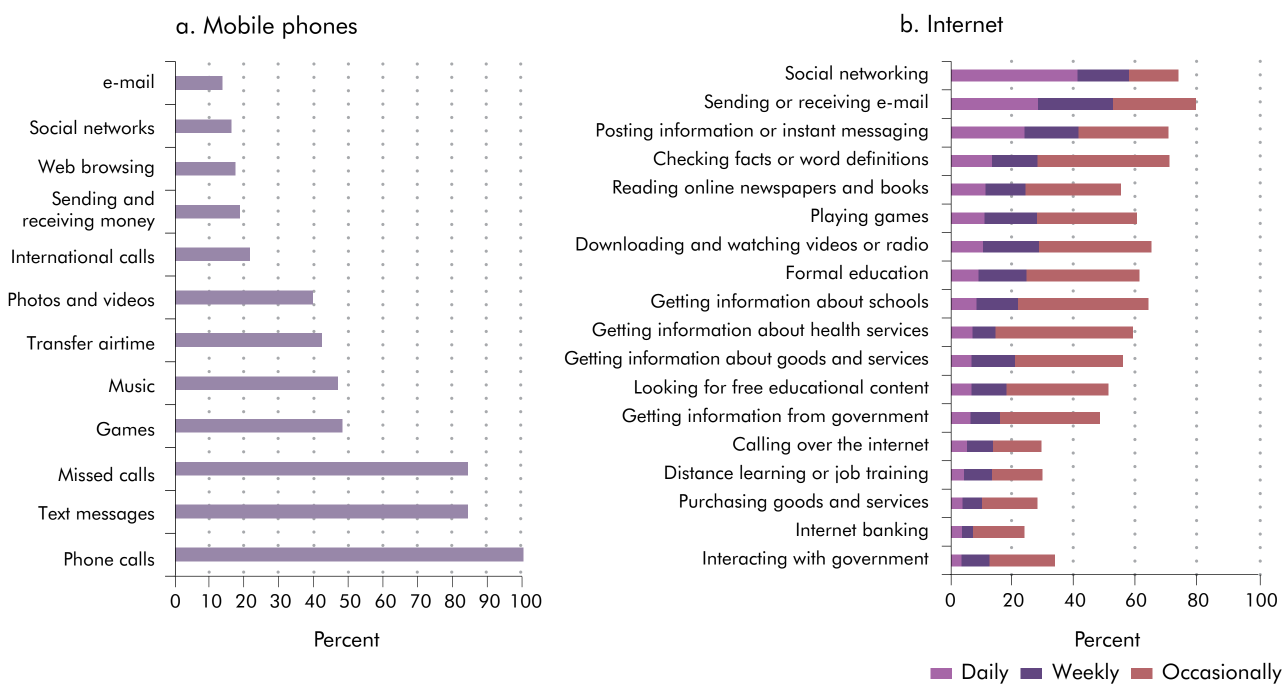
Figure 2.2 All regions are converging in mobile phone access, but South Asia and Sub-Saharan Africa are falling behind in internet access



Source: WDR 2016 team, based on Gallup World Poll, various years. Data at http://bit.do/WDR2016-Fig2_2.

Figure 2.3 How people use mobile phones and the internet in Africa

Percentage of individuals who use mobile phones or internet reporting each type of use, 2011–12



Source: WDR 2016 team, based on Research ICT Africa surveys (various years). Data at http://bit.do/WDR2016-Fig2_3.

Note: Data are simple averages across 12 African countries.

for work, education, and health is more limited but increasing. Across the European Union, around 60 percent of internet users search for health information, and 13 percent make appointments with health practitioners online.[12] In Brazil, 60 percent of internet users use it for educational purposes, and in Mexico, 35 percent.[13] One in four individuals who use the internet in African countries reports doing so to get health and education information.[14] Uses vary across population groups. In Brazil and Mexico, women, rural, and poorer populations are less likely to use the internet for financial transactions or dealing with public authorities, but in both countries these same groups are equally or more likely to use it for educational purposes than men, urban, and richer populations.[15] Across countries, children and youth are most likely to use the internet for education.

The digital divide persists

Despite the rapid spread of digital technologies, more than 800 million people lack mobile access worldwide (63 percent of them in the bottom 40 percent of the income distribution), and 4.3 billion lack internet access (49 percent in the bottom 40).[16] For every person connected to the internet in developing countries, almost three are not, and in some countries, 20 are not. Big gaps remain by income, age, location, and gender (figure 2.4). In African countries, the bottom 40 percent is only one-third as likely to have access to the internet as the upper 60 percent;[17] 18 percent of men report using the internet versus 12 percent of women, and 20 percent of youth versus 8 percent of those more than 45 years old. Such demographic gaps persist also in Latin America, and even in high- and middle-income European countries.[18]

The digital divide reflects inequalities in access and barriers to productive use. Many areas simply remain unconnected (chapter 4). Even when a region is connected to the internet, access is not easy. In Cameroon, Ghana, Kenya, and Uganda, more than three in four users still access the internet in commercial internet cafes, where high costs and slow connections limit use.[19] A survey of 25 developing countries found that although commercial cafes were more expensive than telecenters, they had more skilled staff and more reliable infrastructure and service.[20] But this is not the whole story. Illiteracy and lack of skills are important barriers. In a subsidized internet and mobile telephony program in rural Peru, mobile phone ownership increased, on average, by 12 percentage points, but internet use increased by only 2 percentage points.[21] Explaining this gap is the lower internet use among adults than among youth, and the lack of use among the uneducated. Even among the literate, internet use may be limited by a lack of content in local languages.[22]

Figure 2.4 The digital divide within countries remains wide, especially in internet use

Internet use in Africa, by demographic and socioeconomic characteristics, 2011–12

Source: WDR 2016 team, based on Research ICT Africa surveys (various years). Data at http://bit.do/WDR2016-Fig2_4.

Note: The chart shows a simple average for 12 countries.

Creating jobs, boosting labor productivity, and benefiting consumers

The overall impacts of digital technologies on employment and earnings are positive, if highly heterogeneous (table 2.1). As discussed throughout this chapter, rigorous evidence remains limited, but it suggests that most gains accrue disproportionally to the better educated, with technology complementing the skills and assets of users. But there are exceptions. In Peru, between 2007 and 2009, new internet users had higher income growth than those who remained nonusers, with larger gains in rural areas.[23] And in the United States the diffusion of broadband increased employment rates more in rural areas than in urban.[24]

What explains the aggregate differences? The first factor is the type of technology. Mobile phones can be particularly beneficial to people in more disadvantaged groups—who often lack skills for using the internet, or work in agriculture, where mobile phones alone can pay off. Thus the benefits from mobile phones tend to be widespread. In Peru, for

Table 2.1 Digital technologies affect employment and earnings, the evidence shows

Authors	Country	Technology	Key findings
De los Rios (2010)	Peru	Internet	Internet adoption was associated with labor income gains of between 13 and 19 percent. There was no effect on the probability of finding employment.
Klonner and Nolen (2010)	South Africa (rural)	Mobile phones	Mobile phone coverage increased (wage) employment by 15 percentage points, mostly due to increased employment among women, especially those without significant child care responsibilities. Among men, it induced a shift from agricultural employment to other sectors.
Kolko (2012)	United States	Internet	Broadband expansion was associated with local population and employment growth, but average wages and overall employment rates were unaffected. Localities with broadband became more attractive, and the supply of workers responded to job opportunities.
Marandino and Wunnava (2014)	Uruguay	Laptops and internet	In two years, the One Laptop per Child program had no impact on average households' labor earnings but led to a 33-percent increase in hourly labor income among households below the median income. Richer households already had access to technology before the program.
Ritter and Guerrero (2014)	Peru (rural)	Internet and mobile phones	Access to internet and mobile phones increased wage employment, the production of processed goods, and the prices farmers received for their products. Mobile phones were the main driver for agricultural activity, while internet access was the main driver for employment outside agriculture.

Source: WDR 2016 team.

both mobile and internet use, the better educated benefited most, but while very few of the less educated adopted the internet, they benefited greatly from their new mobile phones.[25] Second is the labor market context. Technology makes a difference when it helps overcome obstacles to employment or higher productivity. In Peru, mobile phones were more beneficial in agriculture, where lack of access to relevant and timely information kept people from accessing better opportunities, whereas internet access made more of a difference outside agriculture, where employers seemed to demand ICT skills and internet use. If the constraints are elsewhere, technology will not make a difference. In rural South Africa, the rollout of mobile phone networks increased employment among women, but only for those who did not have significant family responsibilities.[26]

These aggregate effects of digital technologies on opportunities are mediated through three mechanisms (see figure 2.1):

- *Creating jobs.* Digital technologies promote inclusion by boosting employment and earnings in the ICT sector or in ICT occupations across the economy. But most important, they support jobs and earnings in sectors that use ICT when firms and the self-employed adopt new technologies and grow, as well as through ICT-enabled outsourcing and entrepreneurship.
- *Increasing worker productivity.* By taking on some tasks previously performed by workers, digital technologies augment workers' skills, increasing their productivity and earnings. Digital technologies can also connect people to work and markets and facilitate the accumulation of productive assets. This increases efficiency in the labor market and the overall economy by allowing workers and firms to better leverage existing assets.
- *Benefiting consumers.* When digital technologies automate processes and generate economies of scale, they can lower prices and create new goods and services, thus increasing consumer surplus.

While quantifying these benefits is difficult, the evidence discussed in the rest of the chapter suggests that they accrue most to those already better off (table 2.2). Employment in the ICT sector and in ICT occupations is limited and mostly for high-skilled workers. In industries that use ICT, the potential is greater, especially for those who have skills that better complement the technology. But the largest payoff from digital technologies is increased labor productivity. Better and cheaper information that helps connect people to inputs, outputs, and work is particularly promising for the poor, since it addresses a key barrier to raising incomes for people previously disconnected from markets. The lower communication costs associated with mobile phones, the most common technology for the poor today, can increase the efficiency of agriculture and labor markets, raising household incomes and reducing poverty. As governments and the private sector get better at tailoring digital services to the poor, those gains should increase.

Table 2.2 Benefits of digital technologies for workers and consumers: A scorecard

Channel	Impact so far		Potential impact	
	Poor	Nonpoor	Poor	Nonpoor
Creating jobs				
In the ICT sector and occupations	Negligible	L	Negligible	L
In sectors that use ICT	L	M	L	M
Increasing worker productivity				
Increasing returns to human capital	L	M	L	H
Connecting people to work and markets	M	H	H	H
Benefiting consumers				
Increasing consumer surplus	M	H	H	H

Source: WDR 2016 team.

Note: Poor refers to the bottom 20 percent of the welfare distribution. The differential impact summarizes the discussion in the chapter and is a qualitative assessment of the evidence. ICT = information and communication technology; L = low; M = medium; H = high.

Creating jobs

In ICT sectors and occupations

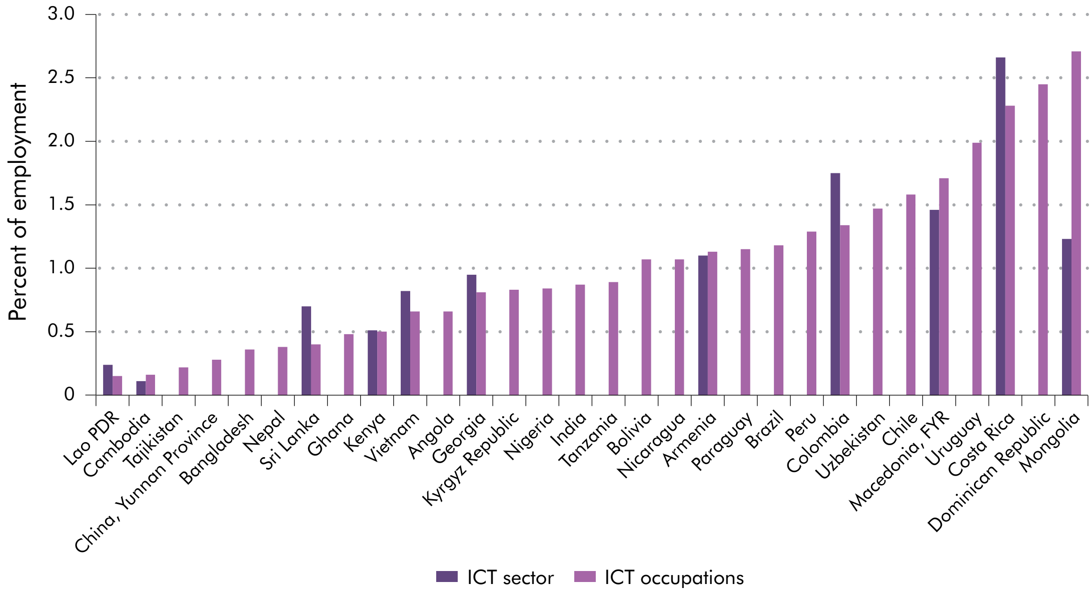
In terms of employment, the ICT sector is small, has high entry barriers, and remains male dominated. The ICT sector employs, on average, 1 percent of the workers in developing countries (figure 2.5). ICT occupations—such as network administrator and electrical and electronic engineer—are also 1 percent of employment in developing countries, and 2–5 percent in member-countries of the Organisation for Economic Co-operation and Development (OECD).[27] Even in the United States, since 2000, new technology-related industries—such as e-commerce and social networking—have accounted for only 0.5 percent of employment.[28] Nor is the sector labor intensive. Instagram, a photo sharing app, had just 13 employees in 2012, when it was bought by Facebook for US$1 billion. Facebook, in turn, had 5,000 employees at the time—compared with 145,000 at Kodak at its peak in photographic film in the 1990s. Yet Facebook's market value is several times what Kodak's was back then.[29] And most of these jobs are high-skilled. In developing countries, on average, half of all workers in the ICT sector have a tertiary education, compared with one-quarter elsewhere. The gender gap is also large, with men 2.7 times more likely than women to work in the sector and 7.6 times more likely to be in ICT occupations.[30]

While not numerous, ICT jobs pay well and can generate additional jobs through consumption and production spillovers. The median hourly earnings in the ICT sector and in ICT occupations are 1.5 times higher than in urban non-ICT sectors or non-ICT occupations in developing countries.[31] The high pay reflects a workforce that is better educated than average. It likely also reflects the relative scarcity of ICT workers in some countries, driving up the skill premium. These high-paying jobs create more demand and new jobs outside ICT. In the United States and Turkey, one job in the high-tech industry generates an average of 3 to 5 additional jobs elsewhere in the local economy.[32] Many of these additional jobs are low-skilled or medium-skilled in such local services as retail, cleaning, and food preparation. Kenya's mobile money service M-Pesa uses more than 80,000 agents or service locations that make an average profit of US$70 a month.[33] Hormuud Telecom—the largest operator in Somalia—employs 5,000 staff but supports 25,000 agents. Given the high skill requirements of the ICT industry, these employment spillovers are more likely to benefit the poor.

Expanding businesses that use ICT

The greatest employment potential of digital technologies lies outside the ICT sector. By improving productivity and boosting firms' growth throughout the economy (chapter 1), digital technologies can increase aggregate employment and earnings. In China, between 1997 and 2007, the increase in internet domains and users per capita had a positive impact on firms' employment in ICT-intensive industries.[34]

Figure 2.5 Employment in the ICT sector and in ICT occupations remains small



Source: WDR 2016 team, based on the Skills Towards Employability and Productivity (STEP) household surveys (World Bank, various years); Central Asia World Bank Skills surveys (World Bank, various years); Survey-based Harmonized Indicators Program (SHIP) (World Bank, various years); Socio-Economic Database for Latin America and the Caribbean (SEDLAC) (CEDLAS and World Bank); and South Asia Region MicroDatabase (SARMD) (World Bank, various years). Data at http://bit.do/WDR2016-Fig2_5. The STEP surveys used in this Report cover 11 countries: Armenia, Bolivia, Colombia, Georgia, Ghana, Kenya, Lao PDR, FYR Macedonia, Sri Lanka, Ukraine, and Vietnam, as well as China, Yunnan Province.

Note: The ICT (information and communication technology) sector includes ICT manufacturing industries, ICT trade industries, and ICT services (OECD 2011). ICT occupations refer to ICT specialists (OECD 2004, 2014).

In Brazil, between 2009 and 2013, firms in industries intensive in the use of ICTs had higher wage increases across skill levels than the rest of the economy (figure 2.6), although they did not experience faster employment growth. Wage growth was especially high for workers moving across firms.[35]

Recent studies, despite measurement difficulties, find a positive causal effect of firms' technology adoption on employment and earnings, especially in firms with skilled workers who can make the best use of digital technologies. Thanks to a tax allowance program for ICT investments in small firms in the United Kingdom, digital technologies raised labor productivity within firms and increased the demand for workers performing high-skilled tasks.[36] In Norway, a 10-percentage-point increase in broadband availability in a municipality raised wages of skilled workers by about 0.2 percent, while lowering wages for low-skilled workers.[37]

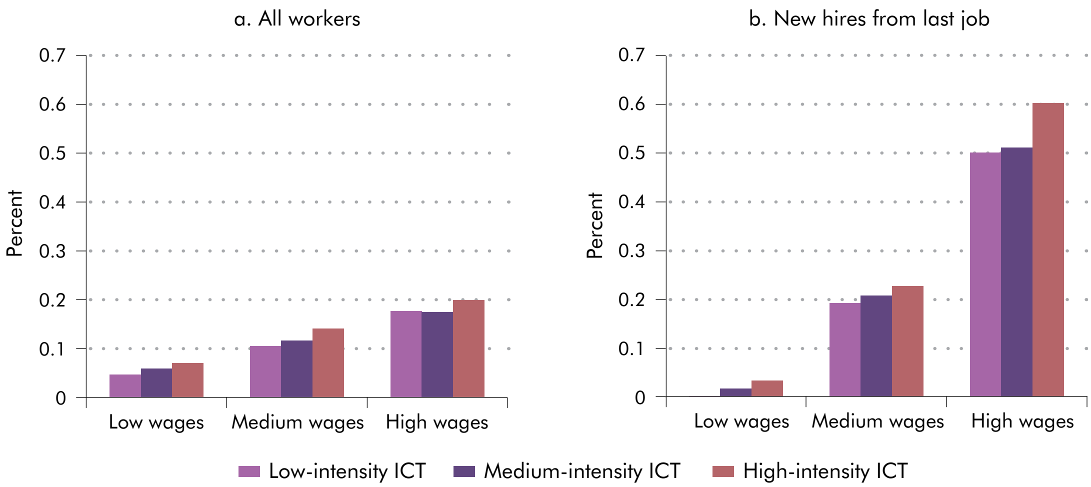
Internet-enabled offshoring and outsourcing, including online work

Internet-enabled offshoring is an important source of jobs in developing countries and for women. An estimated one in four jobs in the United States has already been offshored or could be offshored in the future.[38] These jobs are often in business processing, including call centers and bookkeeping. Such jobs include those that can be broken down into routine tasks but also those requiring high skills and judgment if they can be reliably performed and monitored remotely. Almost half of business process outsourcing (BPO) is in banking and financial services, and another 20 percent is in high-tech and telecommunications. Some tasks of radiologists and other medical services are increasingly also offshored. India, China, the Philippines, and South Africa are the leading BPO hosts.[39] The BPO industry in India employs more than 3.1 million workers, 30 percent of them women.[40] In the Philippines, it employs 2.3 percent of all workers (box 2.1). In rural India, a three-year awareness program on opportunities in the BPO industry increased women's enrollment in relevant training programs, as well as school enrollment among young girls, by 3–5 percentage points.[41]

New technologies are now also challenging the status quo of the outsourcing industry. Many of the characteristics that make jobs "offshorable" also make them more vulnerable to automation. So, as technology improves and wages rise, some of the jobs typically offshored, such as call center jobs, could be automated. Indeed, a local health care company in

Figure 2.6 In Brazil, internet and software use by firms throughout the economy is associated with higher earnings

Average annual wage growth, by firms' ICT intensity and workers' wage levels, 2009–13



Source: Dutz and others 2015, for the WDR 2016. Data at http://bit.do/WDR2016-Fig2_6.

Note: The categories of wage levels are terciles. ICT = information and communication technology.

South Africa is already using Watson, IBM's artificial intelligence system, to assist in customer service.[42]

Outsourcing opportunities are increasing in other areas through online work, providing workers and firms with access to larger, even global, employment marketplaces (box 2.2). People can work for any employer anywhere, with parties buying and selling services that can be delivered online. Upwork (formerly Elance–oDesk), the largest online outsourcing service, had 2.8 million job postings worldwide in 2014.[43] Online jobs range from the very simple that can be completed in a few minutes—such as sign-ups, forum participation, review writing, and website testing—to the more complex, such as software development, translation services, data entry, and administrative support. The online work market, though still a tiny fraction of overall employment, is worth around US$1 billion annually, up from US$700 million in 2009.[44]

Impact-outsourcing brings online work to vulnerable communities. Still in its infancy—employing around 150,000 workers, or 3 percent of the total BPO industry—it is taking hold in India, Kenya, and South Africa. The government of Kerala, India, outsources information technology services to cooperatives of women from poor families through the Kudumbashree ("Prosperity of the Family") project. Average earnings were US$45 a month, with close to 80 percent of women earning at least US$1 a day. Nine in ten of the women had previously not worked outside the home.[45] Samasource, RuralShores, and Digital Divide Data are three private service providers. Samasource splits jobs into microwork for almost 6,400 workers, mostly in Ghana, Haiti, India, Kenya, and Uganda, on average more than doubling their previous income.[46]

Online work can prove particularly beneficial for women, youth, older workers, and the disabled, who may prefer the flexibility of working from home or working flexible hours. On freelancer.com—an online outsourcing platform with more than 10,000 microworkers globally—57 percent of workers are between 16 and 25 years of age.[47] In Elance (part of Upwork), 44 percent of workers are women, compared with just 25 percent in the nonagricultural economy (figure 2.7). In a survey on microworkers .com carried out for this Report, 27 percent of workers see being able to work at home and flexible hours as the main advantages of working online. These are the reasons most cited, even more often than earning extra income, especially among women (figure 2.8).

Internet-enabled entrepreneurship and self-employment

By lowering information barriers and costs, the internet increases experimentation and gives rise to new opportunities for entrepreneurship and self-

Box 2.1 Business process outsourcing and jobs in the Philippines: Opportunities and challenges from technological change

The information technology (IT) and business process outsourcing (BPO) industry in the Philippines has been a driver of economic growth and job creation in the last decade. It has grown at an average of 24 percent annually, and its share of the global offshore services market went from 5 percent in 2006 to 11 percent in 2013. Direct employment reached 1 million full-time employees in August 2014 from virtually zero in 1999, accounting for around 2.3 percent of the country's total employment. The industry has a robust voice sector (primarily call centers), accounting for 64 percent of the industry's revenue. Health care information management employment grew by 47 percent from 2012 to 2013. IT outsourcing revenues also grew by 52 percent from 2012 to 2013, while knowledge process outsourcing grew by 18 percent.

Earnings and skill requirements vary across these sectors. Industry-specific jobs tend to be higher skilled than those that cut across industries (such as human resources business processing), as they require more technical knowledge. In 2012, average annual compensation per employee in the industry was around US$8,849, with the highest average compensation in software development (US$17,383). It was US$8,301 for contact centers and US$7,687 for other BPOs. High-skilled, high-paid occupations—as are most research and development–related jobs in knowledge process outsourcing (such as market research and medical transcription), IT outsourcing (such as software and application maintenance), engineering services (such as engineering design and digital mapping), and creative processes (such as art production and game testing and support)—are intensive in nonroutine cognitive and interpersonal tasks. Middle-skilled occupations are intensive in routine cognitive tasks, mostly in nonvoice BPO (such as back-office finance and accounting or human resources), but can also include many of the jobs in voice business processing (such as customer service and technical support).

Progress in digital technologies and international competition increases the need to move to more high-value-added, nonroutine jobs. In the Philippine IT-BPO industry, 85 percent of the revenues are generated in jobs intensive in routine cognitive tasks, with workers increasingly susceptible to automation. Low wages will delay this process but are unlikely to halt it. As the global market for complex services grows, providing a larger volume of high-value nonvoice services can promote the industry's sustainability. This transition requires a concerted effort among business, academia, and government to make systemic improvements across the IT-BPO ecosystem, such as enhancing telecommunications infrastructure and directing industry-government partnerships toward more nonvoice training and skills development.

Source: WDR 2016 team, based on Capili 2015, for the WDR 2016.

employment (box 2.3). Many are in the ICT sector, but others are ICT-enabled (see also chapters 1 and 4). Alibaba in China, the world's largest e-commerce platform by sales volume, supports an estimated 10 million jobs, or 1.3 percent of China's workforce. Online shop owners using Alibaba in China, on average, employ 2.6 additional workers. Four in ten shop owners are women, 19 percent were previously unemployed, 7 percent were farmers, and about 1 percent are persons with disabilities. Alibaba is estimated to support an additional 2 million jobs, most in logistics.[48] In Morocco, home-based female weavers sell rugs and other textiles over the internet to keep a larger share of their profits.[49] Etsy, a peer-to-peer e-commerce platform focused on handmade or vintage items, and similar services, can take this to scale. Etsy has 20 million active buyers and 1.5 million active sellers worldwide, with 31 percent of its sales outside the United States.[50]

As online commerce, the on-demand or sharing economy—in which people rent assets or command services directly from one another, coordinated through the internet—is growing rapidly, if still small overall and just emerging in developing countries. More than two-thirds of internet users globally are willing to be part of the sharing economy.[51] In Uganda, food delivery services online are used by the diaspora to send in-kind remittances to family members. In Kenya, Sendy connects customers with motorcycle couriers for delivery services, which can then be paid with mobile money. As of March 2015, Airbnb—the largest site for peer-to-peer accommodation—reported operating in more than 34,000 cities and 190 countries, with more than 25 million guests.[52] Peer-to-

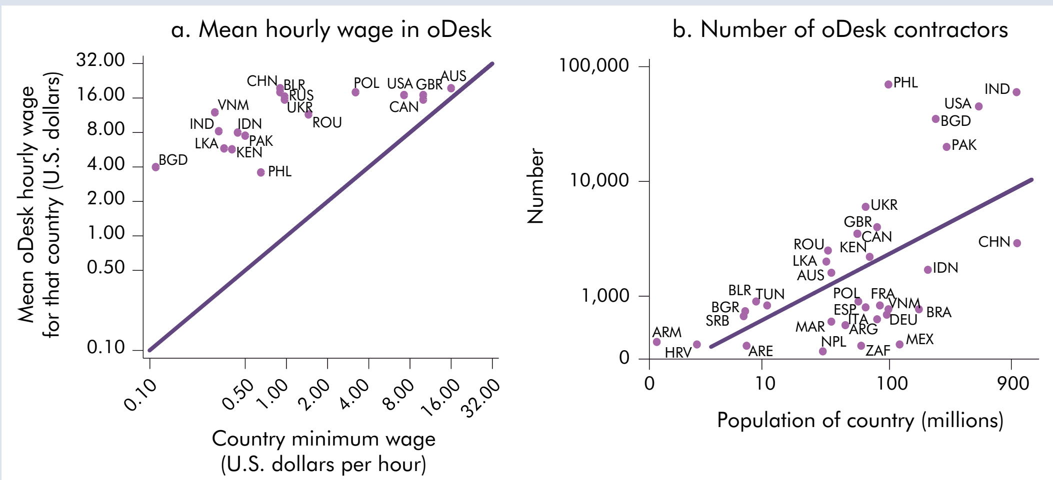
Box 2.2 The economics of online outsourcing

Online outsourcing or freelancing platforms match firms and workers to perform work online. They can reduce contracting costs and the time it takes to match employers and employees. Through Upwork, the largest of these platforms, the time it takes to hire a worker can fall from 43 to 3 days.[a] On the workers' side, around 45 percent of freelancers on Upwork earn most or all of their income through online work. In oDesk—with Elance, one of the two original platforms behind Upwork—hourly earnings are on average 14 times higher than minimum wages in developing countries (figure B2.2.1, panel a). This is partly explained by the fact that online workers are better educated than those in the general economy. High-paying work is concentrated in information and communication technology (ICT) areas such as software development, which can pay twice as much as online work in writing and translation, and even three to four times more than that in customer support and sales.[b]

Thanks to the internet and innovations in monitoring and feedback systems, online labor markets are becoming global. Online job platforms increase the pool of talent for firms, especially for smaller enterprises, and provide an opportunity to monetize skills that may not be in sufficient demand in the local economy. An individual in Mongolia with expertise in web development and a programming language such as Python can make close to US$40 an hour online. On Upwork, 90 percent of the work is offshored. On the largest platforms, most employers are located in developed countries and most workers in developing countries. Australia, Canada, and the United States are the largest employers. On oDesk, Bangladesh, India, Pakistan, the Philippines, and the United States have the largest number of contractors in relation to their populations (figure B2.2.1, panel b).

Yet the internet only partly overcomes labor market segmentation, and some barriers to inclusion and to further expansion of online labor markets remain. On Upwork, a given worker is 1.3 times more likely to find work in her domestic market, and domestic contractors get paid more than international contractors for the same type of work.[c] Online outsourcing is most likely to function like a truly global market when tasks are less complex and involve fewer local institutions and less communications. Additional constraints that could be addressed by policy are related to language (mainly English), regulations, payment platforms, and trust.[d]

Figure B2.2.1 Online labor markets provide work and fairly good pay for workers in developing countries



Source: Agrawal and others 2013.

Note: oDesk is now part of Upwork, together with Elance. In panel a, the line inside the figure is the 45-degree line along which hourly wages in oDesk are the same as the country's minimum wage; in panel b, it is a regression line. In panel b, the number of contractors refers to those who have ever worked on oDesk.

a. http://elance-odesk.com/online-work-report-global, accessed March 26, 2015.
b. Agrawal and others 2013.
c. Lehdonvirta and others 2014.
d. Kuek and others, forthcoming.

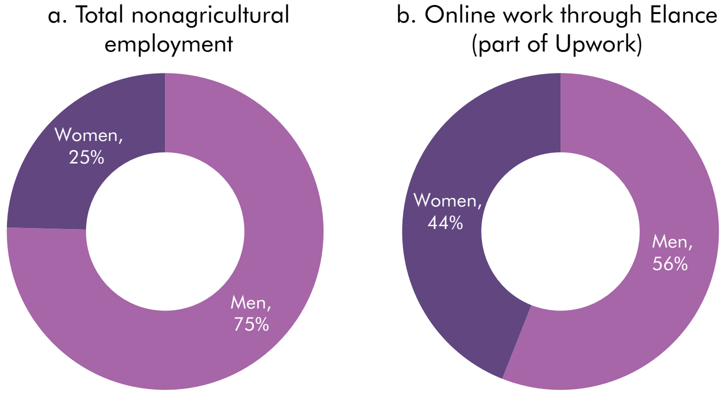
peer car services such as Uber, which operates internationally, or Didi Kuaidi in China, are growing fast. Expanding the principles of the on-demand economy to the urban self-employed in developing countries could be particularly promising. These workers often lack references and documented work histories when seeking jobs and depend on word of mouth to expand their customer base. In this setting, the sharing economy's decentralized, crowd-based rating systems can help control quality, build trust, and maintain a live "resume." Plumbers and handymen can expand their client pool by building strong reputations online.

These new jobs in the sharing economy have advantages for workers, but they also come with trade-offs. The main advantages for workers are supplemental income and flexibility. In the United States, 61 percent of sharing economy participants say earning extra money is their main motive.[53] Workers appear to sort into a working arrangement that suits their preferences and family circumstances. Two-thirds of Uber drivers in the United States vary their hours

Figure 2.7 Online work expands women's access to work

Global nonagricultural employment composition by gender, "offline" and online

percent of total employment

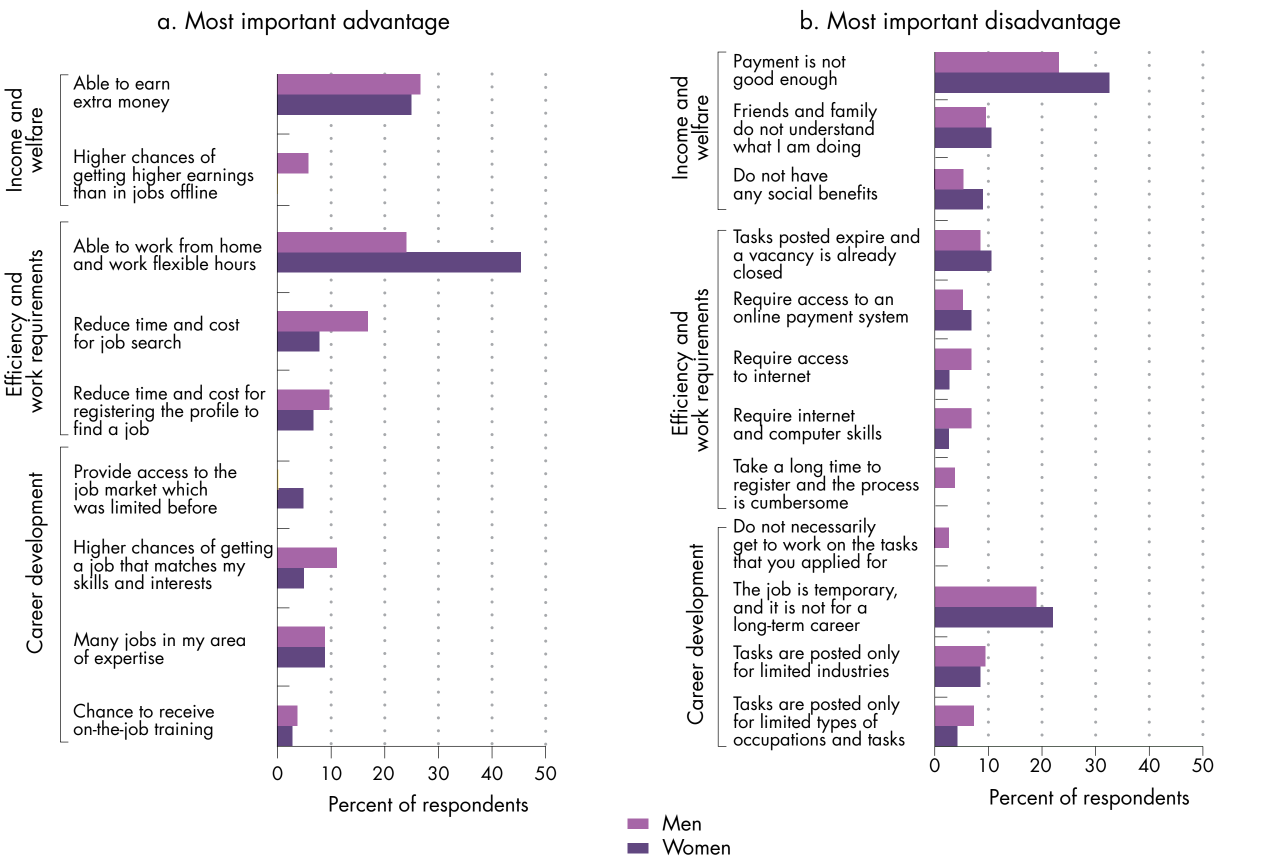


Sources: WDR 2016 team, based on World Development Indicators (World Bank, various years) and Elance Annual Impact Report "Work Differently," June 2013. Data at http://bit.do/WDR2016-Fig2_7.

Note: Results are population-weighted. China is not included. For panel a, latest available data between 2008 and 2013.

Figure 2.8 Flexibility in hours worked and the ability to work from home are the main advantages of online work, but relatively poor pay and lack of career prospects are concerns

Microworkers.com: Most important advantage (panel a) and disadvantage (panel b) of using an online work platform over a traditional job "offline"



Source: Survey of online workers at microworkers.com, where the majority of workers are from developing countries, especially South Asia. Based on Imaizumi and Santos, forthcoming, for the WDR 2016. Data at http://bit.do/WDR2016-Fig2_8.

Box 2.3 Expanding opportunities through online music

Usman Riaz began piano lessons at age six in his native Pakistan. He later wanted to explore new instruments and musical styles, but he could not find the right teachers in his own country. Instead, watching videos online, he taught himself percussive guitar, a style that uses the strings and the instrument's body for percussive effects. Riaz also used the internet to showcase his music. His song "Fire Fly" went viral in 2011. A year later, he shared a stage in Edinburgh with Preston Reed, one of his online idols.

The internet has exposed people around the world to new cultural influences—not just global pop culture hits, but also in the tiniest niches. Whether it has also helped many more artists in developing countries gain access to arts and entertainment markets is difficult to say, given the lack of suitable data. Globally in 2014, revenues for recorded music were about US$15 billion and falling, compared with US$25 billion for live performances, whose revenues are rising.[a] Pirating, YouTube, and music streaming have led to an overall decline of music sales in developed and developing markets. Most of the revenue goes to the biggest stars: the top 1 percent of artists earn about 80 percent of recorded music revenue.[b] At the same time, file sharing has raised the demand for concerts,[c] which has always been the biggest source of income for most musicians.[d] As the cost of recording and distributing music has gone down, online music sharing could become an effective advertising vehicle for musicians in developing countries—although limited internet access and slow speeds make this harder. Even if only a small minority break into national or even international entertainment markets, the welfare benefits of being able to learn from others and share talents on the internet can still be significant.

Source: Kabanda 2015, for the WDR 2016.

a. PricewaterhouseCoopers 2015.
b. Thompson 2015.
c. Holland, Nosko, and Sorensen 2012.
d. Connolly and Krueger 2006.

worked by more than 25 percent from week to week. This flexibility is likely to be valuable for women and youth and for people between jobs. But these benefits come at a possible cost since these jobs do not provide much work security or protection to workers.[54]

Increasing worker productivity

Increasing returns to human capital

Digital technologies can complement human capital, allowing workers to focus their efforts on activities with higher value and making them more productive. Farmers can use precision agriculture or track livestock. Teachers can use massive open online courses (known as MOOCs) or online teaching tools like Khan Academy, better using study time inside and outside the classroom to increase practice and discussion, and dedicating more time to children who fall behind. Researchers can dedicate more time to thinking and innovating rather than spending time searching for information or duplicating other people's work. Managers can work more easily with teams across borders.

In fact, there has never been a better time to be a well-educated worker. Chapter 1 shows how digital technologies increase labor productivity within firms. Workers who are able to work with digital technologies and complement them are well positioned to access more (and more rewarding) employment and higher wages. Returns to education have fallen only in Latin America. Everywhere, average private returns remain high—at 10 percent per year—despite large increases in the supply of educated workers in the last few decades. Returns to tertiary education are the highest, at 14.6 percent; tertiary education is the only educational level for which returns have not fallen since the early to mid-1990s.[55] That reflects strong demand for advanced skills, especially among women (figure 2.9). Returns to education are higher and have been rising more rapidly in ICT-intensive occupations compared to the rest of the economy (figure 2.10).

Connecting people to work and markets

Digital technologies help overcome barriers to productive employment and connect workers and entrepreneurs to (global) markets, clients, and suppliers. This is particularly important for the disadvantaged or often-excluded groups such as the poor, women, minorities, the disabled, and people in remote regions (box 2.4). For all of them, high search costs, long distances, and a lack of information are key obstacles.

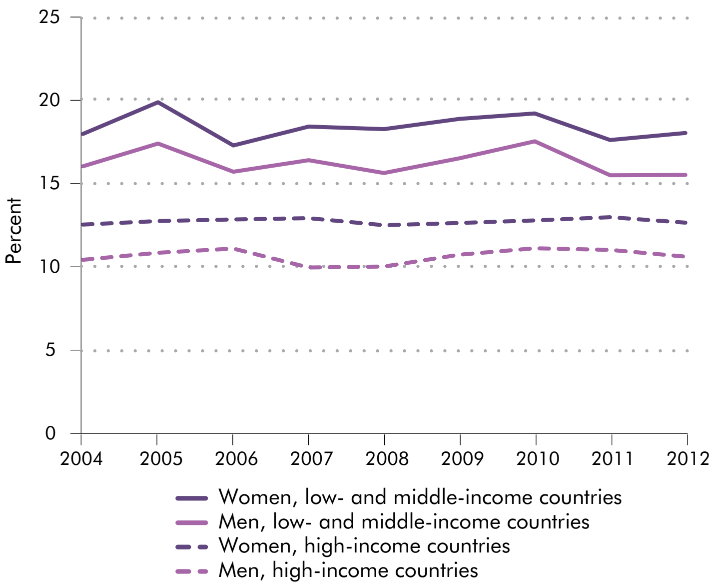
The internet makes labor markets more efficient by connecting a larger pool of individuals and firms at lower cost.[56] Indeed.com, Monster.com, and elempleo .com are international platforms that aggregate job vacancies from different sources and allow firms to post job openings, and workers to apply for jobs and post résumés. Similar services exist for local markets, such as aldaba.com in the Dominican Republic and kariyer.net in Turkey. Social and professional networking sites also provide information on potential workers, often on behavioral aspects and social ties not reflected in traditional resumes. LinkedIn, the largest online professional network, has more than 310 million registered members, 67 percent outside the United States. In Brazil, LinkedIn's penetration rate is already at 8 percent.[57] In most countries, online job search remains concentrated among youth and the best educated and grows with income: online job search among the employed and unemployed is above 20 percent in urban Armenia and Georgia, but below 5 percent in urban Bolivia, Ghana, the Lao People's Democratic Republic, Sri Lanka, and Vietnam.[58]

Online job boards, social media, and matching platforms can improve labor market efficiency, especially in developing countries and in the informal sector, where information failures are large. Online job matching is cheaper and faster than traditional methods.[59] In Peru, integrating mobile phones into traditional public intermediation services increased employment among job seekers by 8 percentage points in the short term.[60] In Germany, online job seekers are better matched to jobs, are happier with work, and have higher chances of promotion and job security.[61] But other studies find no effect of online tools on the speed of matching or on the length of unemployment.[62] The large number of applications per vacancy and stale resumes and job posts makes it costly for employers to select workers and for workers to find available jobs. As online tools become more advanced, however, matching is becoming more effective. In the United States, the average unemployment duration for internet searchers was 25 percent shorter than for noninternet searchers, reversing earlier results.[63]

Online tools can address many labor market frictions, but much of this potential remains unrealized. A first challenge is reaching lower-skilled workers. Some services, such as Souktel, are solving this via mobile phone (box 2.5). Babajob in India and Duma in Kenya have also implemented innovations to reach the bottom of the pyramid. They use text messaging and "missed calls" to connect low-skilled and informal workers to vacancies. A second challenge is

Figure 2.9 Returns to education remain high despite significant expansion in the supply of educated workers, especially for tertiary education

Average return to one additional year of education in tertiary education

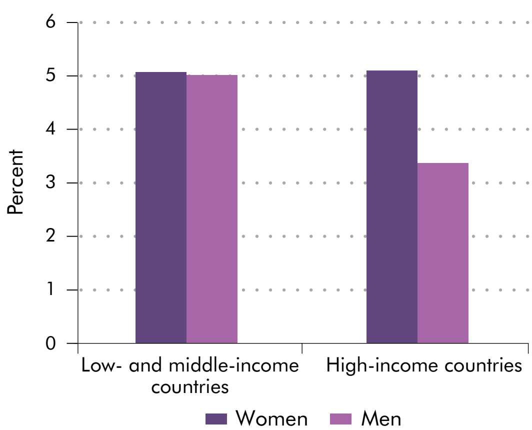


Source: WDR 2016 team, based on Montenegro and Patrinos 2014. Data at http://bit.do /WDR2016-Fig2_9.

Note: Includes 97 countries and only wage employees. The regressions control for potential experience and potential experience squared using individuals' age.

Figure 2.10 Returns to education are particularly high in ICT-intensive occupations

Wage premium, beyond returns to education, for working in an ICT-intensive occupation



Source: WDR 2016 team, based on Monroy-Taborda, Moreno, and Santos, forthcoming, for the WDR 2016. Data at http://bit.do/WDR2016-Fig2_10.

Note: An ICT-intensive occupation scores 4 or higher in an index between 0 (no use of technology at work) and 6 (most use of technology at work). ICT = information and communication technology.

Box 2.4 Bridging the disability divide through digital technologies

For most people, technology makes things easier. For people with disabilities, it makes things possible.
—Mary Pat Radabaugh, formerly with the IBM National Support Center for Persons with Disabilities

Prakash lost his sight at birth. Today he is a successful entrepreneur and programmer running his own information technology (IT) company in a mid-size city in India. Screen-reading and voice-recognition software enable him to use a computer and write computing programs, and the internet helps him find and connect with clients. Technology augments his business and his life.

Around the world, more than 1 billion people have disabilities, 80 percent of them in developing countries. They face infrastructure and environmental barriers to social, financial, and civic participation, which digital technologies can help overcome. Technology enables multiple means of communication—voice, text, and gestures—to access information and engage with others. Magnification, voice recognition, and text-to-speech benefit persons with visual, cognitive, learning, and mobility disabilities. Short message service (SMS), instant messaging, telephone relay, and video captions reduce communication barriers for those with hearing and speech disabilities. Hands-free navigation and gesture-controlled interfaces help those with severe mobility impairments.

But if not designed to be accessible, digital technologies can widen the disparities between persons with and without disabilities. Free and low-cost mobile apps offer increased functionality for persons across the disability spectrum. Assistive software is available for feature phones. Accessibility enhancements for web browsers promote greater internet use by persons with disabilities. Governments should focus on building the capacity of public bureaucracies, teachers, vocational trainers, employers, and information and communication technology (ICT) professionals to design accessible content and support ICTs for persons with disabilities; developing the legal, policy, and regulatory foundation for accessible ICT; supporting, through public-private partnerships, the development of accessible ICT, such as local language text-to-speech and voice-recognition software; and mainstreaming accessibility in all public services offered through ICT, such as disaster warnings and communications, public services, and financial services.

Source: Raja 2015, for the WDR 2016.

providing supporting services. There is high demand for supporting services in online work, especially from women. In Souktel, 40 percent of women and 30 percent of men report a need for career coaching.[64] A third challenge is receiving up-to-date vacancy information, since many postings are stale. Employers also report a fairly high rate of no-shows for interviews. A two-side rating system—quality control on vacancies' expiration dates, and short message service (SMS) reminders to candidates selected for interviews—can address some of these shortcomings.

Making work more flexible

Digital technologies can bring women and new entrants into the labor market, especially in white-collar occupations, by allowing people to work on different schedules or from different locations. In Georgia, Romania, and Ukraine, more than 10 percent of employment is part-time, up from less than 5 percent a decade earlier.[65] Video conferences and e-mail make it easier to work away from an office. In the European Union, telework doubled to reach 9 percent in the first half of the 2000s, and around 23 percent of enterprises in the EU-15 employed teleworkers in 2006, up from 16 percent in 2003 and 18 percent in 2004. In the United States, in 2009, one-quarter of workers used telework regularly.[66]

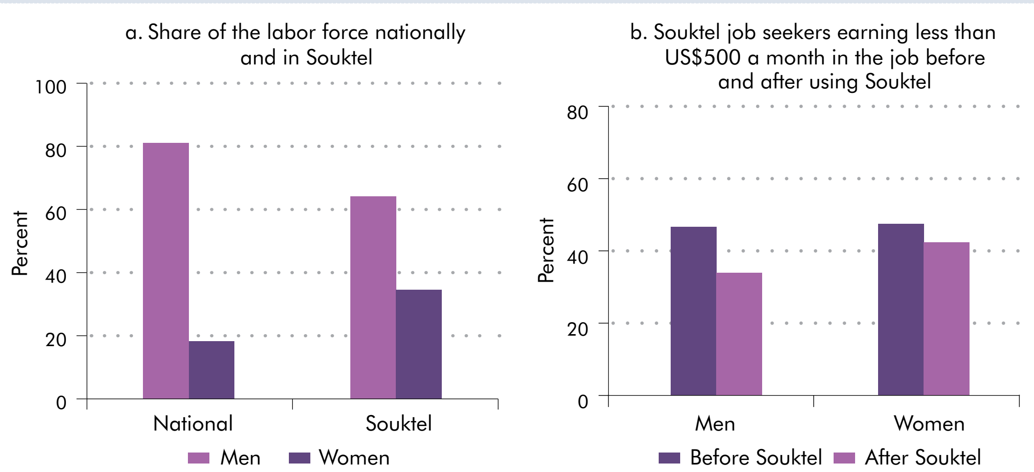
The rise in telework has been particularly rapid among female workers in Europe.[67] Budget airlines, such as JetBlue, manage their customer support centers largely with home workers, mostly women.[68] Telework can also make it easier for youth to combine school and work and for older workers to work longer. These new work arrangements can address skill gaps and increase productivity. Facilitated by the internet, home-based work in a 16,000-employee travel agency in China improved worker productivity by 13 percent.[69] And where there is a shortage of doctors, telemedicine and examinations of digital X-rays can be very helpful. In Uruguay, through teleconferencing,

Box 2.5 Using digital technologies to match workers with jobs: Souktel in West Bank and Gaza

Souktel is an online job-matching service started in 2009 and operating primarily in West Bank and Gaza, but also active in the Arab Republic of Egypt, Jordan, Morocco, Rwanda, and Somalia. There are more than 15,000 registered job seekers. The service registers job seekers through short message service (SMS) and online, provides information on vacancies, advises on resume preparation, and does active job matching by screening potential candidates for vacancies. Notifications on relevant job vacancies are sent through voice calls and SMS once or twice a week. Job seekers in the platform are young (80 percent are age 15–25) and well educated (all have completed secondary and half have completed tertiary education). Among Souktel's core users, 4 of 10 do not have jobs. Women are 30 percent of all online job seekers in Souktel, a share that is 15 percentage points higher than at the national level (figure B2.5.1, panel a). There are 200 registered employers, 80 percent of which are medium in size.

The main benefit that job seekers see in Souktel's service is saving time and money. Most workers look for jobs that match their skills and experiences, but more than one-third look for jobs in new occupations or industries. Souktel connects users to better-paying jobs. The share of workers earning less than the overall average monthly earnings (around US$500 per month) drops both for men and women after finding a job through Souktel (figure B2.5.1, panel b). About 70 percent of users have been invited for a job interview at least once. Employers report that using online job platforms allows them to hire from a prescreened pool of high-quality candidates and reduces the time and cost for hiring. Firms report a reduction in recruiting costs of about 20 percent.

Figure B2.5.1 Online platforms improve female labor force participation and access to higher-paying jobs



Source: Imaizumi and Santos, forthcoming, for the WDR 2016. Data at http://bit.do/WDR2016-FigB2_5_1.

English is being taught to first graders by teachers from the Philippines, raising the children's English scores and the English proficiency of Uruguayan teachers.[70]

Improving access to markets and productive inputs

Digital technologies, especially the internet, make it easier for people to sell products in new markets. E-commerce platforms are one example. In Uganda, wider mobile phone coverage induced market participation of farmers in remote areas, especially among those producing perishable crops.[71] In India, e-Choupal has provided computers and internet access in rural areas. Farmers can place orders for inputs, and directly negotiate the sale of their produce with buyers. With 6,500 kiosks, it now reaches 4 million farmers in more than 40,000 villages.[72]

Digital technologies can increase access to more productive assets and better quality services, raising

Box 2.6 The impact of digital technologies on remittances

Online and mobile money transfer systems offer new cost-effective means of sending money. In Kenya, among the 53 percent of adults who reported having sent remittances in the past year, 90 percent did so using a mobile phone.[a] Today, the average cost of sending money is 8 percent of the remitted value. Mobile technology can lower this cost by removing the need for the physical presence of staff and customers, while ensuring timely and secure transactions.

Digital technologies make domestic and international remittances cheaper. In Kenya, in 2008 shortly after M-Pesa entered the market, the cost of sending US$100 domestically was US$12 by MoneyGram, US$20 by bank wire, US$6 by postal money order, and US$3 by bus, compared to US$2.50 by M-Pesa. In Cameroon, costs have declined by 20 percent since mobile money entered the market. Prices have also fallen for international remittances. In the United Kingdom-Bangladesh corridor, the cost of sending US$200 through Western Union fell from 12 percent in 2008 to 7 percent in 2014 after the entry of digital competition. Between the United States and Mexico, Xoom charges 4.4 percent for online money transfers, down from Western Union's 6.2 percent. But the costs are still high for the poor, since they make many small transactions, which tend to be more expensive—more than 5 percent for amounts less than US$5.

Across the board, traditional remittance service providers are building their own mobile and online capabilities, but international digital remittance services have yet to take off in a substantial way. As of early 2012, only 20 percent of 130 mobile banking operators worldwide offered such services. The value of international remittances through mobile phones accounted for less than 2 percent of global remittances in 2013.

Policy action is called for on several fronts. First is fostering innovative cross-border mobile money transfer technologies. That requires harmonizing banking and telecommunications regulations to enable banks to participate in mobile money transfers, mobile companies to offer mobile money services without exclusivity agreements, and telecommunications firms to offer micro-deposit and savings accounts. It also requires simplifying regulations aimed at stopping money laundering and the financing of terrorism for small-value transfers. And it requires ensuring that mobile distribution networks are open to multiple international remittance service providers.

Second is increasing competition by eliminating telecom monopolies and exclusivity contracts. The experience in the United States-Mexico corridor shows how eliminating an exclusivity agreement between Western Union and Elektra can reduce prices. The interoperability of money transfer operators in remittance markets, as in Indonesia, Pakistan, Sri Lanka, and Tanzania, can reduce prices further.

Source: Plaza, Yousefi, and Ratha 2015, for the WDR 2016.

a. Demirgüç-Kunt and others 2015.

an individual's long-term productive capacity. They can help build human capital throughout the life cycle, managing risks and increasing access to financial capital and remittances (sector focus 2; spotlight 2; box 2.6). Since the poor are often most constrained by these factors, they stand to benefit the most.

Mobile money accounts can drive financial inclusion. In Sub-Saharan Africa, 12 percent of adults have mobile money accounts, compared with just 2 percent worldwide, and 45 percent of them have only a mobile money account.[73] In Kenya, access to mobile money has helped in managing risk. Statistically comparable households that were not connected to M-Pesa, the mobile money service, experienced on average a 6–10 percent reduction in consumption in response to similar shocks.[74] And biometric tools that reduce the costs of identifying borrowers can improve access to financial and other services at the bottom of the pyramid.[75]

Through social and professional networking sites and better connections with friends and family, the internet also enlarges, deepens, and leverages social capital to find jobs and access resources (spotlight 3).[76] In the United States, internet users have a larger extended network activated when looking for a job.[77] Digital technologies can also increase agency and modify aspirations, affecting social norms that can be barriers to participation, employment, and productivity, especially for women,[78] much the same as with soap operas in Brazil and cable television in India.[79] In Africa, the internet appears to broaden social interactions with groups with different political views or religious beliefs.[80] The internet and mobile phones also increase ties between migrants and those remaining in the home country.[81]

Improving access to information

For the poor—who rely on mobile phones and often did not have access to a fixed line—the biggest gains from digital technologies are likely to come from lower information and search costs. When making agriculture and labor market decisions, individuals often rely on informal sources, such as family and neighbors, or are left with no information: six in ten farmers in Boyaca, Colombia, do not know the prices in the capital city.[82] Information technologies can inform workers about prices, inputs, or new technologies more quickly and cheaply, reducing friction and uncertainty, eliminating costly journeys, and reducing the risks of accidents and crime.[83] In rural Niger, mobile phones reduced search costs by 50 percent.[84] In turn, these benefits can reduce poverty. In rural Peru, mobile phones increased household real consumption by 11 percent between 2004 and 2009 and reduced poverty by 8 percentage points.[85] Mobile phones have also been found to reduce poverty in East Africa.[86]

Using technology for getting information on prices, weather, soil quality, and new technologies, and for coordinating with traders is becoming more common in agriculture (sector focus 1). Among fishermen in the Indian state of Kerala, price information on mobile phones increased their profits 8 percent.[87] In Honduras, farmers who got market price information via SMS reported an increase of 12.5 percent in prices received.[88] In Argentina, the TRAZ.AR program to track animals increased profits per kilo of meat by 8 percent.[89] In Pakistan, thanks to mobile phones, farmers shifted to more perishable but higher return cash crops, reducing postharvest losses from the most perishable crops by 21–35 percent.[90]

Digital technologies make the largest difference when learning about information in distant markets or among disadvantaged farmers who face more information constraints.[91] An adult education program on using simple mobile phones in Niger increased internal labor migration and communication with migrants on labor market conditions in faraway regions.[92] Gains and uses are more common when the information transmitted is simple (as with prices or weather) rather than nuanced or difficult to convey (as in agricultural extension).[93] Similarly, when information provided through technology is not relevant to local needs or when there are other constraints to economic activity—such as physical infrastructure or market structure—there are fewer or no gains, as in cases in Ethiopia and Nigeria.[94]

Benefiting consumers

My life became easy after I started using the internet. We can learn about any subject. It also helped me earn some income online by using freelancer sites. It helps me to find health and beauty tips, to know current events and news. Through internet, I am able to stay connected with my friends and relatives.

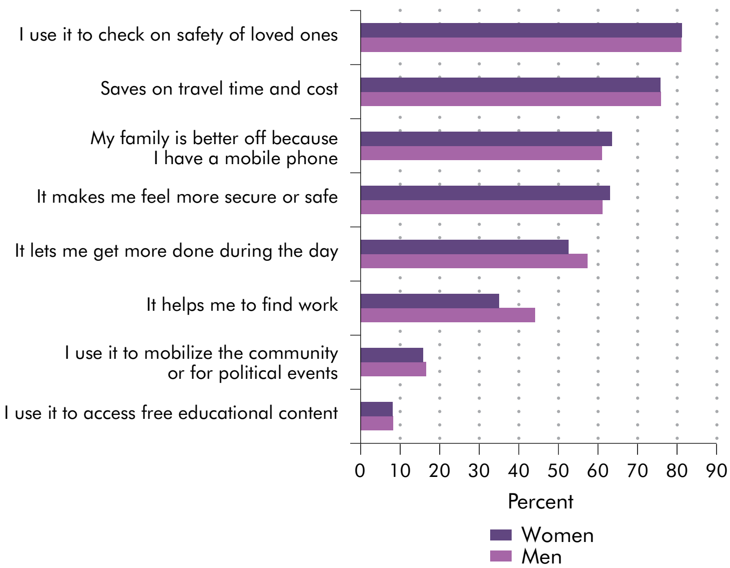
—Young woman, microworker in Amazon Mechanical Turk, September 2014[95]

Beyond earning opportunities, the internet offers many benefits to individuals as consumers, such as consumer convenience, expanded choice, better quality leisure time, and access to more knowledge. These benefits are consumer surplus, often not captured in GDP statistics (chapter 1).

Digital technologies have thus enhanced welfare. Across 12 countries in Africa, 62 percent of people believe that their family is better off because of mobile phones, whereas only 21 percent disagree (17 percent are not sure). And 76 percent of people say mobile phones help save on travel time and costs. A majority (62 percent) also believe that mobile phones make them more secure (figure 2.11). The annual consumer surplus from Google search has been estimated at

Figure 2.11 Mobile phones improve sense of security and save time

Africa: Respondents that agree with each statement on benefits and use of mobile phones, 2011–12



Source: WDR 2016 team, based on Research ICT Africa surveys (various years). Data at http://bit.do/WDR2016-Fig2_11.

US$500 per user, or US$150 billion for the 300 million users.[96] In Estonia, digital signatures saved 20 minutes per signature.[97] In Europe and the United States, consumers are willing to pay an average of US$50 a month for services that they now get for free on the internet.[98] Large consumer surpluses have also been estimated for Brazil, China, and Mexico.[99]

The rapid adoption of digital technologies, despite the costs, speaks for itself. In developing countries, 5 percent of consumption goes into ICT, ranging from 2.8 percent in the poorest households to 6.6 percent in the richest. In Africa, in addition to covering the cost of the hardware, the median phone owner spends more than 6 percent of his or her monthly income on mobile phones for calls and SMSs. The share is over 13 percent when accounting for people who own a mobile phone but do not work (mostly youth and spouses).[100]

Benefits to consumers, while significant, also come with risks. There are concerns about loss of privacy (chapter 4); information overload, as more and more information—some relevant and some not—is at our fingertips; and "overconnectivity," since people are constantly online and reachable. The line between leisure and work is blurring. Digital technologies make leisure time more enjoyable and less costly, but also make workers more productive and allow them to work away from the office. More than one-third of internet users in the United States report working longer hours because of technology, despite also feeling more productive.[101]

Labor market polarization can lead to greater inequality

For workers, digital technologies generate new opportunities for employment and earnings, but also risks. One major risk is related to the speed of labor market changes and the destruction of jobs. Nonstandard forms of work and shorter job tenures are likely to become more common, especially among youth. Internet access has been associated with more job-to-job flows, within the same firm and across employers.[102] Large-scale automation can also accelerate job destruction, especially in developed countries. In addition to factory automation, there is automation of logistics and processing, digitization (data entry, publishing/printing), and self-service (document creation and management versus clerical support, or retail self-checkout).[103]

These changes are good for aggregate productivity, as discussed in chapter 1, but can create challenges for individuals in the transition to new jobs. This is especially the case when the skill needs of new jobs are different from those of the old jobs. Beyond skill-upgrading, the challenge is to ensure that labor regulations facilitate and do not impede these transitions, and that social protection systems support workers when they are between jobs or not working regularly.

A second risk relates to the changing nature of work and the quality of internet-enabled jobs, such as microwork or jobs in the on-demand economy. These new forms of work provide workers and firms with flexibility and improve efficiency in the use of resources, but also come with a possible erosion of workers' bargaining power and a lack of benefits, such as unemployment and health insurance or severance pay. In most cases, workers are considered independent contractors rather than employees. In a world where a job in a firm has been a pathway out of poverty because firms help share risks and provide capital, training, and technology,[104] higher nonwage employment and this "new informality" may not be desirable.

In developing countries, most work does not have these benefits, but especially in advanced countries, a balance is needed between efficiency and protection to avoid a "race to the bottom" in terms of workers' protections. Already, some microwork platforms and companies in the sharing economy provide insurance to workers and collect taxes, but these new developments in the labor market raise questions about traditional approaches for protecting workers. As discussed in chapter 5, this will probably require reforms not only in the new industries but also in the traditional ones to ensure that all workers—irrespective of their type of work contract—have basic protections.

Perhaps the biggest risk from technological change, however, is that of widening income inequality. Although technologies are becoming widespread, the economic payoffs are not. The poor almost exclusively use only mobile phones not connected to the internet. And even if they had access to the internet, they lack the skills to use it productively, with many still unable to read in the first place. Positive impacts from using digital technologies—as with other technologies in the past century—are most likely to be captured by those already better off. In the United States, the adoption of advanced internet applications by firms led to substantial wage growth in the 6 percent of counties that were the wealthiest, the most educated, and had an IT-intensive industry, with no effect elsewhere. Technology explains more than half the difference in wage growth between already well-off counties and others.[105]

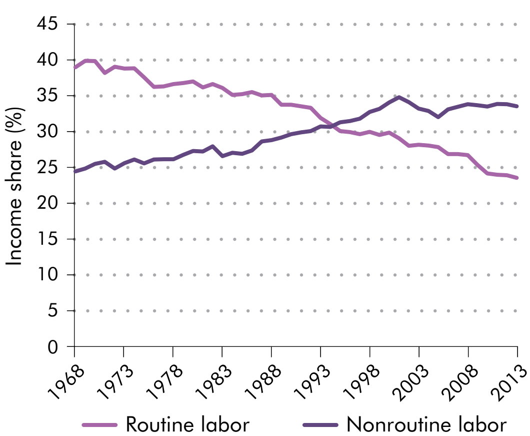
The risk of rising inequality is evident in the declining shares of (routine) labor in national income, and the "polarization" of the labor market—that is, the declining employment in middle-skilled occupations relative to those in low- and high-skilled ones, and the heightened competition for low-skilled jobs. The concern is that the ladder to the middle class is pulled away as middle-skilled jobs disappear or are fundamentally transformed by digital technologies.

Declining shares of labor in national income

Various factors, including technology, are shifting the distribution of income within countries away from routine labor and toward nonroutine labor and capital.[106] In the past few decades, and especially after 2000, the share of national income going to workers has fallen steadily in developed and many developing countries, driven by a falling share of income going to workers performing mostly routine tasks that follow exact, well-defined procedures that can be easily automated (figures 2.12 and 2.13). In the United States, at the technological frontier, the share of income going to routine labor has fallen from 38 to 23 percent since the late 1960s, with a simultaneous rise in the nonroutine labor share from 24 to 34 percent. In Honduras and Romania, in the 2000s, the income share of nonroutine labor increased from 28 to 32 and from 21 to 25 percent, respectively, with declines in the share of routine labor.[107] Where the labor share has fallen most, inequality has risen most (figure 2.14). A growing literature also links recent technological change to widening inequality.[108]

Figure 2.12 United States: Labor share in national income is falling, driven by routine labor

Share of routine and nonroutine labor in total income

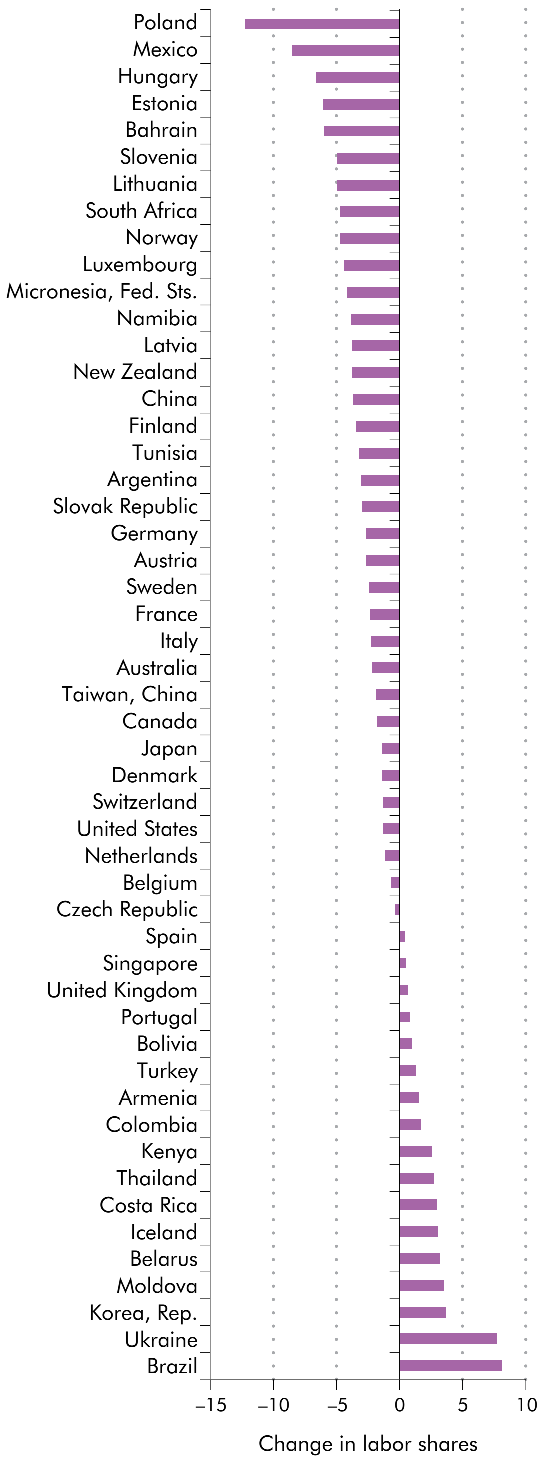


Source: Eden and Gaggl 2014, for the WDR 2016. Data at http://bit.do/WDR2016-Fig2_12.

Figure 2.13 Labor shares in national income are falling in many countries, including some developing countries

Trends in labor shares in output since 1975

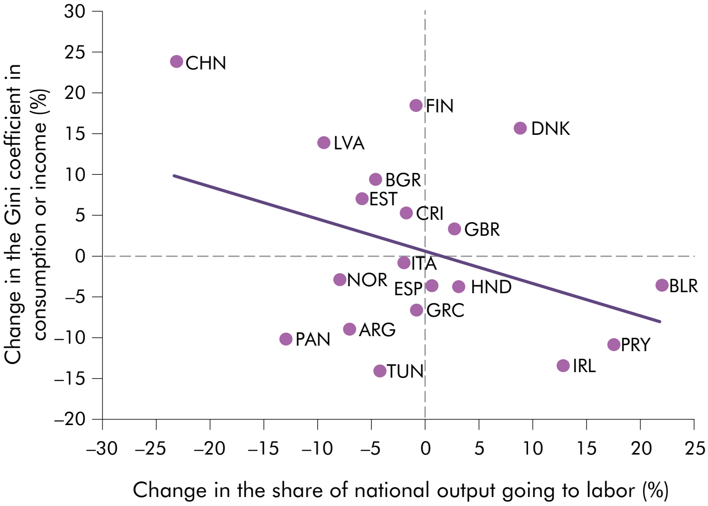
percentage points every 10 years



Source: Karabarbounis and Neiman 2013. Data at http://bit.do/WDR2016-Fig2_13.

Figure 2.14 Falling labor shares in national income are associated with rising inequality

Growth in Gini coefficient vs. growth in labor share in national income, 1995–2010



Source: Eden and Gaggl 2015, for the WDR 2016. Data at http://bit.do/WDR2016-Fig2_14.

Employment polarization

Declining labor shares coincide with the polarization of labor markets, most notably in high-income countries.[109] Employment is growing in high-skilled, high-paying occupations (managers, professionals, technicians) and low-skilled, low-paying occupations (elementary, service, and sales workers). Middle-skilled, middle-paying occupations (clerks, plant and machine operators) are being squeezed (figure 2.15). In high-income countries, on average, the share of routine labor in employment has fallen by about 0.59 percentage points a year since 1995, or almost 12 percentage points for the period. In the United States, local labor markets susceptible to automation due to specialization in routine task-intensive occupations have no net decline in employment, but they experience polarization in manufacturing and services.[110]

There are signs that employment is also polarizing in a number of low- and middle-income countries. The average decline in the share of routine employment has been 0.39 percentage points a year, or 7.8 percentage points for the period. China is an exception, since the mechanization of agriculture increased the share of routine employment.[111] Labor markets in low-income countries such as Ethiopia, with a large share of employment in manual occupations, are also not polarizing; neither is employment in Mongolia or Latin American countries where other factors—such as a commodity-driven boom benefiting low-skilled workers—could play a larger role in shaping labor markets.[112]

Yet declining labor shares in income and job polarization are only symptoms. At their heart is the fact that digital technologies complement and augment some skills (and thus some workers) while replacing others. Since not everybody has the skills that go well with digital technologies, many can end up falling behind. Education and skills thus determine whether the promise of digital dividends is achieved, or whether technological advances translate into more inequality in a race between skills and technology.[113] Understanding this dynamic is critical: inequality will increase if more workers do not acquire the modern skills most in demand. But if education and training systems increase the supply of workers who meet the changes in skill demands, more workers would benefit from technological change and inequality could decrease.

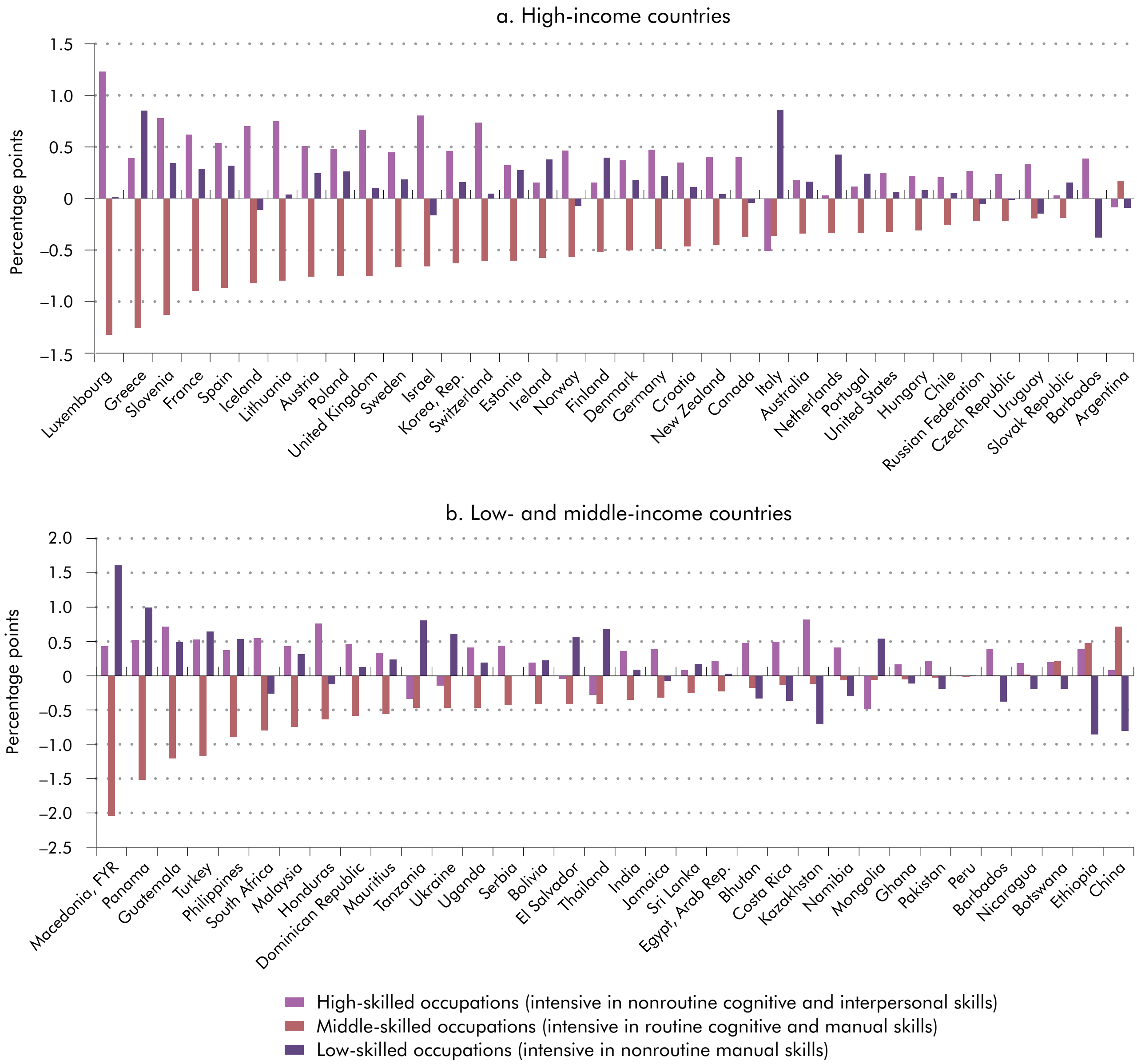
The race between skills and technology

With rising computing power, combined with the connectivity and informational value of the internet, digital technologies are taking on more tasks. They are particularly good at performing tasks that follow explicit, codifiable procedures—that is, routine tasks. Some of these tasks are cognitive, such as processing payrolls, keeping books, or doing arithmetic. Others are manual or physical, requiring simple motions and muscle power, such as driving a train or assembling goods. These tasks can be easily automated. Nonroutine tasks, by contrast, are less amenable to automation. Doing research, maintaining personal relationships, and designing new products have proven hard to automate; so have manual tasks that involve significant dexterity, such as cleaning and providing security services or personal care. Technology is even moving into areas once thought to be the exclusive domain of humans, such as driving or writing news articles.

So, the impact of digital technologies on jobs depends on the type of tasks and how technology either complements or substitutes workers in those tasks. A job comprises many tasks, each characterized by the skills most used to perform it (cognitive, socioemotional, or manual) and by how amenable it is to automation or codification (table 2.3). In some cases, technology augments labor by complementing workers. Both the researcher and the hairdresser do tasks that are nonroutine and not easily programmed into a computer, but technology makes the researcher (who uses more advanced skills at work) much more productive, while barely affecting the hairdresser. This means that technology is *skill-biased*.

Figure 2.15 **The labor market is becoming polarized in both developed and developing countries**

Annual average change in employment share, circa 1995–circa 2012



Sources: WDR 2016 team, based on ILO Laborsta (various years); I2D2 (World Bank, various years); National Bureau of Statistics of China (various years). Data at http://bit.do/WDR2016-Fig2_15.

Note: The figures display changes in employment shares between circa 1995 and circa 2012 for countries with at least seven years of data. The classification follows Autor 2014. High-skilled occupations include legislators, senior officials and managers, professionals, and technicians and associate professionals. Middle-skilled occupations comprise clerks, craft and related trades workers, plant and machine operators and assemblers. Low-skilled occupations refer to service and sales workers and elementary occupations. For the United States, comparable data could be accessed only for a short period (2003–08); consistent with Autor (2014), the observed polarization is limited in this period, with most of it having taken place in earlier years.

In other cases, workers are in jobs that are routine, whether mostly manual or mostly cognitive, and are susceptible to automation and to seeing their jobs profoundly transformed or vanishing. In these cases, technology is *labor-saving*. The fundamental questions then become: To what extent are different occupations and countries' labor markets affected by skill-biased and labor-saving digital technologies?

Table 2.3 Interactions between technology and skills at work

Ease of automation (technology is labor-saving)	Ease of complementarity (technology is labor-augmenting): High (tasks intensive in cognitive analytical and socioemotional skills)	Ease of complementarity (technology is labor-augmenting): Low (tasks intensive in manual skills)
High (routine tasks)	1 Bookkeepers Proofreaders Clerks	2 Machine operators Cashiers Typists
Low (nonroutine tasks)	4 Researchers Teachers Managers	3 Cleaners Hairdressers Street vendors

Source: WDR2016 team, adapted from Acemoglu and Autor 2011.

Note: Workers in occupations in quadrant 4 can benefit greatly because the majority of their tasks are difficult to automate, and the core of their work is in tasks in which digital technologies make them more productive. Occupations in quadrants 1 and 2 are composed of many tasks that can be easily automated. Productivity in occupations in quadrant 3 is by and large not directly affected by digital technologies.

And what are the typical characteristics of workers in occupations that, in the absence of effective policies, stand to gain or lose from technological change?

Skill-biased technological change and the new digital divide

As Brynjolfsson and McAfee write in *The Second Machine Age*, "There's never been a better time to be a worker with special skills or the right education, because these people can use technology to create and capture value. But there's never been a worse time to be a worker with only 'ordinary' skills and abilities to offer, because computers, robots, and other digital technologies are acquiring these skills and abilities at an extraordinary rate."[114] So, recent skill-biased technological change favors workers with advanced skills (table 2.4). Not only is overall employment moving toward occupations intensive in these more advanced skills, but even within a given job, skill demands are similarly shifting.

Because of this, two sets of skills are increasingly important in today's labor markets: ICT skills and

Table 2.4 Recent evidence on skill-biased technological change

Authors	Country	Findings
Akerman, Gaarder, and Mogstad (2015)	Norway	Broadband adoption in firms complements skilled workers performing nonroutine tasks and substitutes for workers performing routine tasks.
Autor, Katz, and Kearney (2008)	United States	Patterns of wage inequality are best explained by a modified version of the skill-biased technical change hypothesis, which emphasizes information technology in complementing abstract (high-education) tasks and substituting for routine (middle-education) tasks.
Autor, Katz, and Krueger (1998)	United States	Digital technologies widen wage differentials. Skill upgrading within industries accounts for most of the growth in the relative demand for college workers, especially in more computer-intensive industries.
Berman, Somanathan, and Tan (2005)	India	Trade openness and reform promote technology adoption and diffusion and increase the nonproduction worker shares of employment and total wages in manufacturing, even within industries.
Gaggl and Wright (2014)	United Kingdom	A tax allowance on ICT investments among small firms leads, in the short run, to an increase in demand for nonroutine cognitive-intensive work, some substitution of routine cognitive work, and no effect on manual work.
Marouani and Nilsson (2014)	Malaysia	Without skill-biased technological change, skilled wage earners should expect lower wages and higher unemployment, and unskilled labor should expect higher wages and lower unemployment.
Srour, Taymaz, and Vivarelli (2013)	Turkey	Domestic and imported technologies increase the demand for skilled labor five to six times more than the corresponding demand for unskilled labor.

Source: WDR 2016 team.

Note: ICT = information and communication technology.

Box 2.7 Skills wanted: Key concepts

Beyond foundational cognitive skills, such as basic literacy and math, a well-educated worker in a modern economy needs to develop the following skills:

Nonroutine, higher-order cognitive skills. These refer to the ability to understand complex ideas, deal with complex information processing, adapt effectively to the work environment, learn from experience, engage in various forms of reasoning, to overcome obstacles by critical thought.[a] More specifically, these include skills such as unstructured problem solving, and critical thinking, learning, and reasoning.

Technical skills, including information and communication technology (ICT) skills. Technical skills are those abilities needed to carry out one's job, such as the ability to repair a water leakage for a plumber, the knowledge to operate a machine for a worker at a factory, or the knowledge to work with a software for a person at a bank.[b] They also include ICT skills. ICT skills refer to the effective application of ICT systems and devices, and range from ICT specialists who have the ability to develop, operate, and maintain ICT systems, to basic ICT users, who are competent users of the mainstream tools needed in their working life (e-mail, Excel, Outlook, PowerPoint, Word).[c]

Nonroutine interpersonal, socioemotional skills. Socioemotional skills (also called soft or noncognitive skills) encompass a broad range of malleable skills, behaviors, attitudes, and personality traits that enable individuals to navigate interpersonal and social situations effectively.[d] These include grit or the perseverance to finish a job or achieve a long-term goal, working in teams, punctuality, organization, commitment, creativity, and honesty.

a. Neisser and others 1996.
b. Cunningham and Villasenor 2014.
c. European Commission (EC 2004); OECD 2004.
d. Cunningham and Villasenor 2014.

higher-order cognitive and socioemotional skills (box 2.7). Since 2000, the ICT intensity of employment has increased by almost 10 percent in low- and middle-income countries, almost twice as fast, on average, as in high-income economies (figure 2.16). The share of employment in occupations intensive in nonroutine cognitive and socioemotional skills has also increased in low- and middle-income countries, from 19 to 23 percent. However, the decline in occupations intensive in routine skills was even larger, from 50 to 44 percent (figure 2.17).[115] This is the driving force behind the polarization of labor markets. The new economy offers, therefore, a premium for ICT skills, strong foundational cognitive and socioemotional skills, and for more advanced nonroutine 21st-century skills such as critical thinking, complex problem-solving, creativity, and expert communication. In fact, workers using these "new economy" skills and technology are better remunerated—by 25–40 percent—than their peers with the same level of education but performing traditional tasks and jobs.[116]

Poor digital literacy limits the productive use of digital technologies

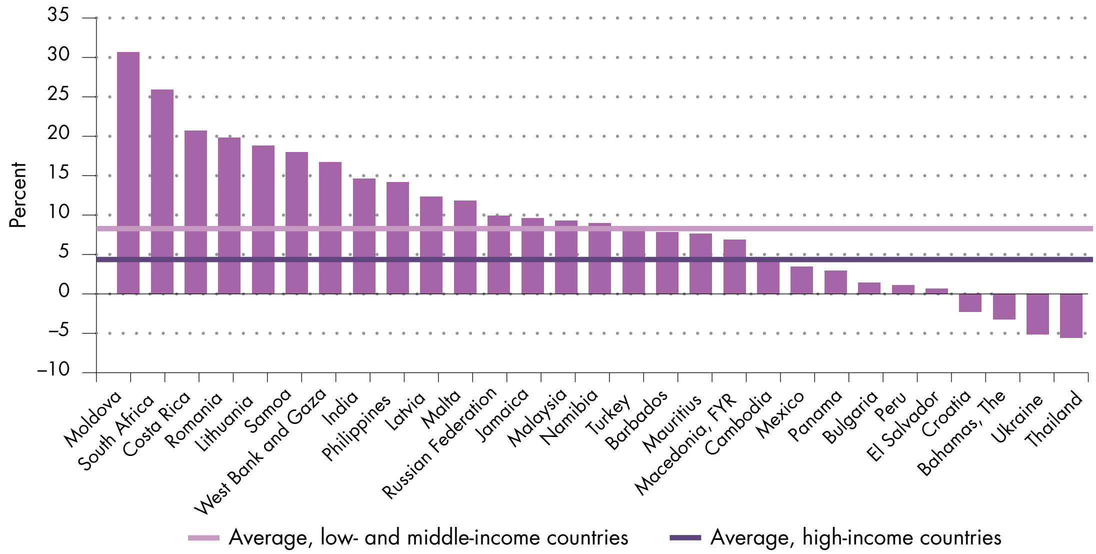
It is hard to use the internet when, even among youth, more than half have a level of functional literacy below what will enable them to participate productively in life, as in Albania, Indonesia, Jordan, Malaysia, or Peru.[117] About three-quarters of third-graders in Mali and Uganda cannot read.[118] Beyond basic literacy, ICT skills are deficient. In Africa, 7 in 10 people who do not use the internet say they just don't know how to use it, and almost 4 in 10 say they do not know what the internet is.[119] In high-income Poland and the Slovak Republic, one-fifth of adults cannot use a computer.[120]

The use of ICT skills at work is unequal, but their importance is growing. On average, one-third of urban workers (and 20 percent of the bottom 40 in urban areas) in developing countries use a computer at work, for example (figure 2.18). This number is likely to raise quickly, with ICT use increasing as countries become richer and as work becomes more complex (figures 2.16 and 2.19).

Employers are looking for ICT skills, but cannot find them. In the former Yugoslav Republic of Macedonia, 43 percent of firms say ICT skills are very important for workers, but more than 20 percent say that workers lack them.[121] Although the same workers lacking ICT skills often also lack other skills or face other barriers to employment, digital literacy limits their employment opportunities (figure 2.20). The use of digital technologies at work is associated with

Figure 2.16 **Employment is becoming more intensive in the use of digital technologies**

Change in the ICT intensity of employment, 2000–12

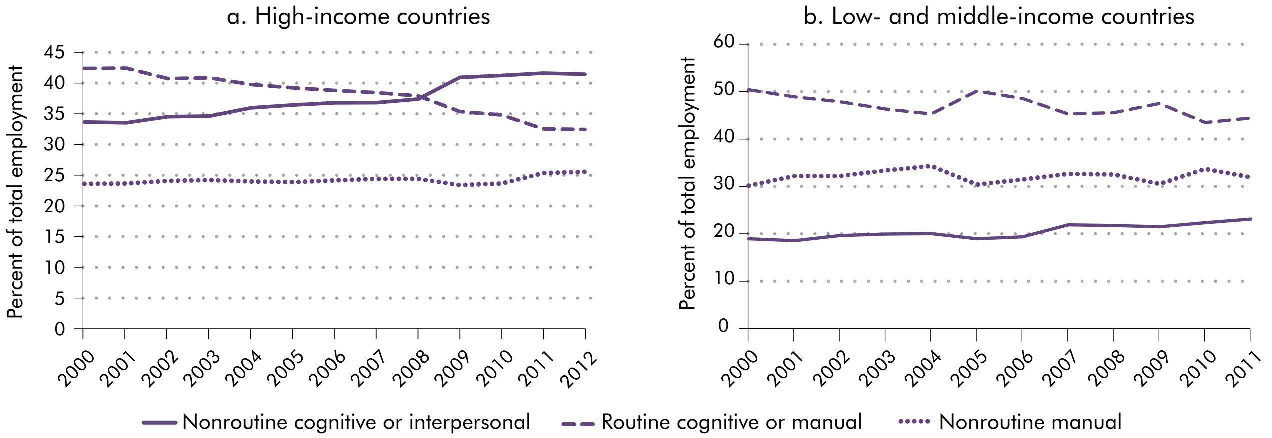


Source: WDR 2016 team, based on Monroy-Taborda, Moreno, and Santos, forthcoming, for the WDR 2016, using ILO Laborsta (various years). Data at http://bit.do/WDR2016-Fig2_16.

Note: ICT (information and communication technology) intensity of employment is based on an index between 0 (no use of technology at work) and 19 (most use of technology at work), averaged by occupation (at the three-digit level) and weighted by employment.

Figure 2.17 **Nonroutine skills are becoming more important over time**

Employment composition by type of occupation according to skills requirements, 2000–12



Source: WDR 2016 team, based on ILO Laborsta (various years). Data at http://bit.do/WDR2016-Fig2_17.

Note: Data are simple cross-country averages. Classification of occupations according to skills requirements follows Autor 2014 and reflects the types of skills most intensely used in each occupation.

higher earnings, even after accounting for educational attainment. Across a sample of eight developing countries, the return associated with using ICT at work is around 40 percent.[122] In Brazil, and focusing on workers most similar to one another, returns to internet use are about 10 percent.[123]

High-order cognitive and socioemotional skills are more important in the new economy

Technological progress is redefining the nature and content of jobs. Some of today's jobs are new and require new skills—software publishers, data scientists, enterprise mobile developers. Others have long existed but have been transformed. Consider, for example, the job description of an accountant in the 1970s and today. Specialized softwares have automated many of the accountant's original tasks, shifting her job toward more advisory services and critical thinking. Employers now demand more "new economy" skills: that is, high-order cognitive and socioemotional skills, as evidenced in countries as diverse as Brazil, Malaysia, and FYR Macedonia (figure 2.21).

At the aggregate level and within firms, new technologies substitute for workers performing routine tasks, while making skilled workers who execute nonroutine abstract tasks more productive.[124] Across 28 studies, more than half of the top five skills demanded by employers are socioemotional, another 30 percent are higher-order cognitive, and 16 percent are technical.[125] High-order cognitive skills include reasoning, problem solving, and critical thinking, while socioemotional skills refer to behavior, personality traits, and attitudes, such as grit, teamwork, self-discipline, dependability, and leadership. These are things that are still hard for technology to replicate.

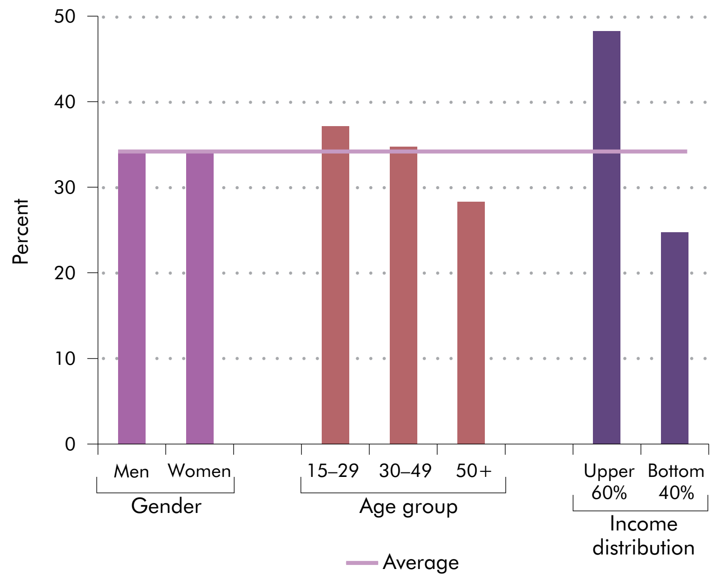
These new economy skills pay off. Workers with strong cognitive and socioemotional skills in Armenia, Georgia, the Kyrgyz Republic, Tajikistan, and Vietnam are more likely to be employed and have better-quality jobs.[126] In Vietnam, within a given industry, performing nonroutine analytical tasks carries a 23-percent earnings premium, and interactive (that is, interpersonal) tasks a 13-percent premium, whether combined with routine or nonroutine tasks (figure 2.22). In Armenia and Georgia, the premium for problem solving and learning new things is close to 20 percent.[127] More generally, in 12 of 16 mostly developing countries, wages in nonroutine occupations increased significantly more than wages in routine occupations between 2005 and 2011.[128]

In addition to technological change, other factors help explain these global labor market trends. Trade, urbanization, structural transformation, and globalization fundamentally shape labor markets and in a number of cases are likely to be even more important than technology. In some Latin American countries, for example, commodity-driven economic booms have boosted low-wage earnings and show no polarization at the aggregate level. Moreover, distinguishing among factors is more difficult because they are related to one another.[129]

Yet technological change seems to be an important part of the explanation. First, occupations most intensive in the use of digital technologies are also most intensive in nonroutine cognitive and interpersonal skills (figure 2.23). Second, globalization and trade do not fully explain the observed polarization.[130] Given

Figure 2.18 In developing countries, one-third of urban workers use digital technology at work

Urban workers who use a computer at work, conditional on working

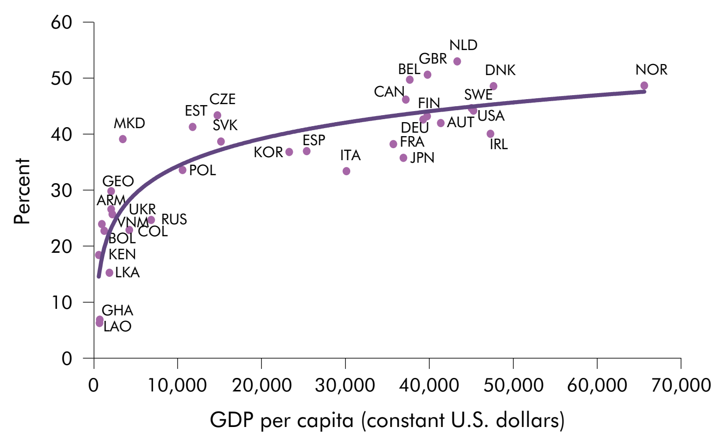


Source: WDR 2016 team, based on STEP household surveys (World Bank, various years). Data at http://bit.do/WDR2016-Fig2_18.

Note: "Average" refers to the average use of technology among all urban workers in 11 countries where the STEP survey was conducted. "Upper 60%" and "Bottom 40%" refer to asset distribution of individuals' households.

Figure 2.19 Employment becomes more intensive in ICT use as economies grow

Share of employment in high–ICT-intensity occupations, circa 2013



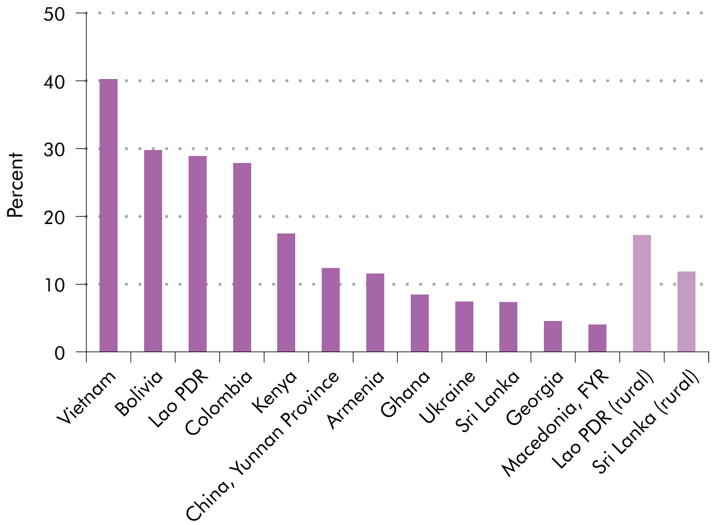
Source: Monroy-Taborda, Moreno, and Santos, forthcoming, for the WDR 2016, based on STEP (World Bank, various years), PIAAC household surveys, and World Development Indicators (World Bank, various years). Data at http://bit.do/WDR2016-Fig2_19.

Note: GDP = gross domestic product; ICT = information and communication technology; PIAAC = Programme for the International Assessment of Adult Competencies.

the weight of China in manufacturing supply chains, the decline in routine labor in the rest of the world could simply be the result of a shift of routine labor to China's manufacturing sector. Between 2000 and 2010, the share of employment in routine occupations

Figure 2.20 Lack of ICT skills is often a constraint to employment

Share of working-age individuals in urban areas who report that lack of ICT skills is a barrier to employment and higher earnings, circa 2013



Source: WDR 2016 team, based on STEP household surveys (World Bank, various years). Data at http://bit.do/WDR2016-Fig2_20.

Note: ICT = information and communication technology.

in China rose from 19 to 27 percent (see figure 2.15, panel b). Yet manufacturing employment in China is also polarizing, for the increase in routine labor is explained by the mechanization of agriculture. Moreover, across most countries with relevant data, employment is polarizing even within services, suggesting an additional effect in skill demand over and above what can be explained by trade or the structural transformation of developing economies.[131] This evidence is also consistent with the evidence for OECD countries linking changes in skills requirements to technological changes, even within occupations.[132]

Labor-saving technologies: Automation and job displacement

There is concern, especially in advanced countries, that technology is killing jobs and depressing wages.[133] Manufacturers are using machines that substitute for workers in warehouses or auto plants. More than 200,000 industrial robots come into use each year, and that number is rising.[134] Increasingly, automation is taking place in services.[135] In call centers, technology can answer routine customer service requests. In retail, technology and "big data" suggest what to buy. Software is handling accounting, translations, and paralegal services. Travel agents have all but disappeared, with three-quarters of all travel in the United States now booked online.[136] In the public sector too, digital technologies are substituting for workers performing routine tasks. In the Indonesian Treasury, electronic budget planning and execution is linked to job redefinitions and reassignments for around 5,000 workers (of 8,000) who previously processed payments, disbursements, and cash management.[137] In Pakistan, the automation of systems in the central bank made 3,000 of 12,000 employees redundant (mostly low-skilled staff). The savings boosted the salaries of remaining employees.[138]

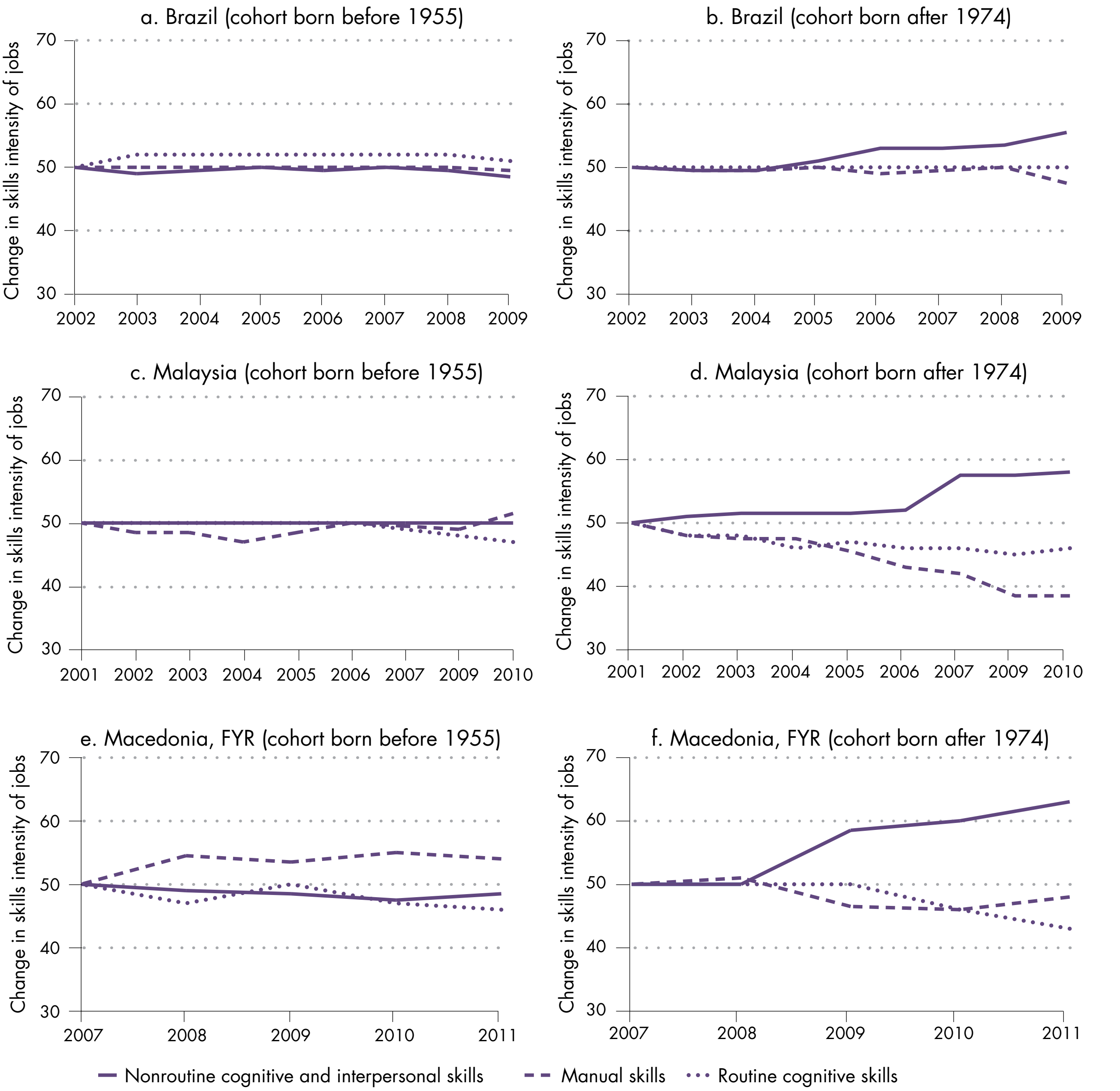
Two-thirds of all jobs could be susceptible to automation in developing countries in coming decades, from a pure technological standpoint (figure 2.24). Estimates for the United States and Europe range between 50 and 60 percent of jobs.[139] Given expected advances in artificial intelligence, falling ICT prices, and increased coverage of the internet, the potential for automation is clear. Rapid automation of a large number of jobs would be problematic: It may take time for new jobs to be created, and even if they are, retraining takes time and may be difficult.

Yet, even if technologically feasible, large-scale net job destruction due to automation should not be a concern for most developing countries in the short term. Even in the United States, on average, there were no net employment declines in local labor markets most susceptible to automation (that is, those specialized in routine, task-intensive occupations).[140] New jobs and new tasks in existing occupations are created. Machines and digital technology are not perfect or even good substitutes for many tasks (at least not yet), especially those requiring adaptability, common sense, and creativity.[141] The expansion of automated teller machines (ATMs) in banks went hand-in-hand with an expansion of bank transactions, branches, and employment. Cashiers continue to do some of the things that ATMs do, but they also do other things, such as client support, where human interaction remains important.[142]

Full automation of jobs takes time, even in the developed world. In the United Kingdom, an exogenous increase in ICT investment between 2000 and 2004 led to a short-term increase in the demand for nonroutine skills, but only to the limited substitution of routine workers during that period.[143] Why? Because it takes time to make the necessary organizational changes (chapter 1), and because labor reorganizations tend to happen in periods of recession rather than in booms.[144] Not all disruptive technologies are adopted quickly, implemented fully, or yield immediate benefits.[145] Barriers to technology adoption, lower wages, and a higher prevalence of jobs based on manual dexterity in developing countries mean that automation is likely to be slower and less widespread there (see figure 2.24). But as wages rise, and in countries with

Figure 2.21 **Nonroutine analytical and socioemotional skills are becoming more important, especially in jobs performed by younger cohorts**

Evolution of the skills intensity of jobs, measured as mean skills percentile of base year, Brazil, Malaysia, and Macedonia, FYR, various years, 2001–11



Sources: WDR 2016 team, based on Socio-Economic Database for Latin America and the Caribbean (SEDLAC) (CEDLAS and the World Bank); East Asia and Pacific Poverty (EAPPOV) Database (World Bank, various years); and Europe and Central Asia Poverty (ECAPOV) Database (World Bank, various years); and following Autor, Levy, and Murnane 2003; Acemoglu and Autor 2011; Aedo and others 2013; Arias and others 2014. Data at http://bit.do/WDR2016-Fig2_21.

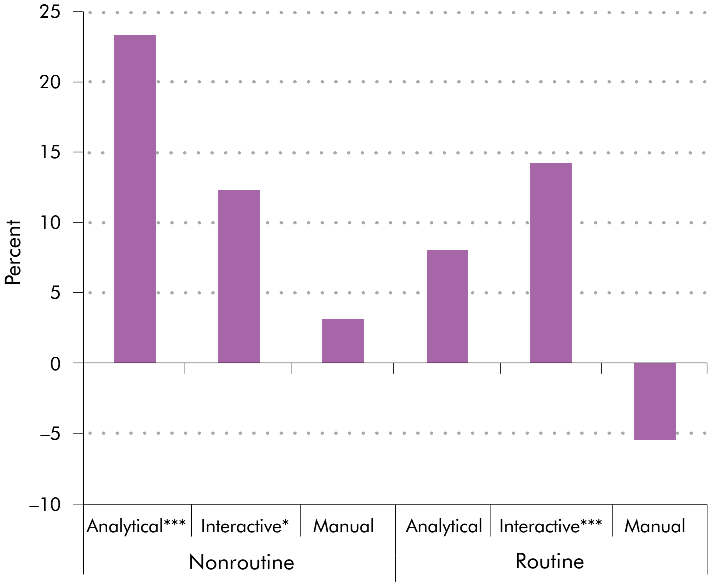
Note: The y-axis represents the percentile of the skill distribution for jobs held by each cohort in any given year, with respect to the corresponding median skills intensity of jobs held by that cohort in the initial year. An increase means that jobs increased in intensity in that particular skill. For Malaysia (panels c and d), data for 2008 were unavailable.

large manufacturing or offshored activities, there is more (and faster) scope for automation.

Concerns about automation are not new. Past fears of technology leading to mass unemployment (and boredom)—from the Luddites in the midst of the Industrial Revolution to Keynes during the Great Depression—have gone unrealized (box 2.8).[146] The assembly line, after all, replaced the artisans making carriages. Back in the 1960s, with the creation in the United States of the National Commission on

Figure 2.22 New economy skills, beyond levels of education, pay off

Urban Vietnam: Average return to different task combinations, controlling for education and demographics, 2012



Source: Bodewig and others 2014. Data at http://bit.do/WDR2016-Fig2_22.

Note: Returns are estimated using a wage regression that controls for education, sex, experience, and economic sector.

Significance level: * = 10 percent, *** = 1 percent.

Technology, Automation, and Economic Progress, there were also concerns about automation in this wave of technological change. Unemployment fears have gone unrealized because new technologies, by fostering entrepreneurship and improving productivity and the allocation of resources, have led in due time to more jobs elsewhere.

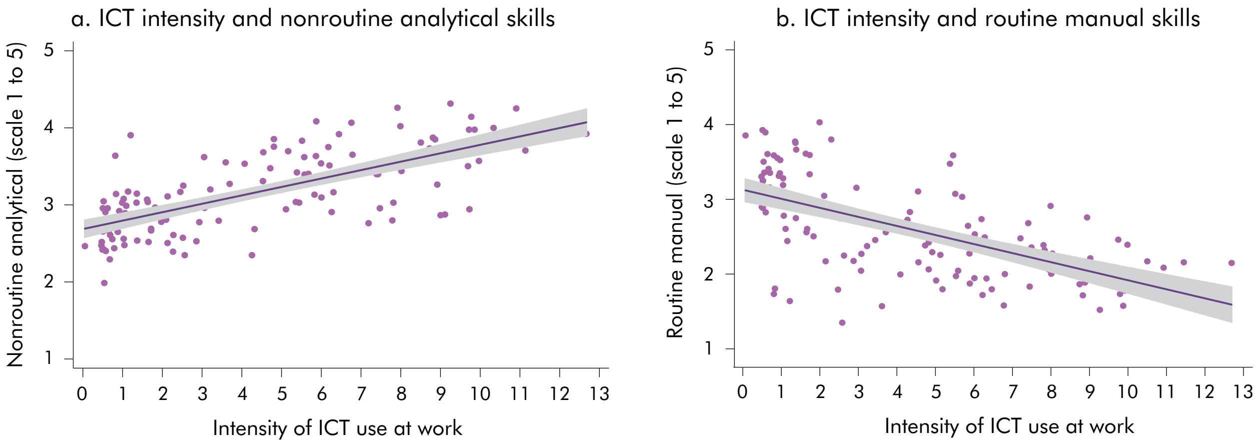
Will this time be different? Large factories and electrification did lead, as now, to a polarization of employment by hollowing out the middle of the skill distribution. The share of employment of blue-collar workers in manufacturing fell from 39 percent in 1850 to 23 percent in 1910, as new capital goods allowed factory owners to unbundle and simplify tasks that could now be performed by unskilled workers. Electrification increased the relative demand for workers intensive in clerical and managerial skills compared with manual and dexterity skills among white-collar workers. Among blue-collar workers, it increased the demand for manual workers relative to the demand for workers performing tasks intensive in dexterity needed to operate machines before electrification.[147]

Despite these similarities, the biggest difference from past waves of technological progress is that the polarization of the labor market today is affecting both blue-collar and white-collar workers.[148] It is probably easier for white-collar workers to transition to other white-collar jobs, but in the aggregate, there may be fewer well-paying jobs for a large and diverse pool of potentially dislocated workers. Even if all those jobs do not fully disappear—unlikely in a short period—they will be significantly transformed.

And here is where a second lesson from history is relevant. Individuals and governments adapted to technological change, but this process took time and required deep institutional changes in education,

Figure 2.23 Digital technologies go hand in hand with nonroutine new economy skills

ICT intensity and skills intensity, by occupation

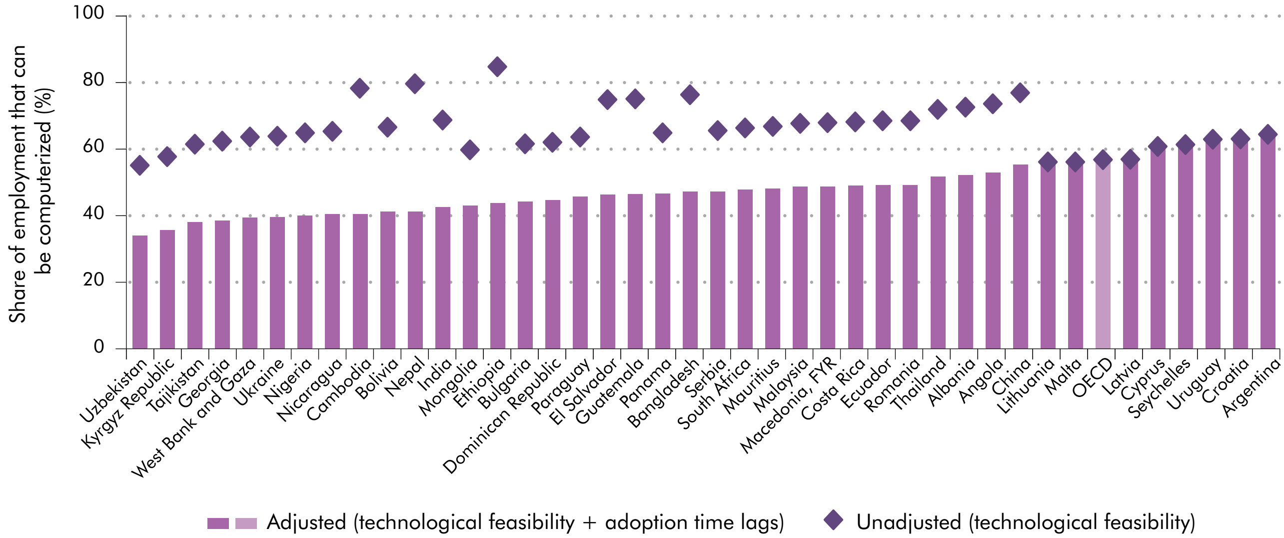


Source: Monroy-Taborda, Moreno, and Santos, forthcoming, for the WDR 2016, based on STEP household surveys (World Bank, various years). Data at http://bit.do/WDR2016-Fig2_23.

Note: Ninety-five percent confidence intervals. The y-axis is a standardized score (from 1 to 5) that reflects the intensity of the use of the particular type of skills as estimated by Autor, Levy, and Murnane (2003) and expanded by Acemoglu and Autor 2011. The intensity of ICT use is an index between 0 (no use of technology at work) and 19 (most use of technology at work). ICT intensity is averaged by occupation. ICT = information and communication technology.

Figure 2.24 From a technological standpoint, two-thirds of all jobs are susceptible to automation in the developing world, but the effects are moderated by lower wages and slower technology adoption

Estimated share of employment that is susceptible to automation, latest year



Sources: WDR 2016 team, based on STEP surveys (World Bank, various years); Central Asia World Bank Skills surveys (World Bank, various years); Survey-based Harmonized Indicators Program (SHIP) (World Bank, various years); Socio-Economic Database for Latin America and the Caribbean (SEDLAC) (CEDLAS and the World Bank); South Asia Region MicroDatabase (SARMD) (World Bank, various years); Europe and Central Asia Poverty (ECAPOV) Database (World Bank, various years); East Asia and Pacific Region Poverty (EAPPOV) Database (World Bank, various years); the I2D2 dataset (International Income Distribution Database; World Bank, various years); ILO Laborsta database (various years); the National Bureau of Statistics of China (various years); Frey and Osborne 2013; Comin and Hobjin 2010. Data at http://bit.do/WDR2016-Fig2_24.

Note: The *unadjusted* probabilities of automation for occupation are from Frey and Osborne (2013), weighted by employment. The *adjusted* probabilities account for the slower pace of technology adoption in poorer countries, using the adoption lag of earlier technologies (Comin and Mestieri 2013). See Monroy-Taborda, Moreno, and Santos, forthcoming, for the WDR 2016. OECD = Organisation for Economic Co-operation and Development.

Box 2.8 Concerns about technological unemployment are not new

We are being afflicted with a new disease of which some readers may not yet have heard the name, but of which they will hear a great deal in the years to come—namely, technological unemployment. This means unemployment due to our discovery of means of economising the use of labour outrunning the pace at which we can find new uses for labour.

—John Maynard Keynes
"Economic Possibilities for Our Grandchildren," 1931

The situation will have been made the more serious by the advances of automation. The world of A.D. 2014 will have few routine jobs that cannot be done better by some machine than by any human being. Mankind will therefore have become largely a race of machine tenders. Schools will have to be oriented in this direction . . . It is not only the techniques of teaching that will advance, however, but also the subject matter that will change. Even so, mankind will suffer badly from the disease of boredom . . . The lucky few who can be involved in creative work of any sort will be the true elite of mankind, for they alone will do more than serve a machine.

—Isaac Asimov
"Visit to the World's Fair of 2014," 1964

social protection, and labor regulations.[149] The answer to whether things may turn out differently this time, while unsatisfactory, is: "It depends." It depends on the ability and speed of creating new jobs elsewhere in the economy (chapter 1). It depends on how individuals, firms, and policy makers respond to the change in skills requirements. And it depends on how well the social protection system supports dislocated workers.

The future of jobs

Be an expensive complement (stats knowhow) to something that's getting cheaper (data).

—Hal Varian, Chief Economist, Google, 2014

Technological progress makes the jobs challenge more complex. Digital and mechanical technologies, and deindustrialization, mean that the manufacturing sector is likely to generate fewer jobs than in the past, especially for unskilled workers.[150] ICT manufacturing can be expected to create jobs, although mostly high-skilled and likely concentrated in specific countries, as now. Since manufacturing jobs have been an important source of better-paying jobs as workers move out of agriculture, this is an important development. The service sector is also increasingly being automated. Of particular concern are jobs that have so far actually grown thanks to digital technologies, such as low- and middle-skilled call center jobs. Employment in the ICT service industry, even more than its manufacturing counterpart, is expected to grow, but also among higher-skilled workers in leading countries.

Future employment growth is likely to come from jobs that cannot be fully or partially automated, largely outside the ICT industry. New jobs are also likely to emerge in the digital economy—in the analysis of data such as data scientists, in the development and maintenance of apps and other software, and in support services. New opportunities will also arise in ICT-enabled services, such as the on-demand economy. But the significance for employment generation, especially in most developing countries, is likely to be small.

The potential for employment creation lies in the rest of the economy, as digital technologies allow businesses to expand. Among the low-skilled, some services that must be delivered face-to-face or require awareness and situational adaptability (housekeepers, hairdressers) are likely to grow. Among the high-skilled, occupations will rely on modern skills involving creativity and social interactions. Some observers call this the polarization in "the high-tech, high-touch" economy.[151]

Although impossible to predict in advance, jobs are likely to arise in new industries and occupations. New industries arising from digital technologies since 2000 account for only 0.5 percent of employment in the United States,[152] and there is evidence of (young) skilled workers having to take on less-skilled jobs.[153] But historically, economies have been able to create enough jobs through technological change. The initial labor market polarization caused by factories in the 19th century in the United States led to an upskilling of employment as increases in middle-skilled sales and clerical employment compensated for the decline in blue-collar jobs. With electrification, displaced workers typically moved to lower-skilled jobs at lower wages, such as truck drivers, but large increases in new middle-skill employment outweighed the decline in blue-collar employment.[154] While the steam engine in the 18th century led to the disappearance of coachmen for horse-drawn carriages[155] and to the substitution of workers in mining, in due time it also was at the center of steam-powered boats, locomotives, and automobiles. Mechanics, road building and maintenance, and dealerships have created many jobs of diverse skill profiles ever since.

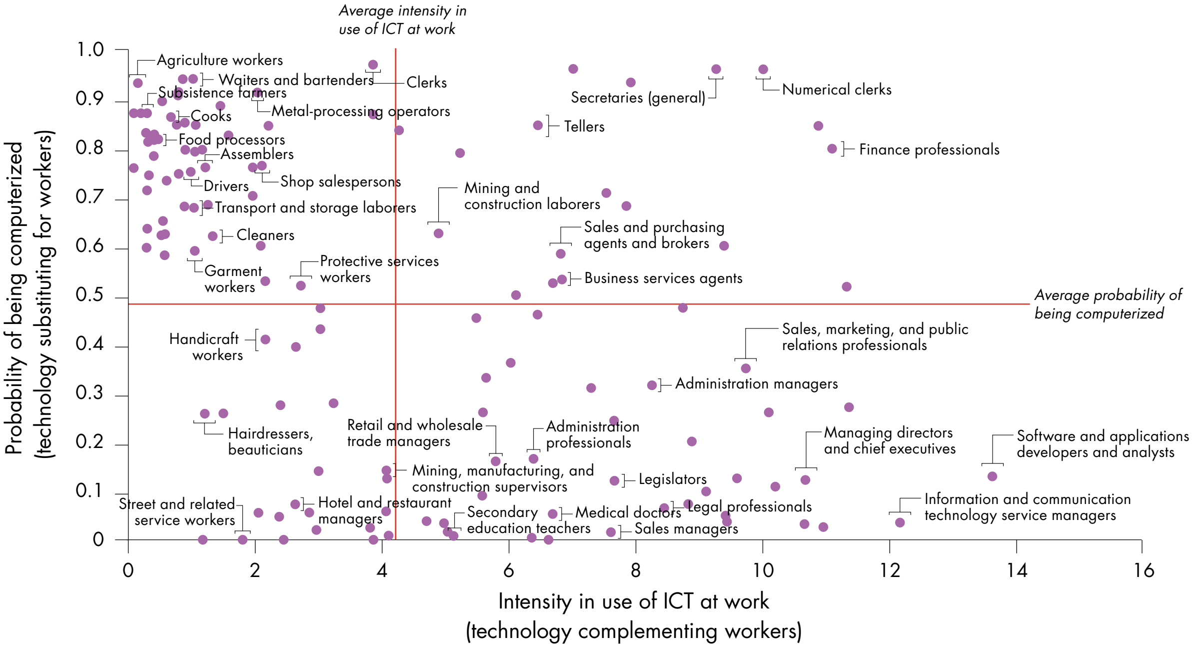
Yet as a result of this process of job creation and destruction, technological change disrupts labor markets and can hurt individuals whose skills are substituted by technology, because they often do not have the skills required in many of the new jobs. Even for those who stay within the same occupations, jobs will be transformed, requiring modern skills. The speed of these changes appears to be accelerating, intensifying creative destruction and the pace of labor market changes.

Since digital technologies have different applicability to different kinds of work, the extent of disruption across countries will reflect differences in economic and occupational structures. Numerical clerks or secretaries, often users of digital technologies, also perform many tasks that can be easily automated. Managers or software developers, by contrast, while intensively using digital technologies, also complement them well, so they are not easily substituted by machines. And for occupations that use little technology, some are hard to automate, such as hairdressers, while others could be automated, such as assemblers (figure 2.25).

More advanced economies can expect larger disruptions in the near future since they use more technology at work and are experiencing faster changes in skill requirements (figure 2.26).[156] And while they have smaller shares of employment in routine occupations susceptible to automation, their higher wages make it easier for automation to be economically viable. Low- and middle-income countries can also expect substantial disruptions, albeit with a time lag, given their rapid technological adoption and large number of workers in routine occupations. Their low skill base suggests important challenges ahead, however. In poorer countries, where wages are lower and technological adoption is slower (chapter 1), the disruptions are likely to arrive more slowly, giving more time for policies and institutions to adapt. All this has implications for

Figure 2.25 The interaction between technology and jobs varies by occupation

Probability of being computerized and intensity in use of ICT at work, by occupation



Sources: WDR 2016 team, based on STEP household surveys (World Bank, various years) and Frey and Osborne 2013. Data at http://bit.do/WDR2016-Fig2_25.

Note: The probability of being computerized is obtained from Frey and Osborne (2013). ICT intensity is an index between 0 (no use of technology) and 19 (most use of technology). ICT = information and communication technology. The red lines represent the average values of ICT intensity (x-axis) and of computerization (y-axis) across the pooled sample of 10 developing countries with STEP household surveys.

whether countries need not just to develop modern skills among children and youth, but also to come up with a strategy for the retraining and lifelong learning of the current stock of (older) workers.

The challenge is to start reforms today to maximize the digital dividends and to prepare for any disruptions. Even if expected labor market changes are similar in Malaysia and South Africa, Poland and Turkey, or Finland and Italy, skill systems vary widely and not all are prepared to equip workers with skills that complement technology. This process needs to start very early in life, and education and training systems are notoriously difficult to change. So, any reform takes many years to have effects, which is why there is a race between skills and technology. Some skill systems are well-positioned, but for many others, skills—and hence, people—are losing the race.

Making the internet work for everyone

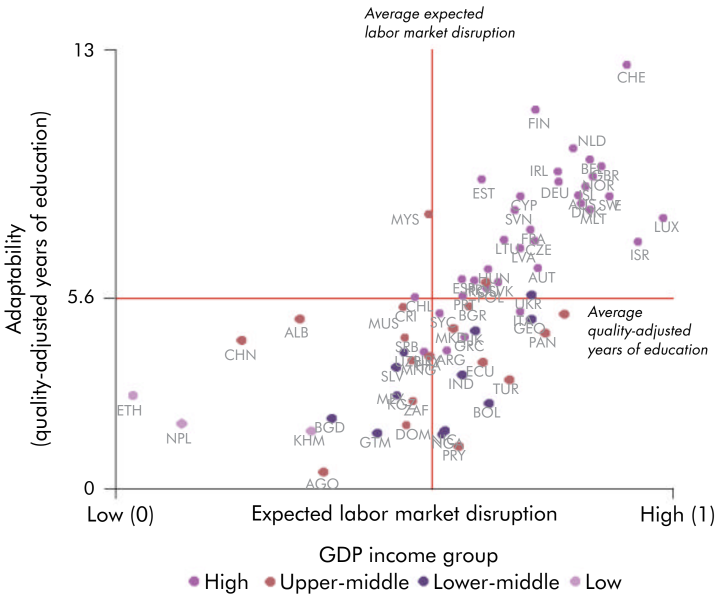
To design policy responses to technological change, it is important to understand who the changes are likely to affect the most, and how the process plays out both in terms of employment and earnings. As discussed, employment is likely to polarize, with routine occupations losing ground to nonroutine occupations. These changes in labor demand have in turn implications for earnings. But employment polarization does not necessarily mean wage polarization.

Three interrelated factors mediate the impact of digital technologies on earnings:

- *Complementarity with technology.* Workers in jobs that use and complement technology are likely to see both an increase in employment and an increase in earnings because of higher productivity. This is the case for workers who use nonroutine cognitive skills and ICT skills. Workers in routine occupations, however, will see less demand for their skills, bringing down both their employment and their wages.
- *Product demand.* If workers produce goods or services that consumers keep buying as they get richer or as the price declines, increases in productivity can translate into increases in wages. This is often the case for workers with nonroutine skills producing, say, knowledge, management expertise, or medical services. If not, increases in productivity can lead to lower employment and earnings in that sector because fewer workers can satisfy demand, as for many agricultural goods.

Figure 2.26 The key policy challenge: Adapting the skills agenda to expected labor market disruptions

Expected labor market disruption and quality-adjusted years of education



Sources: WDR 2016 team, based on STEP surveys (World Bank, various years); Central Asia World Bank Skills surveys (World Bank, various years); SHIP (World Bank, various years); SEDLAC (Cedlas and the World Bank); SARMD (World Bank, various years); ECAPOV (World Bank, various years); EAPPOV (World Bank, various years); the National Bureau of Statistics of China (various years); ILO Laborsta database (various years); World Development Indicators (World Bank, various years); World Economic Forum's Competitiveness Index (WEF, various years). Data at http://bit.do/WDR2016-Fig2_26.

Note: Labor market disruption is an index that goes from 0 (no disruption) to 1 (highest disruption). It is the standardized summation of two components, equally weighted: the probability of an average job being computerized (Frey and Osborne 2013, and adjusting for adoption lags), and the intensity of ICT use at work. For each country, the ICT intensity of employment corresponds to the average for countries at the next level of development, to be more forward-looking. The quality-adjusted years of education are constructed by adjusting average years of education for each country with the World Economic Forum's quality-of-education indicator. For example, if a country has, on average, 10 years of education and scores 3.5 on the indicator (which ranges from 0 to 7), its quality-adjusted years of education are 5. See Monroy-Taborda, Moreno, and Santos, forthcoming, for the WDR 2016. GDP = gross domestic product.

- *Labor supply.* The higher the skill requirements for a job, the more difficult it is for new workers to enter that market. So, higher demand for workers would translate into higher wages. If, however, it is easy to retrain for a new job or skill requirements are low, there can be downward pressure on wages because of increased competition. Workers in nonroutine cognitive occupations are likely to see their higher productivity rewarded as higher earnings because entry barriers are high. But low-skilled workers in nonroutine manual occupations are likely to see their earnings fall over time as middle-skilled workers in routine occupations are displaced and start competing for the available jobs in low-paying occupations (table 2.5).[157]

Therefore, the main winners from technological change will have and use new economy skills and gain employment in nonroutine cognitive occupations.

Table 2.5 Expected impacts of technological change on employment and earnings

Type of occupation (by skills intensity)	Expected impact on	
	Employment	Earnings
Nonroutine cognitive	Positive	Positive
Routine cognitive and manual	Negative	Negative
Nonroutine manual	Positive	Negative

Source: WDR 2016 team, based on Autor 2014.

The young, the better educated, and those already better off are most likely to benefit from digital technologies—with older workers, those with less education, and the poor falling behind. The former group is more likely to have more advanced skills—especially cognitive and ICT skills—regardless of their occupation or work status.[158] In addition, these groups are disproportionally likely to be in, or to move into, occupations that pay well and are likely to grow in the future—those intensive in nonroutine skills (figure 2.27).[159] Recent evidence from the United States shows that there has been a marked decline in the rate at which workers transition into routine employment (particularly among the young) but that women and those with higher education levels have found it easier to adjust to these changes by moving into the high-paying, nonroutine cognitive jobs.[160]

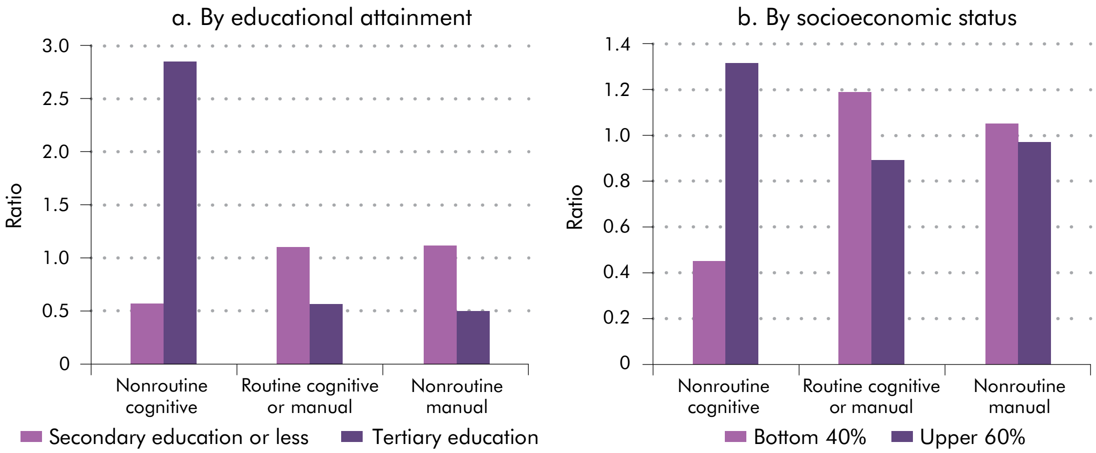
A big challenge for policy makers, especially in rapidly aging societies, is managing skill obsolescence. Recall that the surge in the demand for new economy skills has been concentrated among young workers (see figure 2.21). Digital technologies accelerate the depreciation of skills and work experience, affecting especially older workers (box 2.9). But obsolescence is not destiny or the same for all types of skills. Most literature argues that younger workers have a comparative advantage in tasks where problem solving, learning, and speed are important ("fluid" abilities), and older workers have an advantage when experience and verbal abilities matter more ("crystallized" abilities).[161] But evidence from Germany shows that workers in their 50s experienced a more rapid growth in tasks intense in fluid cognitive skills than those in their 30s.[162] Box 2.10 examines the gender impacts in more depth.

A policy agenda

Digital technologies improve overall welfare and can reduce poverty, but without complementary policies, many benefits can go unrealized and inequality can increase. To capitalize on the benefits—and to do

Figure 2.27 **The less educated and the bottom 40 percent of the welfare distribution are most vulnerable to technological changes in the labor market**

Ratio of employment by occupation type to total employment



Source: WDR 2016 team, based on the I2D2 dataset (International Income Distribution Database; World Bank, various years). Data cover 117 countries. "Bottom 40%" and "Upper 60%" refer to the welfare distribution (either of income or consumption) of individuals' households. Classification of occupations follows Autor 2014. Data at http://bit.do/WDR2016-Fig2_27.

Note: A ratio higher than 1 means that workers with the given level of education are disproportionately likely to be in the given occupation type. A ratio lower than 1 means that workers are relatively unlikely to be in a given occupation type.

so without leaving people behind—internet access (chapter 4) needs to be complemented with an "analog" policy agenda. In addition to supporting entrepreneurship and innovation to expand businesses and job opportunities, this agenda should ensure that education and training systems, labor regulations, and social protection institutions support all workers in seizing the opportunities that the internet generates (chapter 5).

The most crucial element is skills development. A modern economy requires workers with modern skills. For people to become online workers and traders, farmers to use technology to become more productive, or for workers to access modern,

Box 2.9 The challenge of keeping up with new technologies in Mexico

Technology is making many skills obsolete and reducing the returns to experience, especially among older workers.

In Mexico, as in other Latin American countries, wage inequality has declined since 2000. A declining skill premium has been one of the drivers of this trend because the wages of the low-skilled rose and those of the high-skilled fell. The average hourly wage for college-educated workers fell 2 percent a year between 2001 and 2014.

Why have high-skilled wages declined in Mexico, when in most countries, especially outside of Latin America, returns to tertiary education continue to rise (despite increasing educational attainment everywhere)? It could simply be that the supply of educated workers has outpaced demand for them. But there are three alternative explanations for the decline in relative wages of skilled workers: low-quality tertiary educated graduates, a skills mismatch among young workers, or skills obsolescence among older workers.

New research finds that the fall in the skills premium is driven at least partly by skills obsolescence among older workers. First, the earnings of the oldest cohort, above age 50, declined fastest (40 percent during the period). But for the youngest cohort—aged between 23 and 30—earnings increased. Second, earnings start to decline at a younger age over time. If age is a proxy for work experience, this means that, among older workers, the return to education and the return to experience are falling. This could be evidence of an accelerated skills obsolescence.

Source: WDR 2016 team, based on Campos-Vazquez, Lopez-Calva, and Lustig, forthcoming.

Box 2.10 Digital technologies and economic opportunities: A gender lens

Digital technologies can empower women economically and socially. Because social norms and time and mobility constraints are often more severe for women than for men, women could benefit greatly from technology.[a]

Digital technologies can reduce gender gaps in labor force participation by making work arrangements more flexible, connecting women to work, and generating new opportunities in online work, e-commerce, and the sharing economy. In Elance, a platform for online work now part of Upwork, 44 percent of workers are women, compared to an average of 25 percent in the nonagricultural economy globally. Business process outsourcing in India employs more than 3.1 million workers, 30 percent of them women. Four in ten online shop owners on Alibaba are women. Moreover, technology can help improve women's access and accumulation of productive assets. The digitization of land registries, for example, can be particularly beneficial for women.[b] These improved opportunities, in turn, can increase investments in young girls' human capital.[c]

Technology-driven shifts in skills demand can reduce wage gaps, especially among the better educated. Women are well positioned to gain from a shift in employment toward nonroutine occupations, and away from physical work.[d] In Germany and the United States, the use of digital technologies at work explains a significant share of the increase in female labor force participation and employment in the past few decades.[e] Similar changes have taken place in Brazil, Mexico, and Thailand, and also explain a large part of the reduction in gender wage gaps.[f] New technologies level the playing field, particularly among the better educated, who take on jobs that use their comparative advantage in nonphysical work.[g] Recent evidence from the United States shows that it is the better educated and women who are able to get the high-paying jobs intensive in nonroutine skills as middle-skilled jobs shrink.[h]

Digital technologies also impact women's voice and agency. Increased access to information can affect gender norms and affect aspirations, often faster than expected.[i] Social media is an additional outlet for women to participate in public discussions and voice their opinions (spotlight 3). "My Dress, My Choice" in Kenya, a social media movement against female violence that mobilized thousands of Kenyans, including through street protests, eventually led to changes in relevant laws.[j] Some of the new innovations of the digital economy, such as digital payments, mobile money, and taxi sharing rides, can also increase women's agency and control over economic resources, and their safety. For example, in Niger, greater privacy and control of mobile transfers, compared to manual cash transfers, shifted intrahousehold decision making in favor of women, the recipients of the transfer.[k]

But in many countries, gender gaps in technology use, and in working in the ICT sector, remain vast. Over 1.7 billion women in low- and middle-income countries do not own mobile phones. Women in those countries are 14 percent less likely to own a mobile phone than men, on average. Women in South Asia are 38 percent less likely to own a phone than men.[l] Barriers to access can be particularly salient in the case of the internet, especially in poor and remote localities where access is predominantly outside the home, and where social norms for socializing or safety concerns can become a barrier.[m] In Africa, for example, women are 50 percent less likely to use the internet than men.[n] In addition to ownership and access, lack of control over the use of the technology can be an additional barrier for women. In the Arab Republic of Egypt and in India, for example, 12 percent of women stated that they did not access the internet more often because they did not think it was appropriate, and more than 8 percent did not access it more often because family or friends would disapprove.[o] In the labor market, women are also much less likely to work in the information and communication technology (ICT) sector or in ICT occupations, which are well paid. These latter gaps partly reflect women's low participation in science, technology, engineering, and math (STEM) education, itself a product of early gender-based biases in formal and informal education (chapter 5).

Even with gender parity in ownership, access, and control over digital technologies, gains are not automatic. They need to be complemented with analog changes that address the underlying barriers to women's employment, voice, and agency. In rural South Africa, for example, mobile phones increased employment mostly among women, as long as they did not have large child care responsibilities.[p] In addition, technologies can have gender-differentiated effects, as shown throughout this chapter. This suggests that interventions around digital technologies would become more effective if they were more gender-informed, including by having women participate early on in the design of interventions and of the technologies themselves.

Moreover, by circumventing, rather than eliminating, some of the barriers to employability faced by women,

(Box continues next page)

Box 2.10 Digital technologies and economic opportunities: A gender lens *(continued)*

the internet could actually delay necessary reforms. For example, home-based work could help connect women to work in environments where social norms or child care responsibilities are a barrier to women working outside the home. But if working outside the home continues to be seen as unacceptable for women or if there is no availability of affordable child care, technology could end up delaying fundamental reforms. Addressing these underlying constraints remains key to the gender and overall economic agenda.

a. World Bank 2011.
b. World Bank 2014b. In Rwanda, the Land Tenure Regularization Programme demarcated and digitized 10 million plots. Households that registered their land were more likely to invest in it, and this effect was twice as strong for female-headed households (Ali, Deininger, and Goldstein 2014).
c. Oster and Millett 2013.
d. Rendall 2010; Weiberg 2000.
e. Black and Spitz-Oener 2007; Rendall 2010; Weiberg 2000.
f. Rendall 2010; Autor and Price 2013; Black and Spitz-Oener 2007.
g. WDR 2016 team, based on STEP household surveys (World Bank, various years).
h. Cortes and others 2014.
i. La Ferrara, Chong, and Duryea 2012; Jensen and Oster 2009.
j. Seol and Santos 2015.
k. Aker and others 2014.
l. GSMA 2015.
m. Gomez (2014) shows, for developing countries, that women—unlike men—prefer using the internet in public libraries rather than in private cybercafés because they are safer and despite poorer service.
n. WDR 2016 team calculations, based on Research ICT Africa surveys (various years).
o. Intel and Dalberg Global Development Advisors 2012.
p. Klonner and Nolen 2010.

better-paying jobs, skills need to be upgraded. Current and future workers need to develop the lifelong cognitive, technical, and socioemotional skills required of a well-educated worker in the 21st century. Workers also need to be capable of processing the ever-increasing information available on the internet. Building these skills requires actions affecting all relevant environments for learning: families, schools, universities, training systems, and firms. Given the speed of technological changes, these skills will also require constant updating throughout the life cycle as workers prepare for careers that last more than one job. Digital technologies themselves can help (sector focus 2 and chapter 5). Complementary reforms are also needed in tax policy, social protection, and labor market institutions to facilitate the transition of workers from old economy jobs to new economy jobs, and address the distributional consequences of the digital revolution.

Notes

1. World Bank 2014c.
2. Throughout this chapter, "opportunities" refer to people's short- and long-term capacity to generate income (Bussolo and Calva 2014). In addition, and taking a wide perspective, it is also used to include gains to consumers.
3. WDR 2016 team, based on STEP surveys (World Bank, various years); Central Asia World Bank Skills surveys (World Bank, various years); Survey-based Harmonized Indicators Program (SHIP) (World Bank, various years); Socio-Economic Database for Latin America and the Caribbean (SEDLAC) (CEDLAS and the World Bank); South Asia Region MicroDatabase (SARMD) (World Bank, various years); Europe and Central Asia Poverty (ECAPOV) Database (various years); East Asia Pacific Poverty (EAPPOV) Database (World Bank, various years); the I2D2 dataset (International Income Distribution Database) (World Bank, various years); ILO Laborsta database (ILO, various years); and the National Bureau of Statistics of China (various years). Automation probabilities adapted from Frey and Osborne (2013).
4. WDR 2016 team calculations, based on ILO Key Indicators of the Labour Market (KILM; various years), ILO Laborsta database (various years), World Bank's International Income Distribution Database (I2D2; various years), and the National Bureau of Statistics of China (various years). For more details, see figure 2.15.
5. WDR 2016 team calculations, based on World Development Indicators (World Bank, various years).

6. ITU's (International Telecommunication Union) World Telecommunication/ICT Indicators (ITU, various years), Gallup World Poll, and Eurostat Information Society Statistics (EC 2015).
7. This, like the rest of the chapter, is based on household survey data. Subscription data, often based on estimates, are widely available but have upward and downward biases. Although less readily available, household surveys can better account for sharing of mobile phones, or for one individual having more than one subscription or phone.
8. Handel 2015, for WDR 2016; Aker 2010b.
9. WDR 2016 team, based on Research ICT Africa surveys (various years).
10. Veeraraghavan, Yasodhar, and Toyama 2009.
11. WDR 2016 team, based on the Argentina National Institute of Statistics and Census, Brazilian Internet Steering Committee, Colombia Directorate of Statistical Methodology and Production, European Commission Eurostat database (various years), Mexico National Institute of Statistics and Geography, and Uruguay National Institute of Statistics.
12. Eurostat (EC, various years), for the WDR 2016.
13. WDR 2016 team, based on Brazilian Internet Steering Committee and Mexico National Institute of Statistics and Geography.
14. WDR 2016 team, based on Research ICT Africa surveys (various years).
15. WDR 2016 team, based on Brazilian Internet Steering Committee and Mexico National Institute of Statistics and Geography.
16. WDR 2016 team, based on Gallup World Poll, various years.
17. WDR 2016 team calculations, based on Research ICT Africa surveys (various years).
18. ICT surveys for Argentina, Brazil, Colombia, Mexico, and Uruguay; and Eurostat (EC, various years).
19. WDR 2016 team calculations, based on Research ICT Africa surveys (various years).
20. Gomez 2014.
21. Ritter and Guerrero 2014.
22. Galperin and Viecens 2014; Pimienta, Prado, and Blanco 2009.
23. De los Rios 2010.
24. Atasoy 2013.
25. Ritter and Guerrero 2014.
26. Klonner and Nolen 2010.
27. OECD Key Economic Indicators Database, latest year available (circa 2011).
28. Berger and Frey 2014.
29. Brynjolfsson and McAfee 2014.
30. WDR 2016 team, based on STEP household surveys (World Bank, various years).
31. WDR 2016 team, based on STEP household surveys (World Bank, various years).
32. Moretti and Thulin 2013 for the United States; Maloney and Valencia 2015 for Turkey.
33. CGAP 2014.
34. Fernandes and others 2015.
35. Dutz and others 2015, for the WDR 2016.
36. Gaggl and Wright 2014.
37. Akerman, Gaarder, and Mogstad 2015.
38. Blinder and Krueger 2013.
39. Kennedy and others 2013.
40. NASSCOM 2014.
41. Jensen 2012.
42. IBM 2014.
43. See http://elance-odesk.com/online-work-report-global, accessed October 2, 2014.
44. Agrawal and others 2013.
45. Heeks and Arun 2010; Kennedy and others 2013; Monitor Inclusive Markets 2011.
46. Samasource 2015. Digital Divide Data has more than 1,300 employees, with 10 percent of its data management operators having physical disabilities (Digital Divide Data 2014). Ruralshores is active in remote rural areas in India and has 2,500 employees (http://ruralshores.com/about.html).
47. Imaizumi and Santos, forthcoming.
48. China Association for Employment Research 2014.
49. Schaefer-Davis 2005.
50. See https://www.etsy.com/about/?ref=ftr, accessed May 15, 2015.
51. Based on an online survey of 60 countries worldwide done by Nielsen in 2013 (Van Welsum 2015).
52. See https://www.airbnb.com/about/about-us, accessed March 11, 2015.
53. See http://www.gravitytank.com/pdfs/info_graphics/SharingEconomy_web.pdf, as cited in Van Welsum 2015.
54. In a study of Uber in the United States, Hall and Krueger (2015) show that drivers aged 18–29 years are 19 percent of all Uber drivers, compared to 8.5 percent among regular taxi drivers and chauffeurs. Female drivers are 13.8 percent of Uber drivers, compared to 8 percent elsewhere. At the same time, however, Uber drivers are less likely than traditional employees to have health insurance, and half leave Uber within 50 weeks.
55. Montenegro and Patrinos 2014.
56. Bagues and Sylos 2009; Nakamura and others 2009; Stevenson 2009.
57. See http://press.linkedin.com/.
58. WDR 2016 team, based on STEP household surveys (World Bank, various years).
59. Kuhn 2014; Raja and others 2013.
60. Dammert, Galdo, and Galdo 2014.
61. Mang 2012.
62. Kuhn 2014; Kroft and Pope 2014.
63. Kuhn and Mansour 2014.
64. Imaizumi and Santos, forthcoming, for the WDR 2016.
65. Arias and others 2014.
66. OECD 2011.

67. World Bank 2011.
68. See http://blog.jetblue.com/index.php/2013/09/05/unpacked-working-from-home/, accessed June 19, 2015.
69. Bloom and others 2014.
70. See http://www.philstar.com/education-and-home/2013/06/13/953332/filipino-teachers-uruguay.
71. Muto and Yamano 2009.
72. e-Choupal, "The Status of Execution." http://www.itcportal.com/businesses/agri-business/e-choupal.aspx.
73. World Bank 2014a; Demirgüç-Kunt and others 2015.
74. Jack and Suri 2014.
75. Fingerprint scanning among paprika farmers in Malawi increased repayment rates (IFPRI and World Bank 2010).
76. For a discussion on personal networks and labor markets, see Granovetter (1973) and Calvo-Armengol (2004).
77. Boase and others 2006.
78. World Bank 2011.
79. La Ferrara, Chong, and Duryea 2012; Jensen and Oster 2009.
80. WDR 2016 team, based on Research ICT Africa surveys (various years).
81. De, Mohapatra, and Plaza, forthcoming, for the WDR 2016.
82. Camacho and Conover 2011; Jensen 2010.
83. Goyal 2010; Aker 2010a; Best and others 2010; Aker 2011; Martin 2010.
84. Aker and Mbiti 2010.
85. Beuermann, McKelvey, and Vakis 2012.
86. May, Dutton, and Munyakazi 2011.
87. Jensen 2007.
88. Pineda, Aguero, and Espinoza 2011.
89. Galiani and Jaitman 2010.
90. Asad 2014.
91. Aker 2010a; Pineda, Aguero, and Espinoza 2011.
92. Aker 2010a.
93. Aker 2011.
94. Tadesse and Bahiigwa 2015; Jagun, Heeks, and Whalley 2008.
95. Amazon Mechanical Turk is an online work platform. The quote was obtained through an online questionnaire of online workers done in September 2014 for this Report.
96. Varian 2011.
97. Government of Estonia 2015.
98. Interactive Advertising Bureau 2010.
99. Greenstein and McDevitt 2011.
100. WDR 2016 team, based on Research ICT Africa surveys (various years).
101. Pew Research Center 2014.
102. In the United States, the median tenure for male wage and salary workers was lower in 2014 at 5.5 years, compared with 5.9 years in 1983 (Copeland 2015). Dutz and others (2015, for the WDR 2016) show more turnover among young workers in industries intensive in ICT in Brazil. See also Stevenson 2009.
103. Handel 2015, for the WDR 2016.
104. World Bank 2012, 2013.
105. Forman, Goldfarb, and Greenstein 2012.
106. Eden and Gaggl 2014; Karabarbounis and Neiman 2013. Eden and Gaggl (2015, for the WDR 2016) suggest that while the fall in the routine share of labor is linked to technological change, the shift in the labor share compared with that of capital may be a more complex story. In the United States, housing prices have been identified as a key driver in the rise of capital shares (Bonnet and others 2014). This chapter focuses on the fall of routine labor within the labor share, as this is more clearly linked to technological change.
107. From 16 to 14 percent in the case of Honduras, and from 18 to 16 percent in the case of Romania (Eden and Gaggl 2015, for the WDR 2016).
108. Acemoglu 2002; Aghion and others 2015; Dabla-Norris and others 2015; Garicano and Rossi-Hansberg 2006; Jaumotte, Lall, and Papageorgiou 2008; Autor, Katz, and Krueger 1998.
109. Acemoglu and Autor 2011; Akcomak, Kok, and Rojas-Romagosa 2013; Autor and Dorn 2013; Goos, Manning, and Salomons, forthcoming.
110. Autor, Dorn, and Hanson, forthcoming; Autor, Dorn, and Hanson 2013.
111. The number of workers in agriculture declined in China between 2000 and 2010, but the number of workers within the sector that were machine or equipment operators almost doubled (WDR 2016 team, based on the National Bureau of Statistics of China, various years).
112. Dutz and others 2015; Messina, Oviedo, and Pica 2015 for Mexico and Peru.
113. Goldin and Katz (2008) refer to a race between education and technology when discussing the case of the United States, but the phrase was first used by Tinbergen (1975).
114. Brynjolfsson and McAfee (2014, 11).
115. Oviedo and others (forthcoming) use STEP household surveys (World Bank, various years) from 10 developing countries to characterize the typical tasks done across occupations, and show that, indeed, occupations that are considered intensive in nonroutine cognitive and socioemotional skills require workers to do more complex reading, write longer texts, use more advanced math, contact more clients, collaborate more with others, as well as do more thinking, learning, supervising, and presenting. By contrast, these occupations do fewer routine and manual activities, such as operating machines and doing physical activities.
116. WDR calculations based on STEP household surveys (World Bank, various years).

117. This is referred to as functional literacy. *Functional illiteracy* is defined as the proportion of exam takers (15-year-olds) who score below a level 2 on the Programme for International Student Assessment (PISA) reading test (WDR 2016 team, based on OECD PISA 2012 scores).
118. World Bank 2014c.
119. WDR 2016 team, based on Research ICT Africa (various years). Among those who do not cite a lack of connection as a reason for not using the internet, 3 out of 10 say they do not use the internet because they do not know how to.
120. PIAAC survey.
121. World Bank 2010.
122. Valerio and others, forthcoming. Most of this literature remains focused on the returns to computer use (Spitz-Oener 2008; Sakellariou and Patrinos 2003). Most studies are not based on random assignment of the technology, and estimates likely reflect that these workers have other characteristics or skills that command an earnings premium. In a randomized experiment using fictitious resumes for white-collar occupations in Buenos Aires and Bogota, ICT skills increased the probability of receiving a job callback by one percentage point (Lopez-Boo and Blanco 2010).
123. Correa and de Sousa 2015, for the WDR 2016.
124. Akerman, Gaarder, and Mogstad 2015.
125. Cunningham and Villasenor 2014.
126. Valerio and others 2015a, 2015b; Ajwad and others 2014a; Ajwad and others 2014b; Bodewig and others 2014.
127. Valerio and others 2015a; Valerio and others 2015b.
128. Eden and Gaggl 2015, for the WDR 2016.
129. For example, it is often difficult to distinguish between trade and technology (chapter 1).
130. Akcomak, Kok, and Rojas-Romagosa 2013; Autor, Dorn, and Hanson, forthcoming; Eden and Gaggl 2014; Karabarbounis and Neiman 2013; Michaels, Natraj, and Van Reenen 2014.
131. WDR 2016 team, based on I2D2 data (World Bank, various years).
132. Autor 2014; Autor and Dorn 2013; Autor, Levy, and Murnane 2003; Spitz-Oener 2008; MacCrory and others 2014.
133. Autor 2014; Summers 2014; Brynjolfsson and McAfee 2014.
134. Ryder 2015.
135. Autor, Dorn, and Hanson, forthcoming.
136. Statista 2015.
137. World Bank team under the Government Financial Management and Revenue Administration Project. Other regulatory and business processes changes also help explain the redundancy of workers.
138. WDR 2016 team interview with Dr. Ishrat Hussain, former governor of the State Bank of Pakistan, January 30, 2015.
139. Bowles 2014; Frey and Osborne 2013.
140. Autor, Dorn, and Hanson, forthcoming. Their analysis examines the period between 1980 and 2007.
141. Autor 2014.
142. Handel 2000.
143. Gaggl and Wright 2014.
144. Jaimovich and Siu 2012.
145. Handel 2015, for the WDR 2016.
146. Luddites were English textile workers who protested rapid automation in the early 19th century by destroying the machinery used to replace them.
147. Crafts 2015, for the WDR 2016; Katz and Margo 2013; Gray 2013.
148. MacCrory and others 2014.
149. Crafts 2015, for the WDR 2016.
150. For a discussion on "premature" deindustrialization, see Rodrik 2015.
151. Turner 2014.
152. Berger and Frey 2014.
153. Beaudry, Green, and Sand 2014.
154. Crafts 2015, for the WDR 2016.
155. Brynjolfsson and McAfee 2014.
156. Countries in Europe and Central Asia are a case in point. Starting from a comparable institutional and economic level in the early 1990s, countries that carried out the most economic reforms (for example, the Czech Republic, Estonia, and Poland) have seen a more rapid shift toward new economy occupations (Arias and others 2014). Historically, GDP per capita has also been a strong determinant of technology adoption (Crafts 2015).
157. Autor 2014.
158. WDR 2016 team, based on STEP household surveys (World Bank, various years).
159. Acemoglu and Autor 2011; Aedo and others 2013; Arias and others 2014; Autor and Price 2013; Autor, Levy, and Murnane 2003; Bruns, Evans, and Luque 2012.
160. Cortes and others 2014.
161. Skirbekk 2013.
162. Skirbekk 2013.

References

Acemoglu, Daron. 2002. "Technical Change, Inequality, and the Labor Market." *Journal of Economic Literature* 40: 7–72.

Acemoglu, Daron, and David Autor. 2011. "Skills, Tasks and Technologies: Implications for Employment and Earnings." *Handbook of Labor Economics* 4 (12): 1043–1171.

Aedo, Cristian, Jesko Hentschel, Javier Luque, and Martin Moreno. 2013. "From Occupations to Embedded Skills: A Cross-Country Comparison." Background paper for the *World Development Report 2013*, World Bank, Washington, DC.

Aghion, Philippe, Ufuk Akcigit, Antonin Bergeaud, Richard Blundell, and David Hemous. 2015. "Innovation and Top Income Inequality." Working paper, Harvard University, Cambridge, MA. http://scholar.harvard.edu/aghion/publications/innovation-and-top-income-inequality.

Agrawal, Ajay, John Horton, Nico Lacetera, and Elizabeth Lyons. 2013. "Digitization and the Contract Labor Market: A Research Agenda." NBER Working Paper 19525, National Bureau of Economic Research, Cambridge, MA.

Ajwad, Mohamed Ihsan, Stefan Hut, Ilhom Abdulloev, Robin Audy, Joost de Laat, Sachiko Kataoka, Jennica Larrison, Zlatko Nikoloski, and Federico Torracchi. 2014a. *The Skills Road: Skills for Employability in Tajikistan*. Washington, DC: World Bank.

Ajwad, Mohamed Ihsan, Joost de Laat, Stefan Hut, Jennica Larrison, Ilhom Abdulloev, Robin Audy, Zlatko Nikoloski, and Federico Torracchi. 2014b. *The Skills Road: Skills for Employability in the Kyrgyz Republic*. Washington, DC: World Bank.

Akcomak, Semih, Suzanne Kok, and Hugo Rojas-Romagosa. 2013. "The Effects of Technology and Offshoring on Changes in Employment and Task-Content of Occupations." Discussion Paper 233, CBP [Netherlands Bureau for Economic Analysis], The Hague.

Aker, Jenny C. 2010a. "Information from Markets Near and Far: Mobile Phones and Agricultural Markets in Niger." *American Economic Journal: Applied Economics* 2: 46–59.

———. 2010b. "Why Have Mobile Phones Succeeded Where Other Technologies Have Not?" In *Global Development: Views from the Center* (blog). http://www.cgdev.org/blog/why-have-mobile-phones-succeeded-where-other-technologies-have-not.

———. 2011. "Dial A for Agriculture: A Review of Information and Communication Technologies for Agricultural Extension in Developing Countries." *Agricultural Economics* 42 (6): 631–47.

Aker, Jenny C., Rachid Boumnijel, Amanda McClelland, and Niall Tierney. 2014. "Payment Mechanisms and Anti-Poverty Programs: Evidence from a Mobile Money Cash Transfer Experiment in Niger." Working Paper 268, Center for Global Development, Washington, DC.

Aker, Jenny C., and Isaac M. Mbiti. 2010. "Mobile Phones and Economic Development in Africa." *Journal of Economic Perspectives* 24 (3): 207–32.

Akerman, Anders, Ingvil Gaarder, and Magne Mogstad. 2015. "The Skill Complementarity of Broadband Internet." NBER Working Paper 20826, National Bureau of Economic Research, Cambridge, MA.

Ali, Daniel Ayalew, Klaus Deininger, and Markus Goldstein. 2014. "Environmental and Gender Impacts of Land Tenure Regularization in Africa: Pilot Evidence from Rwanda." *Journal of Development Economics* 110: 262–75.

Argentina, National Institute of Statistics and Census. Various years. National Survey on the Access and Use of Information and Communication Technologies. Argentina National Institute of Statistics and Census, Buenos Aires.

Arias, Omar, Carolina Sanchez-Paramo, Maria Davalos, Indhira Santos, Erwin Tiongson, Carola Gruen, Natascha de Andrade, Gady Saiovici, and Cesar Cancho. 2014. *Back to Work: Growing with Jobs in Europe and Central Asia*. Washington, DC: World Bank.

Asad, Saher. 2014. "The Crop Connection: Impact of Cell Phone Access on Crop Choice in Rural Pakistan." Job market paper, George Washington University, Washington, DC.

Asimov, Isaac. 1964. "Visit to the World's Fair of 2014." *New York Times*, August 16.

Atasoy, Hilal. 2013. "The Effects of Broadband Internet Expansion on Labor Market Outcomes." *Industrial and Labor Relations Review* 66 (2): 315–45.

Autor, David. 2014. "Polanyi's Paradox and the Shape of Employment Growth." Draft prepared for the Federal Reserve Bank of Kansas City.

Autor, David, and David Dorn. 2013. "The Growth of Low-Skill Service Jobs and the Polarization of the U.S. Labor Market." *American Economic Review* 103 (5): 1553–97.

Autor, David, David Dorn, and Gordon Hanson. 2013. "The Geography of Trade and Technology Shocks in the United States." *American Economic Review* 103: 220–25.

———. Forthcoming. "Untangling Trade and Technology: Evidence from Local Labor Markets." *The Economic Journal*.

Autor, David, Lawrence Katz, and Melissa Kearney. 2008. "Trends in U.S. Wage Inequality: Revising the Revisionists." *Review of Economics and Statistics* 90 (2): 300–23.

Autor, David, Lawrence Katz, and Alan Krueger. 1998. "Computing Inequality: Have Computers Changed the Labor Market?" *Quarterly Journal of Economics* 1134: 1169–1213.

Autor, David, Frank Levy, and Richard Murnane. 2003. "The Skill Content of Recent Technological Change: An Empirical Exploration." *Quarterly Journal of Economics* 118 (4): 1279–1333.

Autor, David, and Brendan Price. 2013. "The Changing Task Composition of the U.S. Labor Market: An Update of Autor, Levy, and Murnane (2003)." Working paper, Massachusetts Institute of Technology and National Bureau of Economic Reseach, Cambridge, MA.

Bagues, Manuel, and Mauro Sylos. 2009. "Do Online Labor Market Intermediaries Matter? The Impact of Alma Laurea on the University-to-Work Transition." In *Studies of Labor Market Intermediation*, edited by David Autor, 127–54. Chicago: University of Chicago Press.

Beaudry, Paul, David A. Green, and Benjamin M. Sand. 2014. "The Declining Fortunes of the Young since 2000." *American Economic Review* 104 (5): 381–86.

Berger, Thor, and Carl Benedikt Frey. 2014. "Industrial Renewal in the 21st Century: Evidence from U.S. Cities." University of Oxford, Oxford, U.K. http://www.oxfordmartin.ox.ac.uk/publications/view/1849.

Berman, Eli, Rohini Somanathan, and Hong Tan. 2005. "Is Skill-Biased Technological Change Here Yet? Evidence from Indian Manufacturing in the 1990s." Policy Research Paper 3761, World Bank, Washington, DC.

Best, Michael L., Thomas N. Smyth, John Etherton, and Edem Wornyo. 2010. "Uses of Mobile Phones in Post-Conflict Liberia." *Information Technologies and International Development* 6 (2): 91–108.

Beuermann, Diether, Christopher McKelvey, and Renos Vakis. 2012. "Mobile Phones and Economic Development in Rural Peru." *Journal of Development Studies* 48 (11): 1617–28.

Black, Sandra, and Alexandra Spitz-Oener. 2007. "Explaining Women's Success: Technological Change and the Skill Content of Women's Work." NBER Working Paper 13116, National Bureau of Economic Research, Cambridge, MA.

Blinder, Alan, and Alan Krueger. 2013. "Alternative Measures of Offshorability: A Survey Approach." *Journal of Labor Economics* 31 (2): S97–S128.

Bloom, N., J. Liang, J. Roberts, and Z. Ying. 2014. "Does Working from Home Work? Evidence from a Chinese Experiment." Working paper, Stanford University, Stanford, CA.

Boase, Jeffrey, John Horrigan, Barry Wellman, and Lee Rainie. 2006. "The Strength of Internet Ties." *Pew Internet and American Life Project.* http://www.pewinternet.org/files/old-media/Files/Reports/2006/PIP_Internet_ties.pdf.

Bodewig, Christian, Reena Badiani-Magnusson, Kevin Macdonald, David Newhouse, and Jan Rutkowski. 2014. *Skilling Up Vietnam: Preparing the Workforce for a Modern Market Economy*. Washington, DC: World Bank.

Bonnet, Odran, Pierre-Henri Bono, Guillaume Chapelle, and Étienne Wasmer. 2014. "Does Housing Capital Contribute to Inequality? A Comment on Thomas Piketty's *Capital in the 21st Century*." Sciences Po Economics Discussion Paper 2014-07, Paris Institute of Political Studies, Paris.

Bowles, Jeremy. 2014. "The Computerisation of European Jobs." *Bruegel* (blog), July 17. https://www.bruegel.org.

Brazilian Internet Steering Committee. Various years. Survey on the Use of Information and Communication Technologies in Brazil. Brazilian Network Information Center, São Paulo.

Bruns, Barbara, David Evans, and Javier Luque. 2012. *Achieving World-Class Education in Brazil: The Next Agenda*. Washington, DC: World Bank.

Brynjolfsson, Erik, and Andrew McAfee. 2014. *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies*. New York: W. W. Norton.

Bussolo, Maurizio, and Luis Lopez Calva. 2014. *Shared Prosperity: Paving the Way in Europe and Central Asia*. Washington, DC: World Bank.

Calvo-Armengol, Antoni. 2004. "Job Contact Networks." *Journal of Economic Theory* 115 (1): 191–206.

Camacho, Adriana, and Emily Conover. 2011. "The Impact of Receiving SMS Price and Weather Information in Colombia's Agricultural Sector." Working Paper 220, Inter-American Development Bank, Washington, DC.

Campos-Vazquez, Raymundo M., Luis Lopez-Calva, and Nora Lustig. Forthcoming. "Declining Wages for College-Educated Workers in Mexico: Degraded Tertiary Education or Skills Obsolescence?" World Bank, Washington, DC.

Capili, Miro. 2015. "The BPO Industry in the Philippines: An Overview." Background paper for the *World Development Report 2016*, World Bank, Washington, DC.

CEDLAS (Center for Distributive, Labor and Social Studies) and World Bank. Various years. Socio-Economic Database for Latin America and the Caribbean (SEDLAC), La Plata, Argentina. http://cedlas.econo.unlp.edu.ar/eng/index.php.

CGAP (Consultative Group to Assist the Poor). 2014. "10 Myths about M-Pesa: 2014 Update." http://www.cgap.org/blog/10-myths-about-m-pesa-2014-update.

China Association for Employment Research. 2014. "Internet Business Employment and Social Security Research." For an English summary of the report, see http://www.alizila.com/e-commerce-force-china-jobs-not-job-security-report.

China, National Bureau of Statistics of China. Various years. Population Census. Beijing. http://www.stats.gov.cn/english/Statisticaldata/CensusData/.

Colombia, Directorate of Statistical Methodology and Production. Various years. Household Integrated Survey. National Administrative Department of Statistics, Bogota.

Comin, Diego, and Bart Hobjin. 2010. "An Exploration of Technology Diffusion." *American Economic Review* 100 (5): 2031–59.

Comin, Diego, and Martí Mestieri. 2013. "If Technology Has Arrived Everywhere, Why Has Income Diverged?" INET Research Note 26, Institute for New Economic Thinking, New York.

Connolly, Marie, and Alan Krueger. 2006. "Rockonomics: The Economics of Popular Music." In *Handbook of the Economics of Art and Culture*, edited by V. A. Ginsburg and D. Throsby, 667–719. Amsterdam: North-Holland.

Copeland, Craig. 2015. "Employee Tenure Trends 1983–2014." *Employee Benefit Research Institute Notes* 36 (2).

Correa, Paulo, and Filipe Lage de Sousa. 2015. "Internet and Wages: The Case of Brazil." Background paper for the *World Development Report 2016*, World Bank, Washington, DC.

Cortes, Matias, Nir Jaimovich, Christopher Nekarda, and Henry Siu. 2014. "The Micro and Macro of Disappearing Routine Jobs: A Flows Approach." NBER Working Paper 20307, National Bureau of Economic Research, Cambridge, MA.

Crafts, Nicholas. 2015. "The Economic Impact of ICT: A Historical Perspective." Background paper for the *World Development Report 2016,* World Bank, Washington, DC.

Cunningham, Wendy, and Paula Villasenor. 2014. "Employer Voices, Employer Demands, and Implications for Public Skills Development Policy." Policy Research Working Paper 6853, World Bank, Washington, DC.

Dabla-Norris, Era, Kalpana Kochhar, Nujin Suphaphiphat, Frantisek Ricka, and Evridiki Tsounta. 2015. "Causes and Consequences of Income Inequality: A Global Perspective." Staff Discussion Note 15/13, International Monetary Fund, Washington, DC.

Dammert, Ana C., Jose Galdo, and Virgilio Galdo. 2014. "Mobile Phones for Labor Market Intermediation: A Multi-Treatment Experimental Design." http://www.iza.org/conference_files/worldb2014/galdo_j2620.pdf.

De, Supriyo, Sanket Mohapatra, and Sonia Plaza. Forthcoming. "Impact of Migration on ICT Adoption in Sub-Saharan Africa."

De los Rios, Carlos. 2010. *Welfare Impact of Internet Use on Peruvian Households*. Lima: Instituto de Estudios Peruanos.

Demirgüç-Kunt, Asli, Leora Klapper, Dorothe Singer, and Peter Van Oudheusden. 2015. "The Global Findex Database 2014: Measuring Financial Inclusion around the World." Policy Research Working Paper 7255, World Bank, Washington, DC.

Digital Divide Data. 2014. *Building a Global Platform: 2014 Annual Report*. New York: Digital Divide Data.

Dutz, Mark, Lucas Ferreira-Mation, Stephen O'Connell, and Robert Willig. 2015. "Technological Change and Labor Market Segmentation in the Developing World: Evidence from Brazil." Background paper for the *World Development Report 2016,* World Bank, Washington, DC.

EC (European Commission). 2004. *E-skills for Europe: 2010 and Beyond*. Brussels: European Commision, Enterprise and Industry Directorate General.

———. 2015. Eurostat Information Society Statistics. European Commission, Luxembourg, http://ec.europa.eu/eurostat/statistics-explained/index.php/Information_society_statistics_-_households_and_individuals.

———. Various years. Eurostat (database). European Commission, Luxembourg, http://ec.europa.eu/eurostat/data/database.

Eden, Maya, and Paul Gaggl. 2014. "The Substitution of ICT Capital for Routine Labor: Transitional Dynamics and Long-Run Implications." Working paper, available at the Social Science Research Network.

———. 2015. "The Global Distribution of Information and Communication Technologies: The Role of Industrial Composition." Background paper for the *World Development Report 2016,* World Bank, Washington, DC.

Estonia, Government of. 2015. E-Estonia presentation. Tallin, November.

Fernandes, Ana, Aaditya Mattoo, Huy Nguyen, and Marc Schiffbauer. 2015. "The Impact of Broadband on Chinese Exports in the Pre-Alibaba Era." Background paper for the *World Development Report 2016*, World Bank, Washington, DC.

Forman, Chris, Avi Goldfarb, and Shane Greenstein. 2012. "The Internet and Local Wages: A Puzzle." *American Economic Review* 102 (1): 556–75.

Frey, Carl, and Michael Osborne. 2013. "The Future of Employment: How Susceptible Are Jobs to Computerisation?" Working paper, Oxford University, Oxford, U.K.

Gaggl, Paul, and Greg Wright. 2014. "A Short-Run View of What Computers Do: Evidence from a UK Tax Incentive." Discussion Paper 752, University of Essex, Colchester, U.K.

Galiani, Sebastián, and Laura Jaitman. 2010. "Traceability Applied to SMEs in Argentina: A Case Study." Inter-American Development Bank, Washington, DC.

Gallup. Various years. World Poll. Washington, DC, http://www.gallup.com/services/170945/world-poll.aspx.

Galperin, Hernan, and Fernanda Viecens. 2014. "Connected for Development? Theory and Evidence about the Impact of the Internet Technologies on Poverty Alleviation." Universidad de San Andres, Buenos Aires. http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2397394.

Garicano, Luis, and Esteban Rossi-Hansberg. 2006. "Organization and Inequality in a Knowledge Economy." *Quarterly Journal of Economics* (November): 1383–1435.

Goldin, Claudia, and Lawrence F. Katz. 2008. *The Race between Education and Technology*. Cambridge, MA: Harvard University Press.

Gomez, Ricardo. 2014. "When You Do Not Have a Computer: Public-Access Computing in Developing Countries." *Information Technology for Development* 20 (3): 274–91.

Goos, M., A. Manning, and A. Salomons. Forthcoming. "Explaining Job Polarization: Routine-Biased Technological Change and Offshoring." *American Economic Review* 104 (8): 2509–26.

Goyal, Aparajita. 2010. "Information, Direct Access to Farmers, and Rural Market Performance in Central India." *American Economic Journal: Applied Economics* 2 (3): 22–45.

Granovetter, Mark. 1973. "The Strength of Weak Ties." *American Journal of Sociology* 78 (6): 1360–80.

Gray, Rowena. 2013. "Taking Technology to Task: The Skill Content of Technological Change in the Early

Twentieth Century United States." *Explorations in Economic History* 50 (3): 351–67.

Greenstein, Shane, and Ryan McDevitt. 2011. "The Global Broadband Bonus: Broadband Internet's Impact on Seven Countries." In *The Linked World: How ICT Is Transforming Societies, Cultures and Economies*, edited by B. Van Ark, 35–42. New York: Conference Board.

GSMA (Groupe Speciale Mobile Association). 2015. "Bridging the Gender Gap: Mobile Access and Usage in Low- and Middle-Income Countries." http://www.gsma.com/newsroom/press-release/results-of-new-mobile-phone-gender-gap-survey/.

Hall, Jonathan, and Alan Krueger. 2015. "An Analysis of the Labor Market for Uber's Driver-Partners in the United States." https://s3.amazonaws.com/uber-static/comms/PDF/Uber_Driver-Partners_Hall_Kreuger_2015.pdf.

Handel, Michael. 2000. "Models of Economic Organization and the New Inequality in the United States." PhD diss., Harvard University.

———. 2015. "The Effects of Information and Communication Technology on Employment, Skills, and Earnings in Developing Countries." Background paper for the *World Development Report 2016,* World Bank, Washington, DC.

Heeks, Richard, and Shoba Arun. 2010. "Social Outsourcing as a Development Tool: The Impact of Outsourcing IT Services to Women's Social Enterprises in Kerala." *Journal of International Development* 22 (4): 441–54.

Holland, Julie, Chris Nosko, and Alan Sorensen. 2012. "Supply Responses to Digital Distribution: Recorded Music and Live Performances." *Information Economics and Policy* 24 (1): 3–14.

IBM (International Business Machines Corporation). 2014. "IBM Announces First Commercial Application of IBM Watson in Africa." http://www.ibm.com/news/za/en/2014/10/08/Z027713X96105D22.html.

IFPRI (International Food Policy Research Institute) and World Bank. 2010. "Innovations in Rural and Agriculture Finance." In *Focus 18*. Washington, DC: World Bank.

ILO (International Labour Organization). Various years. Key Indicators of the Labour Market (KILM). ILO, Geneva, http://www.ilo.org/empelm/what/WCMS_114240/lang--en/index.htm.

———. Various years. Laborsta (database). International Labour Organization, Geneva, http://laborsta.ilo.org/.

Imaizumi, Saori, and Indhira Santos. Forthcoming. "Linking Workers to Jobs: Using Mobile Phones and Online Job Search Platforms and Online Outsourcing Platforms in Developing Countries." Background paper for the *World Development Report 2016,* World Bank, Washington, DC.

Intel and Dalberg Global Development Advisors. 2012. "Women and the Web." http://www.intel.com/content/dam/www/public/us/en/documents/pdf/women-and-the-web.pdf.

Interactive Advertising Bureau. 2010. "Consumers Driving the Digital Uptake: The Economic Value of Online Advertising-Based Services for Consumers." http://www.iab.net/media/file/White-Paper-Consumers-driving-the-digital-uptake_FINAL.PDF.

ITU (International Telecommunication Union). Various years. World Telecommunication/ICT Indicators (database). ITU, Geneva, http://www.itu.int/en/ITU-D/Statistics/Pages/publications/wtid.aspx.

Jack, William, and Tavneet Suri. 2014. "Risk Sharing and Transactions Costs: Evidence from Kenya's Mobile Money Revolution." *American Economic Review* 104 (1): 183–223.

Jagun, Abi, Richard Heeks, and Jason Whalley. 2008. "The Impact of Mobile Telephony on Developing Country Micro-Enterprise: A Nigerian Case Study." *Information Technologies and International Development* 4 (4): 47–65.

Jaimovich, Nir, and Henry Siu. 2012. "The Trend Is the Cycle: Job Polarization and Jobless Recoveries." NBER Working Paper 18334, National Bureau of Economic Research, Cambridge, MA.

Jaumotte, Florence, Subir Lall, and Chris Papageorgiou. 2008. "Rising Income Inequality: Technology, or Trade and Financial Globalization?" Working Paper 08/185, International Monetary Fund, Washington, DC.

Jensen, Robert. 2007. "The Digital Provide: Information (Technology), Market Performance, and Welfare in the South Indian Fisheries Sector." *Quarterly Journal of Economics* 122 (3): 879–924.

———. 2010. "The (Perceived) Returns to Education and the Demand for Schooling." *Quarterly Journal of Economics* 125 (2): 515–48.

———. 2012. "Do Labor Market Opportunities Affect Young Women's Work and Family Decisions? Experimental Evidence from India." *Quarterly Journal of Economics* 127 (2): 753–92.

Jensen, Robert, and Emily Oster. 2009. "The Power of TV: Cable Television and Women's Status in India." *Quarterly Journal of Economics* 124 (3): 1057–94.

Kabanda, Patrick. 2015. "The Internet, Music and Development." Background paper for the *World Development Report 2016,* World Bank, Washington, DC.

Karabarbounis, Loukas, and Brent Neiman. 2013. "The Global Decline of the Labor Share." NBER Working Paper 19136, National Bureau of Economic Research, Cambridge, MA.

Katz, Lawrence, and Robert Margo. 2013. "Technical Change and the Relative Demand for Skilled Labor: The United States in Historical Perspective." NBER Working Paper 18752, National Bureau of Economic Research, Cambridge, MA.

Kennedy, Robert, Sateen Sheth, Ted London, Ekta Jhaveri, and Lea Kilibarda. 2013. *Assessing the Opportunity for Building a Thriving Industry.* Ann Arbor: William Davidson Institute at the University of Michigan.

Keynes, John Maynard. 1931. *Essays in Persuasion.* London: Macmillan.

Klonner, Stefan, and Patrick Nolen. 2010. "Cell Phones and Rural Labor Markets: Evidence from South Africa." In *Proceedings of the German Development Economics Conference, Hannover, 56*. http://econpapers.repec.org/paper/zbwgdec10/.

Kolko, Jed. 2012. "Broadband and Local Growth." *Journal of Urban Economics* 71 (1): 100–13.

Kroft, Kory, and Devin Pope. 2014. "Does Online Search Crowd Out Traditional Search and Improve Matching Efficiency? Evidence from Craigslist." *Journal of Labor Economics* 32 (2): 259–303.

Kuek, Siou Chew, Cecilia Paradi-Guilford, Toks Fayomi, Saori Imaizumi, and Panos Ipeirotis. Forthcoming. *The Global Opportunity in Online Outsourcing*. Washington, DC: World Bank.

Kuhn, Peter. 2014. "The Internet as a Labor Market Matchmaker." *IZA World of Labor 2014* (article 18). http://wol.iza.org/articles/internet-as-a-labor-market-matchmaker.

Kuhn, Peter, and Hani Mansour. 2014. "Is Internet Job Search Still Ineffective?" *Economic Journal* 124 (581): 1213–33.

La Ferrara, Eliana, Alberto Chong, and Suzanne Duryea. 2012. "Soap Operas and Fertility: Evidence from Brazil." *American Economic Journal: Applied Economics* 4 (4): 1–31.

Lehdonvirta, Vili, Helena Barnard, Mark Graham, and Isis Hjorth. 2014. "Online Labour Markets: Leveling the Playing Field for International Service Markets?" http://ipp.oii.ox.ac.uk/sites/ipp/files/documents/IPP2014_Lehdonvirta_0.pdf, accessed May 6, 2015.

Lopez-Boo, Florencia, and Mariana Blanco. 2010. "ICT Skills and Employment: A Randomized Experiment." IZA Discussion Paper 5336, Institute for the Study of Labor, Bonn.

MacCrory, Frank, George Westerman, Yousef Alhammadi, and Erik Brynjolfsson. 2014. "Racing with and against the Machine: Changes in Occupational Skill Composition in an Era of Rapid Technological Advance." Paper presented at the Thirty-Fifth International Conference on Information Systems, Auckland, December 14–17. http://aisel.aisnet.org/cgi/viewcontent.cgi?article=1052&context=icis2014.

Maloney, William, and Felipe Valencia. 2015. "Technological Adoption, Human Capital and Job Creation." Working paper, World Bank, Washington, DC.

Mang, Constantin. 2012. "Online Job Search and Matching Quality." IFO Working Paper 147, Institute for Economic Research, Munich.

Marandino, Joaquin, and Phanindra Wunnava. 2014. "The Effect of Access to Information and Communication Technology on Household Labor Income: Evidence from One Laptop per Child in Uruguay." IZA Discussion Paper 8415, Institute for the Study of Labor, Bonn.

Marouani, Mohamed, and Bjorn Nilsson. 2014. "The Labor Market Effects of Skill-Biased Technological Change in Malaysia." Working Paper DT/2014/24, DIAL [Développement, Institutions et Mondialisation]. http://EconPapers.repec.org/RePEc:dia:wpaper:dt201424.

Martin, Brandie. 2010. *Mobile Phones and Rural Livelihoods: An Exploration of Mobile Phone Diffusion, Uses, and Perceived Impacts of Uses among Small- to Medium-Size Farm Holders in Kamuli District, Uganda*. Ames: Iowa State University.

May, J., V. Dutton, and L. Munyakazi. 2011. "Information and Communication Technologies as an Escape from Poverty Traps." PICTURE Africa Research Project, Nairobi. Centre d'Économie de la Sorbonne. http://www.researchgate.net/publication/253341123.

Messina, Julian, Ana Maria Oviedo, and Giovanni Pica. 2015. "Inequality and Polarization in Latin America: Patterns and Determinants." Unpublished paper, World Bank, Washington, DC.

Mexico, National Institute of Statistics and Geography. Various years. Survey on the Availability and Use of Information and Communication Technology in Households. National Institute of Statistics and Geography, Aguascalientes.

Michaels, Guy, Ashwini Natraj, and John Van Reenen. 2014. "Has ICT Polarized Skill Demand? Evidence from Eleven Countries over Twenty-Five Years." *Review of Economics and Statistics* 96 (1): 60–77.

Monitor Inclusive Markets. 2011. "Job Creation through Building the Field of Impact Sourcing." Working paper, Rockefeller Foundation, New York. https://www.rockefellerfoundation.org/app/uploads/Job-Creation-Through-Building-the-Field-of-Impact-Sourcing.pdf.

Monroy-Taborda, Sebastian, Martin Moreno, and Indhira Santos. Forthcoming. "Technology Use and Changing Skills Demands: New Evidence from Developing Countries." Background paper for the *World Development Report 2016*, World Bank, Washington, DC.

Montenegro, Claudio, and Harry Patrinos. 2014. "Comparable Estimates of Returns to Schooling around the World." Policy Research Working Paper 7020, World Bank, Washington, DC.

Moretti, E., and P. Thulin. 2013. "Local Multipliers and Human Capital in the US and Sweden." *Industrial and Corporate Change* 22 (1): 339–62.

Muto, M., and T. Yamano. 2009. "The Impact of Mobile Phone Coverage Expansion on Market Participation: Panel Data Evidence from Uganda." *World Development* 37 (12): 1887–96.

Nakamura, Alice, Kathryn Shaw, Richard Freeman, Emi Nakamura, and Amanda Pyman. 2009. "Jobs Online." In *Studies of Labor Market Intermediation*, edited by David Autor, 27–65. Chicago: University of Chicago Press.

NASSCOM. 2014. *The IT-BPM Sector in India: Strategic Review 2014*. New Delhi: NASSCOM.

Neisser, Ulric, and others. 1996. "Intelligence: Knowns and Unknowns." *American Psychologist* 51 (2): 77–101.

OECD (Organisation for Economic Co-operation and Development). Various years. OECD Key Economic

Indicators (KEI) Database. OECD, Paris, http://stats.oecd.org/mei/default.asp?rev=4.

———. 2004. *Information Technology Outlook*. Paris: OECD.

———. 2011. *The Future of Families to 2030*. Paris: OECD.

———. 2014. *Measuring the Digital Economy: A New Perspective.* Paris: OECD.

Oster, Emily, and Bryce Millett. 2013. "Do IT Service Centers Promote School Enrollment? Evidence from India." *Journal of Development Economics* 104: 123–35.

Oviedo, Ana Maria, Maria Laura Sanchez Puerta, Indhira Santos, Emmanuele Dicarlo, Salvatore Lo Bello, and Sebastian Monroy-Taborda. Forthcoming. *The Skill Content of Occupations across Low- and Middle-Income Countries: Evidence from Harmonized Data.* Washington, DC: World Bank.

Pew Research Center. 2014. "Digital Life in 2025: Technology's Impact on Workers." http://www.pewinternet.org/files/2014/12/PI_Web25WorkTech_12.30.141.pdf.

PIAAC (Programme for the International Assessment of Adult Competencies). Various years. OECD, Paris, http://www.oecd.org/site/piaac/.

Pimienta, Daniel, Daniel Prado, and Alvaro Blanco. 2009. *Twelve Years of Measuring Linguistic Diversity in the Internet*. Paris: UNESCO.

Pineda, Allan, Marco Aguero, and Sandra Espinoza. 2011. "The Impact of ICT on Vegetable Farmers in Honduras." Working Paper 243, Inter-American Development Bank, Washington, DC.

Plaza, Sonia, Seyed Reza Yousefi, and Dilip Ratha. 2015. "Technological Innovations and Remittance Costs." Background paper for the *World Development Report 2016*, World Bank, Washington, DC.

PricewaterhouseCoopers. 2015. "Global Entertainment and Media Outlook 2015–2019." http://www.pwc.com/gx/en/global-entertainment-media-outlook/.

Raja, Deepti Samant. 2015. "Bridging the Disability Divide through Digital Technologies." Background paper for the *World Development Report 2016*, World Bank, Washington, DC.

Raja, Siddhartha, Saori Imaizumi, Tim Kelly, Junko Narimatsu, and Cecilia Paradi-Guilford. 2013. "Connecting to Work: How ICTs Could Help Expand Employment Opportunities." World Bank, Washington, DC. http://documents.worldbank.org/curated/en/2013/09/18221189/connecting-work-information-communication-technologies-help-expand-employment-opportunities.

Rendall, Michelle. 2010. "Brain versus Brawn: The Realization of Women's Comparative Advantage." Working Paper 306, University of Zurich, Department of Economics, Center for Institutions, Policy and Culture in the Development Process.

Research ICT Africa. Various years. Household survey. Capetown, South Africa. http://www.researchictafrica.net/home.php.

Ritter, Patricia, and Maria Guerrero. 2014. "The Effect of the Internet and Cell Phones on Employment and Agricultural Production in Rural Villages in Peru." Working paper, University of Piura, Piura, Peru. http://udep.edu.pe/cceeee/files/2014/07/3B_2_RitterGUERRERO.pdf.

Rodrik, Dani. 2015. "Premature Deindustrialization." NBER Working Paper 20935, National Bureau of Economic Research, Cambridge, MA.

Ryder, Guy. 2015. "How Can We Create Decent Jobs in the Digital Age?" In *World Economic Forum* (blog). https://agenda.weforum.org/2015/01/how-can-we-create-decent-jobs-in-the-digital-age/.

Sakellariou, Chris, and Harry Patrinos. 2003. "Technology, Computers, and Wages: Evidence from a Developing Economy." Policy Research Paper 3008, World Bank, Washington, DC.

Samasource. 2015. http://www.samasource.org.

Schaefer-Davis, Susan. 2005. "Women Weavers Online: Rural Moroccan Women on the Internet." In *Gender and the Digital Economy: Perspectives from the Developing World*, edited by Cecelia Ng and Swasti Mitter, 159–85. New Delhi, India: SAGE Publications.

Seol, Boo Kang, and Indhira Santos. 2015. "#MyDressMyChoice: Tackling Gender Discrimination and Violence in Kenya One Tweet at a Time." *Let's Talk Development* (blog), May 4. http://blogs.worldbank.org/developmenttalk/mydressmychoice-tackling-gender-discrimination-and-violence-kenya-one-tweet-time, accessed May 4, 2015.

Skirbekk, Gordo. 2013. "Skill Demand and the Comparative Advantage of Age: Jobs Tasks and Earnings from the 1980s to the 2000s in Germany." *Labour Economics* 22: 61–69.

Spitz-Oener, Alexandra. 2008. "The Returns to Pencil Use Revisited." *Industrial and Labor Relations Review* 61 (4): 502–17.

Srour, Ilina, Erol Taymaz, and Marco Vivarelli. 2013. "Skill-Biased Technological Change and Skill-Enhancing Trade in Turkey: Evidence from Longitudinal Microdata." IZA Discussion Paper 7320, Institute for the Study of Labor, Bonn.

Statista. 2015. New York, http://www.statista.com/statistics/285344/sources-used-to-plan-leisure-personal-business-trips-2013/.

Stevenson, Betsy. 2009. *The Internet and Job Search*. In *Labor Market Intermediation*, edited by David Autor, 67–86. Chicago: University of Chicago Press.

Summers, Lawrence. 2014. "Lawrence H. Summers on the Economic Challenge of the Future: Jobs." *Wall Street Journal*, July 7. http://online.wsj.com/articles/lawrence-h-summers-on-the-economic-challenge-of-the-future-jobs-1404762501.

Tadesse, Getaw, and Godfrey Bahiigwa. 2015. "Mobile Phones and Farmers' Marketing Decisions in Ethiopia." *World Development* 68: 296–307.

Thompson, Derek. 2015. "The Death of Music Sales." *Atlantic*, January 25.

Tinbergen, Jan. 1975. *Income Distribution*. Amsterdam: North Holland Publishers.

Turner, Adair. 2014. "The High-Tech, High-Touch Economy." *Project Syndicate,* April 16.

Uruguay, National Institute of Statistics. Various years. Survey on the Use of Information and Communication Technology. National Institute of Statistics, Montevideo.

Valerio, Alexandria, Katia Herrera-Sosa, Sebastian Monroy-Taborda, and Dandan Chen. 2015a. "Armenia Skills toward Employment and Productivity (STEP) Survey Findings (Urban Areas)." World Bank, Washington, DC.

———. 2015b. "Georgia Skills toward Employment and Productivity (STEP) Survey Findings (Urban Areas)." World Bank, Washington, DC.

Valerio, Alexandria, Maria Laura Sanchez, Namrata Tognatta, and Sebastian Monroy-Taborda. Forthcoming. "The Skills Payoff in Low and Middle Income Countries: Empirical Evidence Using STEP Data." World Bank, Washington, DC.

Van Welsum, Desiree. 2015. "Sharing Is Caring? Not Quite. Some Observations about the Sharing Economy." Background paper for the *World Development Report 2016,* World Bank, Washington, DC.

Varian, Hal. 2011. "Economic Value of Google." In "The Data Frame: The Web 2.0 Summit 2011 Conference," San Francisco, October 17–19. http://www.web2summit.com/web2011.

Veeraraghavan, Rajesh, Naga Yasodhar, and Kentaro Toyama. 2009. "Warana Unwired: Replacing PCs with Mobile Phones in a Rural Sugarcane Cooperative." *Information Technologies and International Development* 5 (1): 81–95.

WEF (World Economic Forum). Various years. Competitiveness Index (database). WEF, Davos, http://www.weforum.org/reports/global-competitiveness-report-2014-2015.

Weiberg, Bruce. 2000. "Computer Use and the Demand for Female Workers." *Industrial Relations Review* 53 (2): 290–308.

World Bank. Various years. Central Asia World Bank Skills surveys (database), World Bank, Washington, DC.

———. Various years. East Asia Pacific Region MicroDatabase, World Bank, Washington, DC.

———. Various years. Europe and Central Asia Poverty (ECAPOV) database, World Bank, Washington, DC.

———. Various years. I2D2 (International Income Distribution Database). World Bank, Washington, DC, http://econ.worldbank.org/WBSITE/EXTERNAL/EXTDEC/EXTRESEARCH/0,,contentMDK:20713100~pagePK:64214825~piPK:64214943~theSitePK:469382,00.html.

———. Various years. Skills Towards Employability and Productivity (STEP) household surveys (database), World Bank, Washington, DC, http://microdata.worldbank.org/index.php/catalog/step/about.

———. Various years. South Asia Region MicroDatabase (SARMD) (database), World Bank, Washington, DC.

———. Various years. Survey-based Harmonized Indicators Program (SHIP) (database), World Bank, Washington, DC, http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/AFRICAEXT/EXTPUBREP/EXTSTATINAFR/0,,contentMDK:21102610~menuPK:3084052~pagePK:64168445~piPK:64168309~theSitePK:824043,00.html.

———. Various years. World Development Indicators (database). World Bank, Washington, DC, http://data.worldbank.org/data-catalog/world-development-indicators.

———. 2010. *Skills Demand Survey for FYR Macedonia*. Washington, DC: World Bank.

———. 2011. *World Development Report 2012: Gender Equality and Development*. Washington, DC: World Bank.

———. 2012. *World Development Report 2013: Jobs.* Washington, DC: World Bank.

———. 2013. *World Development Report 2014: Risk and Opportunity: Managing Risk for Development.* Washington, DC: World Bank.

———. 2014a. *The Opportunities of Digitizing Payments.* Prepared by the World Bank Development Research Group for the G20 Australian Presidency. Washington, DC: World Bank.

———. 2014b. *Levelling the Field: Improving Opportunities for Women Farmers in Africa*. Washington, DC: World Bank.

———. 2014c. *Youth Employment in Sub-Saharan Africa*. Washington, DC: World Bank.

SECTOR FOCUS 2

Education

Educational policy makers and planners face a persistent challenge related to the potential use of information and communication technologies (ICTs) in remote, low-income communities around the world: most products, services, usage models, expertise, and research related to ICT use in education come from high-income contexts and environments. One consequence is that "solutions" enabled by technology are imported and "made to fit" in environments that are often much more challenging. Sometimes this works; sometimes it doesn't. The One Laptop per Child project in Peru provided hundreds of thousands of pieces of low-cost computing equipment to students in rural schools. But early research found no evidence of increased learning in math or language.[1] This is one high-profile example of the difficulties faced in introducing hardware-centric educational technology projects conceived in highly developed environments into less developed places without sufficient attention to local contexts.

An alternate approach would consider how to innovate using existing technology that is already available in a local environment. In addition to exploring the uses of new technologies, it might also be useful to ask, *How can we innovate using what is already available?* In many low-resource communities, the best technology is the one that people already have, know how to use, and can afford. In most circumstances, this is the mobile phone. The SMS Story project in rural Papua New Guinea is one example of an innovative approach to using a "new" technology in ways that meet local needs and that the original designers of the technologies may not have dreamed of.

Few educational environments are more challenging than those found in remote locales in the Pacific island nation of Papua New Guinea. These areas are characterized by poverty, low levels of literacy, geographic remoteness, linguistic diversity (over 800 languages are spoken across the island nation), low teacher quality, and a lack of teaching and learning materials. Many rural classrooms have few books—and some none at all. Few students read at grade level, and teachers often do not know what materials they are meant to cover in a given week—or how to teach them effectively. Most of them do, however, have mobile phones.

The SMS Story project demonstrates that it is possible to orient and motivate teachers in useful ways using technologies already at hand. It sent daily text message stories and teaching tips to teachers as an aid to help improve student reading. The result? Teachers were reminded and motivated to teach reading every single day. While reading comprehension did not noticeably improve, the intervention halved the number of children who could not read anything. While this was hardly a "silver bullet" solution, SMS Story offers one model for using connected technologies in simple ways to help address some long-standing, seemingly intractable challenges facing educators in rural schools in Papua New Guinea. While no one would suggest that these results imply that these schools do not need books, such simple interventions can be modestly transformative in ways that are inclusive, efficient, and scalable.[2]

The evidence base for investments in educational technologies in middle- and low-income countries is weak—but growing. Until recently, there were few rigorous randomized studies on the impact of investments in educational technologies that could inform related policy decisions; now there are almost two dozen. In addition, a significant body of practical evidence has also been collected based on experiences

This sector focus was contributed by Michael Trucano.

in middle- and low-income countries. Characteristics of many successful technology-enabled educational projects in such places include:

- A focus on the "guided use" of technology, and not just providing tools for general use;
- Providing relevant curricular materials;
- The shared use of devices in school settings;
- Attention to pedagogy, teacher support, and development;
- Using technologies in ways that are supplemental and practical; and
- Using evaluation mechanisms that go beyond outputs.[3]

A number of key challenges remain that inhibit the potential positive impact of new technologies on teaching and learning. Foremost among these are a pernicious focus on providing technology alone, and a related belief that educational challenges can be overcome simply by providing more and better devices and connectivity. The so-called Matthew Effect of educational technology holds that those most likely to benefit from the use of new technologies in educational settings are those who already enjoy many privileges related to wealth, existing levels of education, and prior exposure to technology in other contexts. Policies that neglect to consider this phenomenon may result in projects that exacerbate existing divides within an education system, and indeed within larger society.

Education challenges cannot be overcome simply by providing more and better ICT devices and connectivity. There is sometimes talk that technology will replace teachers. In reality, experience from around the world demonstrates that, over time, the role of teachers becomes more central—and not peripheral—as a result of the introduction of new technologies.[4] That said, *while technology will not replace teachers, teachers who use technology will replace those who do not.* These teachers, in addition to having a suite of basic technology-related skills, will be asked to take on new, often more sophisticated duties and responsibilities in ways that will challenge the existing capacity of many educational systems to prepare and support teachers over time.

Understanding the local education challenge and context before proposing a technology-driven solution is a critical first step. A number of recent articles in the popular press have proclaimed many high-profile efforts to use new technologies within educational systems, including variations of the One Laptop per Child initiative in countries around the world, as "failed experiments." The speed of technological change almost always outpaces the ability of educational planners to keep up. When it comes to the use of technology in education, educational systems may therefore be fated to exist effectively in a state of permanent experimentation. That said, experiments should, by definition, teach something. A sad fact of too many experiments in educational technology use around the world remains that they have implemented technological "solutions" to problems that have not been well understood. If you are pointed in the wrong direction, technology may help you get there more quickly. At a fundamental level, many of these efforts are not really failures of technology, but rather a result of poor planning and an inability to learn from failure and adapt. As such, they are not a result of technology failures, but rather human ones.

Notes

1. Cristia and others 2012.
2. Kaleebu and others 2013.
3. Drawn from Arias Ortiz and Cristia (2014).
4. McEwan 2014; Trucano 2015.

References

Arias Ortiz, Elena, and Julián Cristia. 2014. *The IDB and Technology in Education: How to Promote Effective Programs?* Washington, DC: Inter-American Development Bank.

Cristia, J., P. Ibarraran, S. Cueto, A. Santiago, and E. Severin. 2012. "Technology and Child Development: Evidence from the *One Laptop per Child* Program." IDB Working Paper IDB-WP-304, Inter-American Development Bank, Washington, DC.

Kaleebu, N., A. Gee, R. Jones, and A. H. A. Watson. 2013. *SMS Story Impact Assessment Report, VSO, Papua New Guinea.* Papua New Guinea Department of Education, VSO (Voluntary Services Overseas), and Australian Aid. http://www.vsointernational.org/sites/vso_international/files/sms-story-impact-assessment-report_tcm76-41038_0.pdf.

McEwan, P. 2014. "Improving Learning in Primary Schools of Developing Countries: A Meta-Analysis of Randomized Experiments." *Review of Educational Research Month* (October 7), Wellesley College, Wellesley, MA.

Trucano, M. 2015. "Mobile Phones & National Educational Technology Agencies, Sachet Publishing & the Khan Academy: What's Happening with Educational Technology Use in Developing Countries?" Excerpts from the World Bank's EduTech blog (Volume VI). World Bank, Washington, DC. http://siteresources.worldbank.org/EDUCATION/Resources/EduTechBlog2014_all_the_posts.pdf.

SPOTLIGHT 3

ENABLING DIGITAL DEVELOPMENT

Social media

When considering another person in the world, a friend of your friend knows a friend of their friend, on average.

—Lars Backstrom and colleagues, "Four Degrees of Separation" (2012)

That remarkable statement cannot yet be applied to everyone in the world, but a 2011 study showed that it pertained to the active users of Facebook—some 721 million people at the time, and their 69 billion friendships.[1] The average of 3.7 intermediary links between randomly selected people in the global Facebook population contrasts with the 5.7 links between Nebraska residents and Bostonians documented in Milgram's famous "six degrees of separation" study from 1967.[2] From 2011 to early 2015, the network's user base had doubled, with each user having an average of 338 "friends." This is more than twice Dunbar's number, which asserts that 150 is the maximum number of stable relationships that humans can retain.[3] These statistics show some of the ways in which social networks are expanding and changing with the advent of social media on the internet.

Social networks are fundamental to human society. They constitute the fabric of relationships that support trust, reputation, and social cohesion. For instance, a debtor may be less likely to default on a loan if both she and her lender share a dense network of mutual friends. Social networks exert peer pressure on behavior and shape aspirations for work, marriage, and consumption. By defining social boundaries, they can be instruments both of social inclusion and exclusion. They also are a conduit of gossip, slander, harassment, bullying, and infectious disease, as well as job opportunities and innovative ideas.

One of the clearest channels by which networks affect economic development is the diffusion of innovations. Networks provide the medium through which people learn of an innovation. Adoption by a trusted person then initiates a chain reaction of adoptions through the network, accelerating as peer pressure bears on laggards. The impacts can be large. An experimental study on the adoption of weather insurance (an unfamiliar innovation) by Chinese farmers found that, while attending an intensive information session on the product boosted take-up rates by 43 percent, merely having a friend who attended such a session had almost half that effect, and was equivalent in impact to a 15-percent subsidy.[4] Impacts were larger when those initially informed were more central to the network. Social networks are also important channels for transmission of health behavior, and there is a tendency for people with poor health behavior to clump in networks isolated from those with healthier behaviors.[5]

Enter the internet, in the form of Facebook, LinkedIn, and Twitter based in the United States; Sina Weibo and WeChat in China; VK in the Russian Federation; and many other social media platforms designed to encourage the formation of social links. There are many types of social media, but social networking sites and microblogs are most relevant in the context of social and economic development. A simple typology is based on whether communication is directed at specific recipients, and whether ties are explicit (prompted by invitation, acceptance, or reference within a social network) or not (table S3.1).

Social scientists distinguish between weak ties and strong ties in social networks. Weak ties exist between

WDR 2016 team, incorporating contributions from Robert Ackland and Kyosuke Tanaka.

Table S3.1 Relationships in different types of social media

	Direction of ties and examples	
Type of ties	**Directed**	**Undirected**
Explicit	Friendship networks (Facebook, Google+)	Microblog networks (Sina Weibo, Twitter)
Implicit	Semantic networks (recommendation systems, social tagging systems)	News groups, blogs

Source: Ackland and Tanaka 2015.

people who could be considered acquaintances rather than friends. Such ties can be useful to transmit novel information about technologies or other useful and new knowledge, since information comes from people with whom interaction is more sporadic. Strong ties, between people who have more in common (family, friends, or close colleagues), are a source of emotional support but may be less important as a source of novel information, since members of a close group are likely to have the same information. Strong ties within "closed" groups with relatively weak ties to outsiders can be important, as this may increase trust and facilitate coordination, in part because of the high reputational cost of bad or unproductive behavior within the group. Social capital is likely higher in groups linked by strong ties. Social networking sites are considered more important for developing strong ties, while microblogs foster weak ties. One observer compared Facebook to a cocktail party where you are surrounded by people you know and like, while Twitter is like someone standing at a street corner with a megaphone shouting "Check this out!"

Social media platforms change the dynamics of social networks in at least three ways. First, they encourage expansion of the scope and density of networks, since links are very easy to form, regardless of physical distance. Second, they speed the diffusion of information between links. Third, they increase the visibility of opinions and some behaviors across the network. Research on the development impacts of social media is still at an early stage, but there is some evidence on how they affect economic development, how they prompt changes in behavior, how they help in emergency situations, and how they can increase people's voice.[6]

Social media and economic development

Social media act as a channel for communication and information exchange, thus reducing transaction costs for economically beneficial, as well as potentially harmful, interactions. Research in Nigeria showed that social media supported microfinance by facilitating information flow to the poor and small business owners.

A study of a group of women in Jakarta showed that their use of social media encouraged their entrepreneurial activities and helped them find customers for their products, although the specific context of this study—they were middle-class urban residents—may not be transferable to every other place. Social media sites can also be a source for economically useful data, including about consumer preferences and complaints.

Social media and behavioral change

Commercial ventures take advantage of the features of social media—often for marketing purposes—as they exploit the huge amounts of information about personal preferences, buying habits, and relationships. But online behavior can also be channeled in ways that are consistent with development. For instance, individuals can be encouraged to share their progress in meeting exercise or learning goals with their social network, thus using peer pressure and competition to maintain motivation. Experiments show that, in principle, networks can be manipulated to encourage desired outcomes. For instance, an online experiment showed that when participants were networked in tight clusters, a promoted health practice diffused more quickly than in a loosely structured network.[7]

Social media and emergencies

Before, during, and after natural disasters or other urgent crises, social media platforms are useful for disseminating information and as a management tool, such as to channel requests for assistance. The key contribution is that information does not just flow one way from officials to citizens as through radio or television, but in all directions between officials, citizens, and the private sector.

SPOTLIGHT 3

Social media and community voice

Recent events such as the Occupy Wall Street movement or the Arab Spring have raised questions about the role of social media in facilitating social change. Some analysts think social media played a central role, including by spreading democratic ideals across borders. They also make movements less dependent on charismatic leaders or ideologues. Others are more skeptical, arguing that revolutions occurred long before social media, and the apparent inability to form strong leadership through such tools can reduce the chances for lasting change. An additional issue is the role of social media in spreading false information or to correct misinformation. The intensity of a crisis changes the quality of information shared on Twitter. And, interestingly, fact-checking conversations on Twitter are more likely to occur between strangers than between friends. Whether social media can encourage collective fact-checking will influence its role in social learning in the context of social and economic development.

There is still much to learn about the role that social media can play in development. One important lesson is that their impact is country-specific and context-specific. Variations in access to technology and education obviously matter. But there are also large variations in how people use social media and how they share information. People will more likely share information broadly if they think they can influence events or policy. There is evidence that people in more authoritarian countries are less likely to forward (re-tweet) information.

Finally, general-purpose social media platforms may have less of an impact in poor communities compared with more targeted social media interventions. Examples in other parts of the Report show that purpose-built platforms set up by public institutions or development agencies as part of program delivery may be more effective. They could, for instance, deliver extension services to farmers or connect participants with leaders to foster aspirational change.

Notes

1. By March 2015, Facebook had 1.4 billion active monthly users worldwide.
2. Milgram 1967.
3. Dunbar 1992.
4. Cai, de Janvry, and Sadoulet 2015.
5. Centola 2011.
6. See Ackland and Tanaka 2015 for individual references.
7. Centola 2010.

References

Ackland, Robert, and Kyosuke Tanaka. 2015. "Development Impact of Social Media." Background paper for the *World Development Report 2016*. World Bank, Washington, DC.

Backstrom, Lars, Paolo Boldi, Marc Rosa, Johan Ugander, and Sebastiano Vigna. 2012. "Four Degrees of Separation." Presented at ACM Web Science Conference 2012, Evanston, IL, June 22–24.

Cai, Jing, Alain de Janvry, and Elisabeth Sadoulet. 2015. "Social Networks and the Decision to Insure." *American Economic Journal: Applied Economics* 7 (2): 81–108.

Centola, Damon. 2010. "The Spread of Behavior in an Online Social Network Experiment." *Science* 329 (5996): 1194–97.

———. 2011. "An Experimental Study of Homophily in the Adoption of Health Behavior." *Science* 334 (6060): 1269–72.

Dunbar, Robin. 1992. "Neocortex Size as a Constraint on Group Size in Primates." *Journal of Human Evolution* 22 (6): 469–93.

Milgram, Stanley. 1967. "The Small World Problem." *Psychology Today* 2 (1): 60–67.

CHAPTER 3

Delivering services

Have digital technologies made governments more willing and able to deliver services to their citizens? Not yet. Governments have invested heavily in digital technology over the past two decades, and these efforts have made it easier in many countries for businesses to file taxes, and for the poor to get an official identity allowing them to receive welfare payments and vote in elections. Digital technologies have also enabled governments to receive regular feedback from service users, improving service quality. But all too often the successes are isolated—limited to a few activities, sectors, or locales. Many investments in e-government fail to have any impact other than wasting scarce fiscal resources. Digital channels for mobilizing citizens to pressure policy makers to become more responsive have had little effect. And the new technologies have enhanced the capacity of unaccountable governments for surveillance and control. In sum, digital technologies have helped willing and able governments better serve their citizens, but they have not yet empowered citizens to make unwilling governments more accountable.

Efficient service delivery requires a capable government that can implement policies and spend public resources effectively. It also requires an empowered citizenry able to hold politicians and policy makers to account so that governments serve citizens and not themselves or a narrow set of elites.[1] Digital technologies can strengthen government capability and empower citizens through three mechanisms (figure 3.1). They overcome information barriers and promote participation by citizens in services and in elections. They enable governments to replace some factors used for producing services through the automation of routine activities, particularly discretionary tasks vulnerable to rent-seeking, and to augment other factors through better monitoring, both by citizens through regular feedback on service quality and within government through better management of government workers. And by dramatically lowering communication costs through digital platforms, they enable citizens to connect with one another at unprecedented scale, fostering citizen voice and collective action.

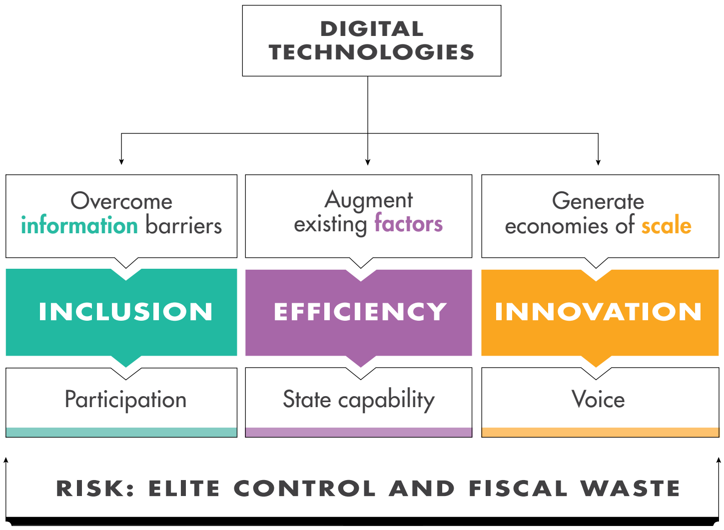
But the impact of these mechanisms on capability and empowerment depends on the strength of government institutions. Institutions are the formal and informal rules that shape the incentives and behaviors of politicians, government officials, and citizens. Strong institutions create incentives for politicians to work toward the public good and for bureaucrats to be accountable to those politicians. Digital technologies, aligned with the incentives of politicians, government officials, and service providers, can thus be highly effective in improving outcomes. By contrast, politicians in clientelist political institutions are largely accountable to a small set of elites and reject digitally enabled reforms that hurt vested interests; instead, they use these technologies for greater control. And patronage-based bureaucracies resist e-government advances that would reduce discretion and rent-seeking. This misalignment between digital technologies and weak or unaccountable institutions creates the twin risks of increasing elite control and wasting scarce public resources on ineffective e-government projects.

Why do these institutional constraints persist? Digital technologies, particularly social media, have uncovered egregious abuses of public authority and triggered both virtual and physical citizen protests around scandals. But they haven't sustained collective action around failures of service delivery. Service delivery problems are more difficult to monitor and attribute to specific government officials, and only rarely become salient in flashpoint events that trigger protests—like the excessive use of force by police. And they cannot be improved by one-off actions that change a bad policy or pass a new law. Addressing service delivery failures requires sustained citizen voice through effective offline mobilization by civil society organizations. But in the absence of willing and able governments to partner with, civil society initiatives often remain small, with limited citizen interest or impact.

The dependence of digital technology on initial institutional conditions, though, varies by service and activity. For services and activities based on more routine tasks that are easy to monitor, digital technologies can improve outcomes rapidly and significantly—even when institutions are relatively weak. In effect, the technology substitutes for the institutions, as with cash transfers, licensing and registration services, and monitoring elections, all much improved by digital technologies in many low-income countries. But for services and activities that require more discretion from workers and are hard to monitor, the quality of institutions is much more important, and digital technologies have an incremental effect. The technology only complements or augments the initial institutions, as with teaching, health care, and organizational management, where digital technologies have an impact only if institutions are strong.

Given the importance of institutions for service delivery, the policy agenda is to use digital technologies to strengthen institutions. The variation in interaction of institutions and digital technologies by service and activity, and the considerable heterogeneity of institutions even within countries, can guide policy and open many possibilities for service improvements in even the most challenging contexts—in short, for digital dividends.

Figure 3.1 A framework for digital technologies and government service delivery



Source: WDR 2016 team.

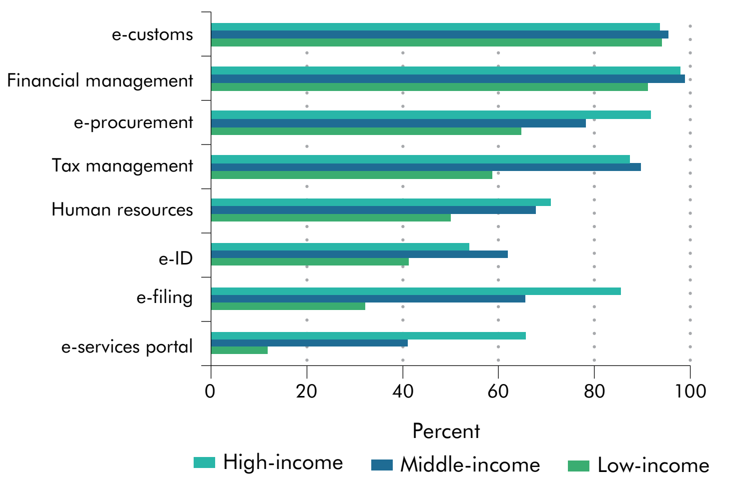
Connected governments

The advent of the internet in the mid-1990s triggered the rapid diffusion of e-government systems to automate core administrative tasks, improve the delivery of public services, and promote transparency and accountability. By 2014, all 193 member-states of the United Nations had national websites: 101 enabled citizens to create personal online accounts, 73 to file income taxes online, and 60 to register a business.[2] In all, 190 countries had automated government financial management, 179 had automated customs, and 159 had automated tax systems. And 148 countries had digital identification schemes, although only 20 had multipurpose digital identification for such services as voting, finance, health care, transportation, and social security.

Developing countries have invested more in core government administration systems like financial management, customs, and tax management than in transactional government-to-citizen and government-to-business services like e-filing of taxes and portals that enable citizens to access a variety of services from one website (figure 3.2). Policy priorities are also evident in cross-national patterns of the detailed indexes of different e-government systems constructed for this report.[3] The level of e-government unsurprisingly increases with per capita income, but the gap between high-income and low-income

Figure 3.2 Low-income countries have invested heavily in e-government

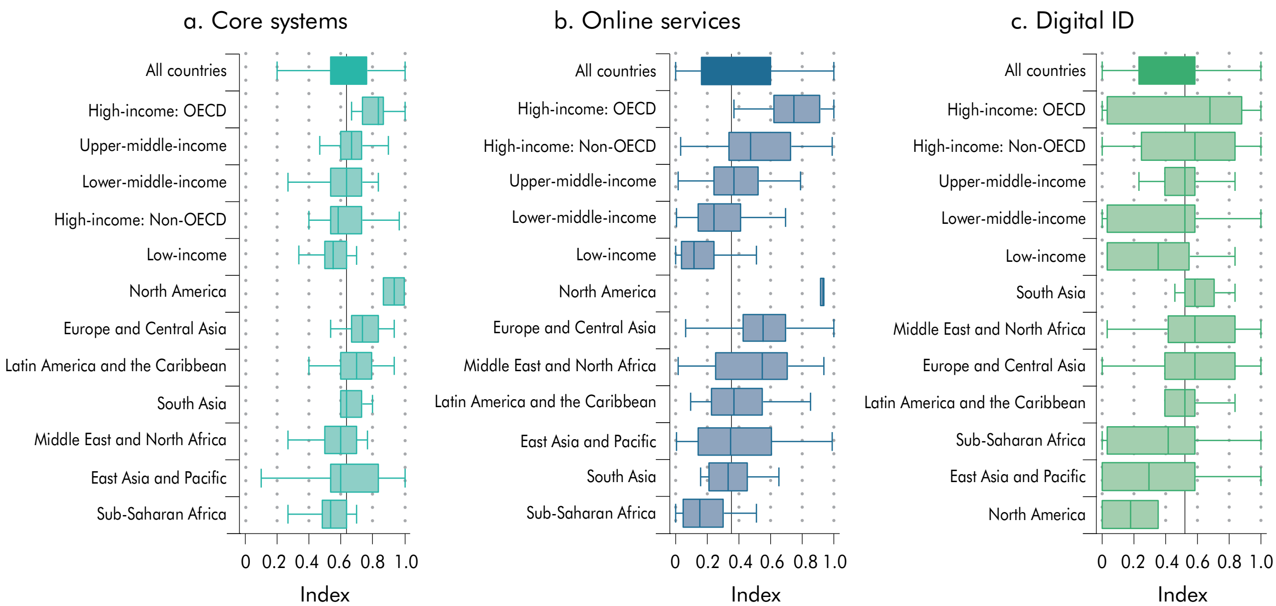
Main e-government systems, 2014



Sources: WDR 2016 team, based on World Bank Global e-Government Systems database 2015b; World Bank Global Digital Identification for Development (ID4D) database 2015c; UN 2014. Data at http://bit.do/WDR2016-Fig3_2.

Figure 3.3 The priority in low-income countries has been core e-government systems, 2014

Indexes of e-government systems, by income and region



Sources: WDR 2016 team, based on World Bank (2015b) Global e-Government Systems database; World Bank Global Digital Identification for Development (ID4D) database; UN 2014. Data at http://bit.do/WDR2016-Fig3_3.

Note: The left and right of each box plot represent the first and third quartiles, and the line in the middle of each box plot is the median. The two ends of the whiskers represent the 10th and the 90th percentile observations. The core e-government index in panel a measures the automation and integration of countries' financial management information systems (including budget formulation and execution functions, source of public finance data, and treasury account structure); human resources management information systems (including personnel management and payroll); e-tax systems (including e-filing and tax administration systems); e-customs; and e-procurement. The online services, panel b, index is prepared by the United Nations Department of Economic and Social Affairs as part of its overall e-government index. The Digital ID index, panel c, measures the extent to which electronic identification can be used to access services, whether it features magnetic-strip or smart-chip technology, and whether it has embedded digital signature capabilities. OECD = Organisation for Economic Co-operation and Development.

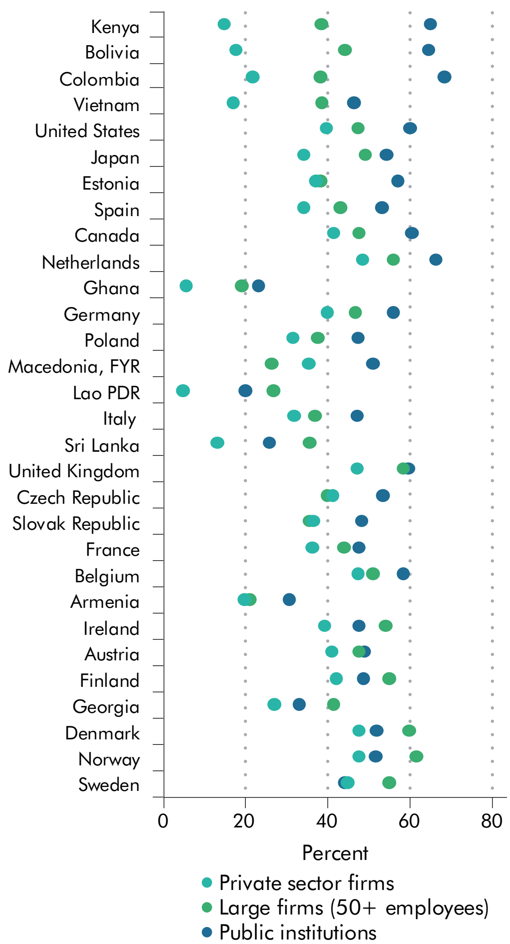
countries is lowest for administrative systems and highest for online services for citizens and businesses, with digital identification systems in the middle (figure 3.3). Fifteen middle-income countries score in the top quartile of administrative e-government systems, with Brazil, Colombia, Mexico, and Peru in the top 10 worldwide, and Nepal, Rwanda, and Uganda scoring highly among low-income countries. India and Pakistan have more advanced digital identification systems than high-income North American countries, pointing to the potential for "leapfrogging" that these technologies offer.

Governments are more intensive users of information technology than firms. Survey data on the use of digital technologies (computers, mobile phones, and the internet) in nonagricultural jobs from 30 countries show that in all but one country, a higher share of public sector workers are in jobs that require frequent use of the technology in their daily work as compared to private sector workers (figure 3.4). This gap is not surprising for developing countries, where most firms are small and in the informal sector. For example, more than 60 percent of public sector workers are in jobs that require intensive use of technologies in Bolivia, Colombia, and Kenya, compared with only approximately 20 percent of private sector workers. But the gap persists in 22 of the countries when the public sector is compared only with large private sector firms (those with more than 50 employees). Governments are also more intensive users of technology in high-income countries like Germany, Japan, and the United States.

Whether this substantial investment in e-government has strengthened state capability and improved outcomes will be explored at length in the next section. One indication of the limited return on these investments is citizen use of e-government services, which has lagged behind supply (figure 3.5, panel a). Even in countries where internet access is not a constraint, as in Europe, citizens use e-government mostly to get information (on average 44 percent of individuals in the European countries for which data are available visited a government website at least once in the past year to get information) and not for trans-

Figure 3.4 Governments use digital technologies more intensively than private sector firms, 2014

Share of workers in jobs that require intensive use of digital technologies (private or public sector)



Sources: WDR 2016 team, based on STEP 2014 and PIAAC 2014 household surveys. Data at http://bit.do/WDR2016-Fig3_4.

Note: Excludes the agricultural sector. Public institutions include government administration, public utilities, and state-owned corporations. The countries are sorted in descending order of the gap between the public and the private sectors.

acting with government (only 29 percent returned a form online in the past year). These patterns are also reflected in surveys of citizens in Australia, Canada, and New Zealand—countries that rank 8, 10, and 15, respectively, in the provision of online services. The majority of respondents use government websites for information and prefer to use traditional channels like voice calls to undertake transactions such as registering their children for day care.[4]

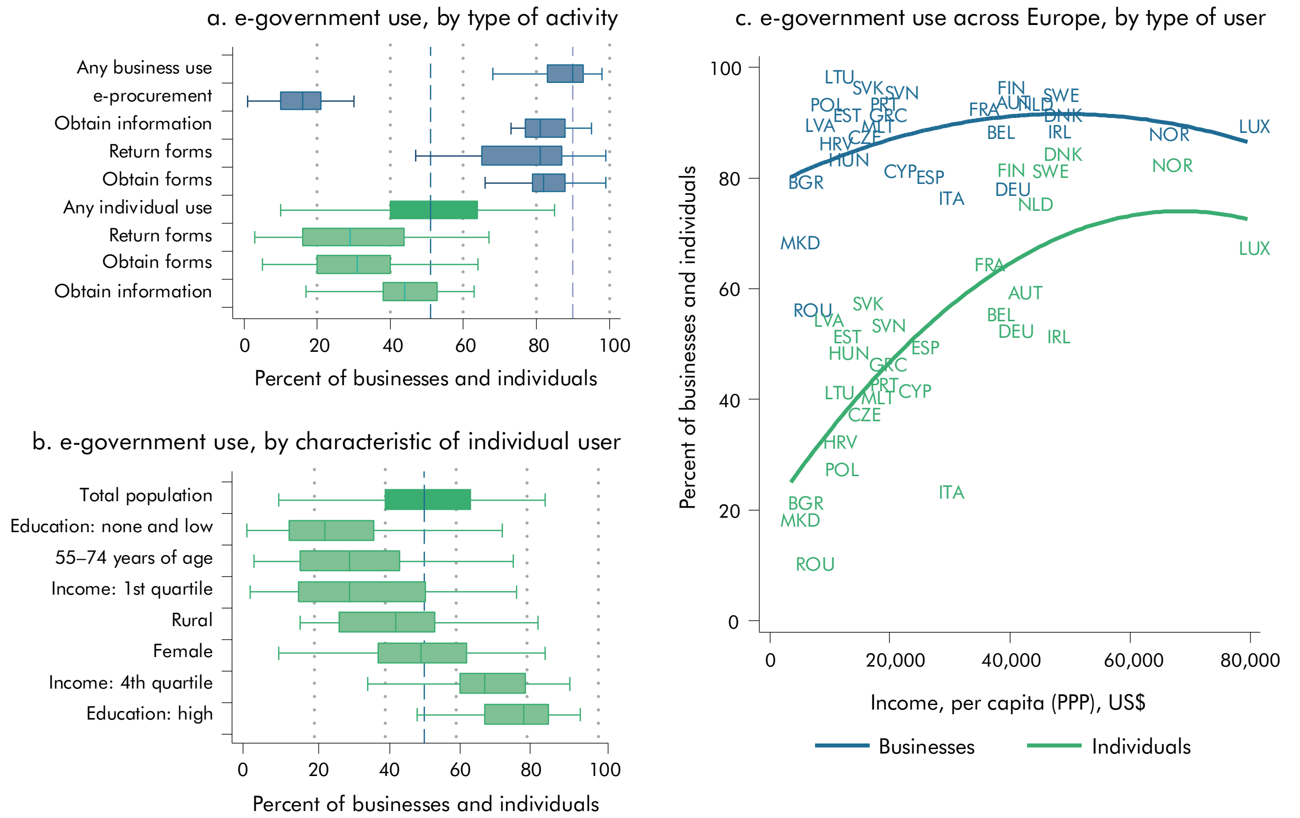
Both between and within European countries, the use of e-services depends on income. Three times as many citizens use online services in the richest countries than in the poorest, with a similar gap between the highest and lowest income quartiles within countries (figure 3.5, panel b). Within countries, use is unsurprisingly associated with age, education, and urban residence. Businesses are more likely than individuals to use the internet to transact with the government (figure 3.5, panel c), and the use of e-services by business is also less sensitive to income across countries.

In low-income countries, limited internet access means that mobile phones, not the internet, drive interconnectedness, as chapter 2 discussed. Surveys of the use of digital technologies in 12 African countries reveal that only 5 percent of individuals had used the internet to obtain information from, or interact with, the government, compared to 63 percent of respondents who had used their mobile phones to contact health workers (figure 3.6). Internet-based e-services will therefore be biased against the poor in developing countries. Mobile e-government portals have become more common, nearly doubling from 25 countries in 2012 to 48 in 2014, but still are not on par with internet services.[5] More than three-quarters of countries archive information on their websites for education, health, and finance services, but fewer than half send e-mail or Rich Site Summary (RSS) updates, and only a handful send short message service (SMS) updates.

Greater state capability and citizen participation

What impact have these significant investments in e-government had on strengthening government capability to deliver services and expanding citizen participation? If politicians and policy makers want to improve services, they need a capable government to convert policies and spending into better outcomes. Resources must be collected and spent without leakage. Teachers and health workers must be present in classrooms and clinics, and then must be motivated to work. Beneficiaries of government programs must be properly identified and reached. And governments often must help citizens make better decisions, overcoming bad habits or a lack of information. But as underlined in the 2004 *World Development Report*, *Making Services Work for Poor People*, and subsequent research, weaknesses in each of these links in the service delivery chain make services fail in developing countries. Improving government capability or implementation capacity is key for effective service delivery.

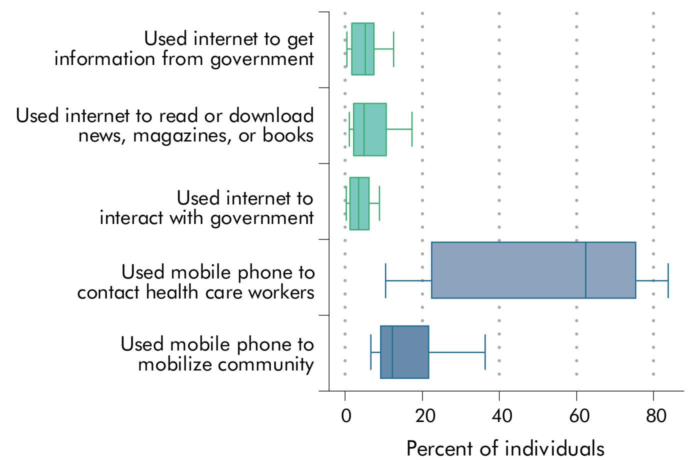
Figure 3.5 Citizen use of e-government in Europe depends highly on income, 2014



Source: WDR 2016 team, based on Eurostat (EC 2014). Data at http://bit.do/WDR2016-Fig3_5.

Note: Panels a and b show how businesses (in blue) and individuals (in green) use e-services for 29 European countries by type of activity and individual characteristics. Panel c shows the variation in use across the European countries. *Individuals* refer to those aged 16 to 74; *businesses* refer to those with 10 or more employees. PPP = purchasing power parity.

Figure 3.6 Mobile phones are the main channel for citizens to interact with governments in Africa, 2014



Sources: WDR 2016 team, based on Research ICT Africa surveys 2014 of 11 countries. Data at http://bit.do/WDR2016-Fig3_6.

Note: The left and right of each box plot represent the first and third quartiles, and the line in the middle of each box plot is the median. The two ends of the whiskers represent the 10th and the 90th percentile observations.

Digital technologies can help improve government capability and citizen participation by:

- *Informing citizens and giving them an official identity* so that individuals can make better decisions for their health, their safety, and education for their children, and can access a variety of publicly and privately provided services;
- *Streamlining processes* to reduce discretion and opportunities for rent-seeking, ensuring that public resources are collected and spent efficiently, without leakage;
- *Receiving feedback* from service users to regularly track satisfaction, identify problems, and improve service quality;
- *Improving service provider management through better monitoring* so that government workers both show up at work and are productive.

Digital technologies have had varying impacts across these channels (table 3.1). The clearest impact involves addressing a lack of information and weak

Table 3.1 The impact of digital technology on government capability to deliver services: A scorecard

Channel	Impact of technology	Main problem to address	Do digital technologies solve the problem?
Informing citizens and giving them an identity	H	Poor information and communication	• Yes, when poor information is the main barrier to improving service outcomes
Streamlining processes	M	High transaction costs; rent-seeking	• Sometimes, given the considerable heterogeneity of impacts across countries and the high risks and rewards of reforms
Receiving user feedback	M	High transaction costs; rent-seeking	• Yes, when citizens have an incentive to complain and services can be easily monitored • No, otherwise
Improving service provider management	L	Information asymmetries	• Yes, for reducing ghost workers and absenteeism • No, for improving provider accountability for services that cannot be easily monitored

Source: WDR 2016 team.

Note: Channels are arranged by degree of technology impact. L = low; M = medium; H = high.

communication—citizens' lack of knowledge about issues that affect their welfare, their inability to communicate with one another and with government, and government's inability to be informed about citizens. For example, the provision of information to citizens, particularly to poor citizens in remote locations through mobile phones, has helped people make better decisions on a variety of issues. And digital identification, by giving poor citizens a verifiable identity, has enabled them to participate in public and private services previously denied to them.

Digital technologies have been less effective in solving government failures associated with rent-seeking and in strengthening the incentives of government bureaucrats and service providers to perform due to principal-agent problems associated with information asymmetries. Automating government functions and services has been at best partially successful; these are often complex and costly systems to implement. The failure rate is high, and so is the risk of wasting public funds. Citizen feedback has been effective when citizens have an incentive to provide feedback and the services are fairly easy to monitor, and when governments have the capacity to respond to this feedback. It is not effective when these conditions are absent. Aside from a few isolated examples of reducing absenteeism, digital technologies have not significantly improved service provider management in government bureaucracies.

Informing citizens and giving them an identity

Digital technologies are enabling governments to overcome barriers of geography, low physical connectivity, and limited administrative capacity to provide information and deliver services to previously unreached citizens, improving citizen participation and choice. The most popular and promising innovations in poor countries entail the use of mobile phones to implement a variety of health interventions—so-called "m-health" (mobile health) initiatives. These can focus on either health providers, such as point-of-service data collection, disease surveillance, health-promotion campaigns, and telemedicine; or on citizens, such as SMS reminders to parents to get children vaccinated or to patients to undertake therapy (sector focus 3). While hundreds of pilot m-health initiatives are underway, robust evidence in developing country contexts is limited largely to the positive effects of reminding patients to adhere to their antiretroviral therapy schedules.[6] Initial results from pilots in Bangladesh, India, South Africa, and Tanzania suggest that regular SMS communication can induce similar behavior changes in expectant mothers by providing information on neonatal health.[7] The initial results are also promising from m-health initiatives that assist health providers in recording patient information, monitoring pregnancies, and reporting drug stock-outs.[8]

Box 3.1 Digital technology and crisis management

Digital technologies have helped monitor and manage human and natural disasters, such as wars, floods, earthquakes, and epidemics. The internet can help in coordinating data flows and improving the timeliness of decision making, while mobile phones can disseminate vital information. Social media can also help survivors communicate their status and mobilize volunteer resources and donations outside the disaster zone. A few examples of responses to recent crises show the range of possibilities:

- The Ebola epidemic in Guinea, Liberia, and Sierra Leone created logistical challenges for the organizations that responded, not least how to pay fieldworkers in remote and rural locations, many of them not local. The United Nations Development Programme set up a scheme to use mobile phones to make direct payments to the Ebola response workers in Sierra Leone and Liberia, who numbered some 60,000 at the height of the crisis.[a]
- The earthquakes that struck Nepal in April and May 2015 left at least 8,500 people dead, more than 17,000 injured, and many thousands homeless. Although donations came in from all over the world, ensuring that aid reached the areas most affected proved a challenge. One response, coordinated by Kathmandu Living Labs,[b] was to develop a dynamic map (quakemap.org) as a centralized platform for displaying incident reports and offers of assistance. The map is built around the OpenStreetMap and uses the Ushahidi platform for incident reports—both based on open-source software and crowdsourced information.[c]
- Recovering from conflict and civil war requires long-term nation building, and more than 40 countries have adopted Truth and Reconciliation Commissions (TRCs) to assist in this process.[d] The Liberia TRC received some 20,000 statements from Liberians, at home and in the diaspora. Many depositions were audio and video recordings, now stored as a permanent memorial at the TRC website (http://trcofliberia.org/). Interestingly, the videos have been viewed four times more often than the TRC's final report, indicating the reach of multimedia for storytelling at the human scale.[e]

a. See http://www.sl.undp.org/content/sierraleone/en/home/presscenter/articles/2015/05/12/mobile-pay-for-thousands-of-ebola-workers.html.
b. See http://www.kathmandulivinglabs.org/.
c. See http://www.bbc.com/news/world-asia-32603870.
d. Kelly and Souter 2014.
e. Best 2013.

This use of digital technologies to overcome geographic, infrastructure, and administrative bottlenecks to information and communication is particularly powerful in emergencies like disease outbreaks, natural disasters, and conflict (box 3.1).

Digital technologies can also strengthen social norms and promote civic behavior like voluntary tax compliance or energy conservation through "peer comparisons"—making an individual's actions more observable to others and making others' actions more observable to the individual.[9] For instance, tax evasion is pervasive in developing countries. Some governments collect less than half the taxes due to them.[10] Simple behavioral nudges, such as naming and shaming tax delinquents by publishing their names on websites, can be a cost-effective intervention even in low government capacity contexts. Such peer comparisons have improved tax compliance in Norway and the United States, although the developing country evidence is more mixed.[11] Comparisons of a household's power consumption with that of neighbors, as done by companies like Opower, can also help conserve energy through peer pressure.[12]

Weaknesses in civil registration in developing countries mean that approximately 2.4 billion people in the world do not have birth certificates and other official documents to prove who they are, preventing many from opening bank accounts, registering property, or receiving public transfers.[13] Digital identification (ID) programs that use biometrics to register and authenticate individuals, although complex and thus risky to implement, provide a robust solution to this problem. They enable poor countries to leapfrog the decades-long processes that developed countries went through to build their traditional, paper-based civil registration systems (see spotlight 4). These schemes are expanding; 148 of 197 countries have some form of electronic ID. But only 20 countries have a multipurpose ID with digital signature capability that can be used for multiple online and offline services; 100 have digital identification systems limited to a few functions (services like voting or public sector payroll that cover only subsets of the general population); and 49 have no digital ID of any kind.[14]

Evidence on the impact of these schemes, while largely anecdotal, points to significant potential benefits of reducing leakages in government welfare

Box 3.2 Empowering women through digitally enabled social programs

Safety net programs are becoming more effective through digital systems for registering, authenticating, and paying beneficiaries, promoting inclusion and empowering women.

Consider the Absa Sekulula ("It's easier") welfare payment card in South Africa, the Benazir Income Support Programme (BISP) in Pakistan, and a pilot mobile money cash transfer experiment in rural Niger. The programs in Pakistan and South Africa rely on a debit card payment mechanism linked to an efficient management information system and biometric identity database. When beneficiaries register, their personal data and biometrics are captured and authenticated in minutes, a biometric debit card is issued in a few days, and the system automatically credits cardholder accounts monthly with the appropriate grant amount. In Pakistan, 4.5 million BISP beneficiary households receive their payments through debit cards within 72 hours of disbursement from the government. So, the elderly, parents, and people with disabilities no longer have to wait in line for cash or worry about keeping their payments safe. The Niger pilot led to improved nutrition for children, in part because of the time savings for mothers.

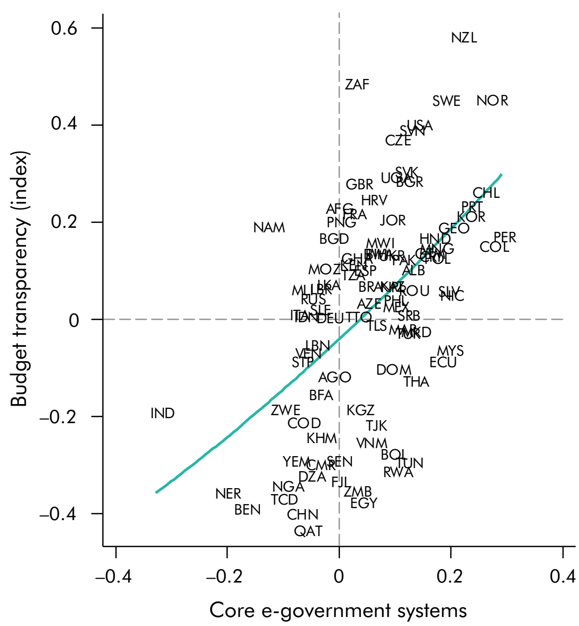
Female empowerment is one major benefit of the BISP and the Niger programs. Women in BISP mostly receive the payments on behalf of their households, increasing their authority to make decisions on how the cash is spent, their mobility, and their engagement with formal institutions. The Niger mobile transfer, by reducing the observability of the amount and timing of the cash transfer, increased women's bargaining power in the household, changing household agricultural activities and expenditures in ways that benefit women. To quote Amina Bibi, a BISP beneficiary, "Women are being encouraged and empowered. Because of this program people who did not let their women leave the house earlier are allowing them to do so. Women now have confidence that they, too, can do something for the betterment of their family."

Sources: WDR 2016 team, based on http://worldbank.org/safetynets/howto; http://www.bisp.gov.pk; Oxford Policy Management 2015; Aker and others 2014.

programs and empowering women through financial inclusion and access to government cash transfers (box 3.2). Biometric registration, authentication, and payments in India's National Rural Employment Guarantee Scheme, the world's largest workfare program, reduced the time for paying beneficiaries by 29 percent and leakages by 35 percent (see spotlight 4).[15] But these schemes are complex and have all the risks of wastage associated with large government information technology projects. They also raise concerns about government surveillance, violation of privacy, and data integrity.

A more recent initiative around digital informational services is the open data movement, publishing government data in machine-readable format as a platform for the private sector to develop applications to deliver new e-services to citizens. Countries continue to join the Open Government Partnership, but initiatives are in their infancy. According to the Global Open Data Index, only 13 percent of the datasets in 110 countries were "open"—public, machine-readable, and nonproprietary.[16] Many governments have no desire to open their data or lack the capability to do so. Making meaningful, good-quality data publicly available depends on sound core administrative systems—countries with more advanced core systems have greater budget transparency (figure 3.7)—and on effective interministerial

Figure 3.7 e-government systems increase the transparency of government budgets, 2014



Sources: WDR 2016 team, based on Open Budget Index 2014 data (International Budget Partnership 2014) and the World Bank (2015b) Global e-Government Systems database. Data at http://bit.do/WDR2016-Fig3_7.

Note: Controlled for income. Budget transparency is measured by the Open Budget Index.

cooperation and coordination. The necessary supportive ecosystem of a vibrant private sector and civil society to use open data is also often missing.

The impact after governments open up is also unclear. In the United States and the United Kingdom, the take-up of open data has been limited to a few sectors where there is consumer demand, like real estate, transport, energy, and health care, so the private sector has an incentive to develop applications on the open data platform.[17] In Kenya, Moldova, and the Philippines, which have opened hundreds of government datasets, the motive has been more to increase transparency than to spur business opportunities for the private sector. In locales in Kenya and the Philippines, fewer than 15 percent of survey respondents with internet access had heard of the Open Data Initiative.[18] Some media and civil society organizations use open data in their advocacy campaigns, but such initiatives generally are few and fragmented.

Streamlining processes

Automation applied to an efficient operation will magnify the efficiency . . . automation applied to an inefficient operation will magnify the inefficiency.

—Bill Gates

The efficiency of some government tasks and services can be improved through automation that eliminates routine manual processes prone to error and manipulation, reduces the number of government intermediaries in a transaction, and establishes audit trails to curtail rent-seeking. Digital registration and payment systems have, for example, significantly reduced leakages in transport subsidies for the poor in Colombia (box 3.3). Given the importance of mobilizing and managing resources, almost all countries have tried to automate budget preparation, execution, and accounting and some aspects of tax and customs administration. Management information systems are also extensively used in education, health, land management, and social protection services. In the past decade, one-stop shops or service centers that provide citizen and business services—such as registration, licensing, records, bill payments—in a single physical space or web portal have become popular, with initiatives in many countries, including Azerbaijan, Bangladesh, Brazil, Cambodia, India, Kenya, Moldova, Mozambique, Oman, Peru, and Uganda (box 3.4).

Given the methodological difficulties in measuring government productivity, the impact of e-government must be assessed indirectly through, for instance, changes in firms' perceptions of tax compliance costs, the competitiveness of government procurement, and corruption in taxation and government contracting after the introduction of e-government systems in a country. These indirect measures, from regular surveys of firms in select European and Central Asian

Box 3.3 Targeted public transit benefits in Bogotá

Public transit is essential for 64 percent of the 8 million people living in Bogotá, Colombia. As in many major cities, housing is often distant from work, especially for low-income residents. But using public transit can be costly for the poor, who spend about 25 percent of their income on transportation, compared to 3.5 percent for high-income residents. To help overcome this spatial mismatch, the city built an integrated public transport system (SITP) anchored by the *Transmilenio* bus rapid transit and collective bus transport. To increase affordability for low-income users, the city introduced a subsidy—in 2014; it gave a 50-percent discount for 40 trips per month. Eligibility is tied to a database of beneficiaries of social programs (SISBEN), and by February 2015 it reached about 26 percent of the target population.

The subsidy is transferred on smart fare cards activated and replenished at charging stations. This technology makes it easier and more flexible to provide targeted demand-side subsidies with lower scope for leakage and abuse. Most public transit systems, in contrast, rely on undifferentiated supply-side subsidies. Linking the transit user and SISBEN databases makes targeting efficient. Introduction of the smart card system has not been without startup problems. The smart cards do not work on the entire system yet. Someone traveling on different portions ("Phases") of *Transmilenio* and on the collective system will need two smart cards and possibly cash as well. These parallel systems need to be integrated into the SITP. Technically, this is straightforward (for example, by using turnstiles that receive the smart cards in all the buses and stations). The challenge is to achieve consensus between the bus operators, the collection firm in charge of the smart cards, and the city's government.

Source: Rodriguez and Monroy-Taborda, forthcoming, for the WDR 2016.

Box 3.4 Streamlining services through one-stop service centers

With committed political leadership, one-stop computerized service centers can provide citizens with access to a broad range of public services from multiple government departments at one location quickly and easily—expanding options, saving time, speeding delivery, and reducing opportunities for corruption.

In rural Karnataka, India, for instance, the more than 800 Nemmadi Centers operating since 2006 provide birth and death certificates, caste certificates, income certificates, ration cards, land records, and pensions, among other services. Compared with typical government offices, citizens get these services in the centers with 3.4 fewer visits, 58 fewer minutes spent in the visits, 23 days faster processing, and 50 percent less chance of being asked for a bribe.[a] But this experience of Karnataka is not replicated in many other states of India. One study found that the scope and impact of service centers vary considerably across states. The greater the prevalence of petty corruption, the fewer services offered, particularly services for which bribes can be extracted.

The integrated citizen assistance units (*unidades de atendimento integrado,* or UAI) in Minas Gerais, Brazil, provide another model. With 30 shops and 1,800 employees, the UAI offer access to services from 15 government agencies. In 2012, they handled more than 6.2 million citizen transactions, up sevenfold in three years. Employment and ID services are most popular, with the majority of users from lower-income groups.

The UAI were designed to overcome institutional constraints that plagued the state's prior attempt at service integration. The earlier generation of service centers was staffed by low-performing civil servants seconded by participating agencies and lacked standard operating procedures. Long wait times could be abused by citizens willing to pay to advance in the queue.

The new system strengthened oversight from the Secretariat for Planning and Management, which reports directly to the governor. It introduced a first-come, first-served ticketing system. And citizen complaints submitted online must be resolved within two days. Coordinators at the UAI "situation room" monitor the average wait time, the number of citizens served, and the number of attendants on duty at each service center to reallocate resources to manage demand in real time. A private contractor staffs the service centers, thus bypassing restrictions for civil servants and allowing the centers to offer extended hours to citizens. Each participating agency provides an on-site supervisor to oversee its programs. Conflicts occasionally arise between UAI coordinators and the agency-employed supervisors. As one government official noted, "When you tell a police officer he is no longer the authority in that place, it doesn't go down very well."[b]

Sources: Bussell 2012; Majeed 2014.

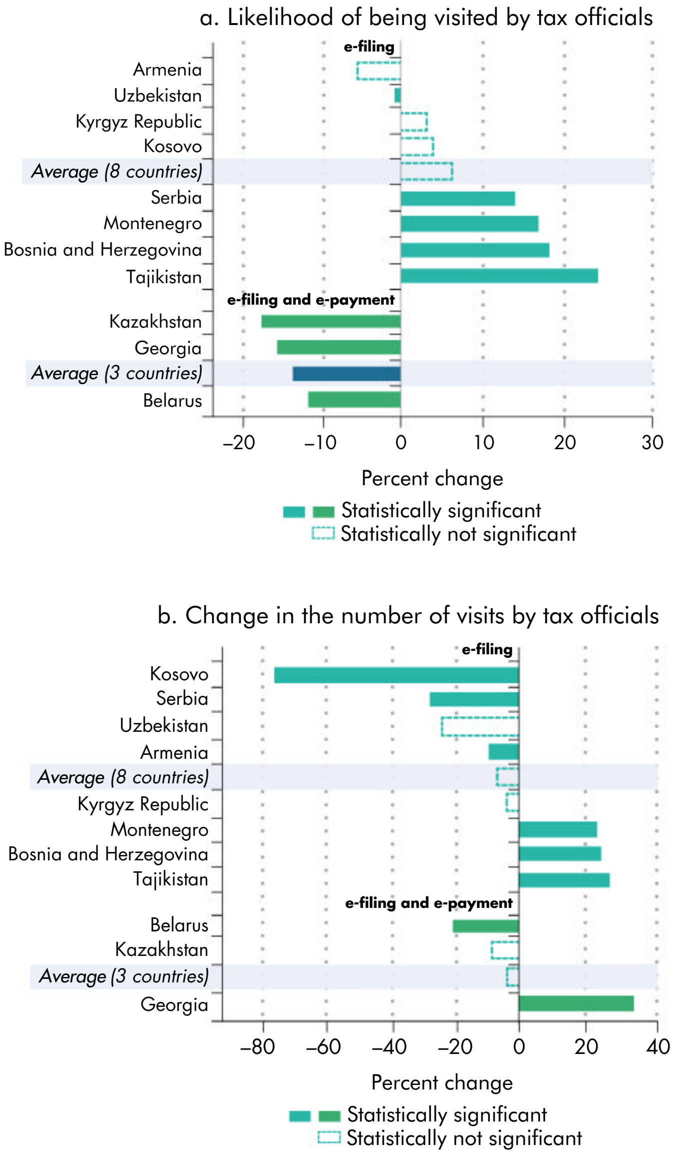
a. Bussell 2012.
b. Majeed 2014.

countries, show that the impact of e-government is mixed and varies considerably across countries.[19]

Filing of taxes electronically (e-filing) is meant to reduce the administrative burden to businesses and citizens by minimizing interactions with tax officials and reducing opportunities for rent-seeking—and by lowering the time it takes businesses to file tax returns, make payments, and receive refunds. Indeed, advanced e-filing systems in a country (e-filing of tax forms and e-payment of taxes) lowered the likelihood of being inspected by tax officials by an average 13 percent in select countries in Europe and Central Asia.[20] But shifting only to the simpler e-filing system that did not enable online payment of taxes had no effect (figure 3.8, panel a). Nor did e-filing on average reduce the number of visits by tax officials (figure 3.8, panel b). These effects vary considerably across countries, with Belarus, Kazakhstan, and Kosovo having the biggest declines in inspections, and Bosnia and Herzegovina, Montenegro, and Tajikistan reporting an increase in inspections after the introduction of the e-government system. E-filing also lowered firms' perceptions of paying bribes to tax officials only marginally, with medium-size firms and firms that export less likely to pay bribes to tax officials after the introduction of e-filing.

E-filing and e-payment help on average to reduce the time it takes businesses to prepare and pay taxes, as measured by the assessments of experts in the Doing Business data for 75 countries that introduced these systems between 2005 and 2014 (figure 3.9). Overall the time taken declined by roughly 25 percent in the five years after the system was introduced across the sample, with the time dropping by more

Figure 3.8 The likelihood of being visited and the number of visits by tax officials after e-filing was introduced vary in select European and Central Asian countries



Source: Kochanova, Hasnain, and Larson, forthcoming, for the WDR 2016. Data at http://bit.do/WDR2016-Fig3_8.

Note: The panels show the impact of introducing electronic tax filing after controlling for firm-specific characteristics and fixed effects. The bars stand for the average effects in each country. Based on a sample of 25,969 firms (panel a) and 14,232 firms (panel b) from the World Bank Enterprise Survey.

than half in Belarus (from 987 hours to 183 hours), Costa Rica (from 402 hours to 163 hours), and Kenya (from 432 hours to 202 hours).[21]

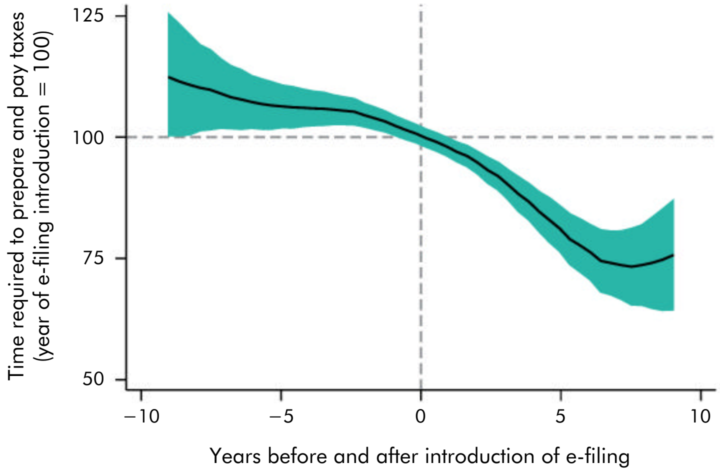
To have impact, e-government systems need to be accompanied by regulatory and administrative reforms—changing laws and management practices, simplifying tax procedures, and increasing the ability of taxpayers and tax officials to use these systems. The importance of complementary reforms is illustrated by the contrasts of South Africa and Belarus with Tajikistan and Uganda. South Africa's tax modernization reforms, which began in 2007, coupled the technology initiatives with simplifying the tax code and reforming business processes in the tax authority. For example, revenue targets became a compulsory feature of the performance scorecards of managers. Online tax filing increased from 40,000 individual tax returns in 2006 to more than 2 million in 2009, with significant reductions in tax compliance costs.[22] In Belarus, e-filing was similarly part of a broader reform to lower compliance costs for citizens, including simplifying the tax code, setting up taxpayer facilitation services, and reaching out to the business community. But in Tajikistan, e-filing was not mandatory, use was low, and most businesses continued to submit paper returns, in part because they did not trust that online submissions would be secure but also because tax inspectors continued to pester firms.[23] And in Uganda, the electronic forms were more complicated than the manual ones, and taxpayers had to file paper returns in addition to the e-filing.[24] As a result, the time to prepare and pay taxes increased in Uganda, and tax inspections increased in Tajikistan.

Effective service delivery requires efficient and transparent government procurement of goods and services. Procurement is particularly vulnerable to collusion and corruption; e-procurement, through greater transparency and less discretion, can result in significant budgetary savings and better-quality infrastructure. In India and Indonesia, e-procurement increased competition by making information on government contracts widely available and by encouraging more firms, particularly those outside the region where the project was located, to bid. It also improved the quality of the infrastructure projects through shorter delays and better construction.[25]

Firms' perceptions of the impact of e-procurement in Europe and Central Asia, however, are quite mixed. Systems that provide only information on government contracts online or that also enable firms to bid for these contracts online had no effect on average on firm perceptions of the competitiveness of public procurement (figure 3.10, panel a). In Belarus, Georgia, and the Slovak Republic, firms were more likely to bid for government contracts after an e-procurement system was introduced, but in Armenia, Bosnia and Herzegovina, and Tajikistan they were less likely. Transactional e-procurement systems increased the competitiveness of procurement only in the higher-income countries in the sample, suggesting that nontechnological factors correlated with a country's level of development determine their impact. Surprisingly, e-procurement was not associated with any reduction on average in firm perceptions of corruption in government contracting, but again with considerable variation (figure 3.10, panel b). Nor were there significant average differences across types of firms or in the functionality of the systems. This negative finding is striking because one of the main reasons for investing in these systems is reducing corruption in contracting and increasing the value-for-money of government capital spending.

E-procurement is also conditional on regulatory, institutional, and human resource factors for impact. In one of India's leading reformers in e-procurement, Karnataka state, reform was underpinned by an amended procurement law that made it mandatory to use the government e-procurement portal for all state departments and agencies. Run from the chief minister's office to give it authority, the system was implemented under a public-private partnership to bring in skills from the market.[26]

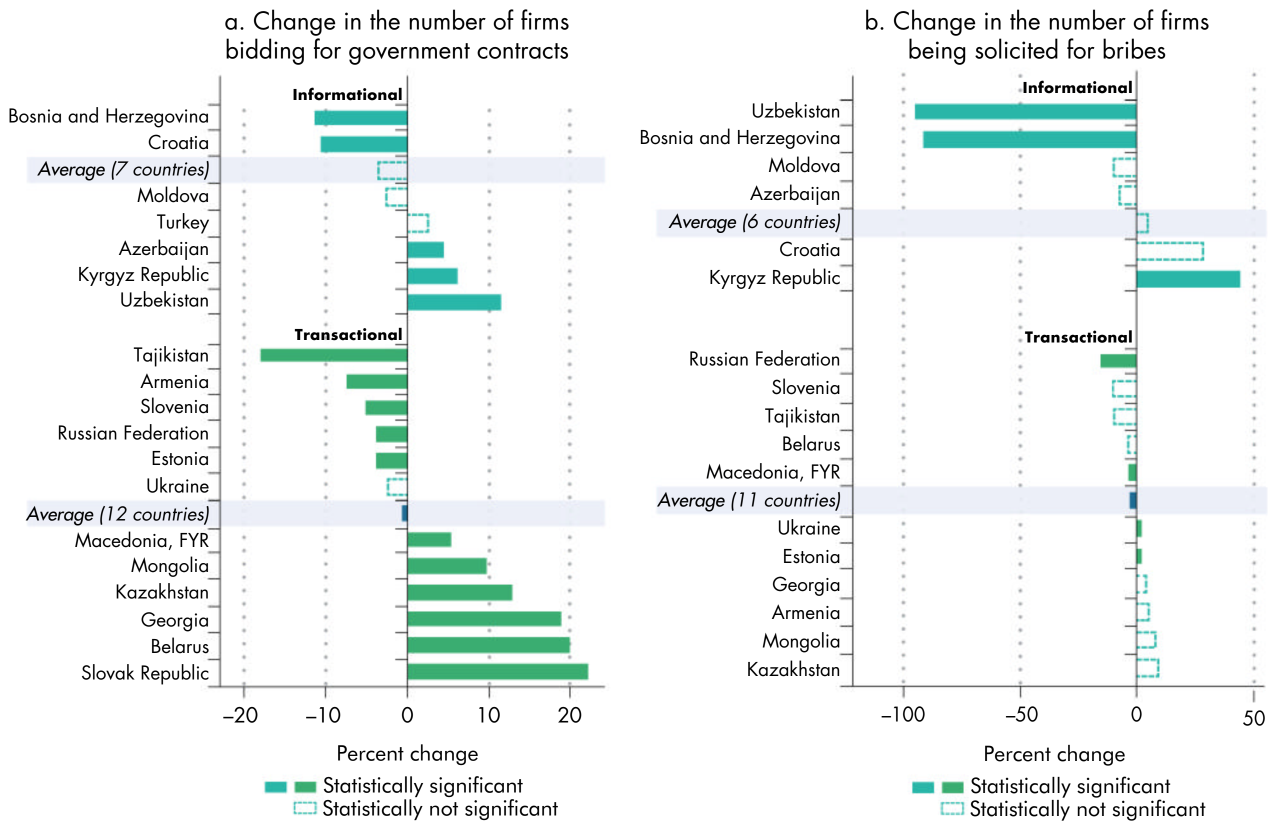
Figure 3.9 e-filing and e-payment on average reduced the time required to prepare and pay taxes



Sources: WDR 2016 team, based on World Bank (2015b) e-Government Core Systems database and the Doing Business database for 2014 data. Data at http://bit.do/WDR2016-Fig3_9.

Note: Shaded area shows the 95 percent confidence interval for 75 countries.

Figure 3.10 e-procurement has no effect on firms' likelihood of bidding for a government contract or of being solicited for a bribe in select European and Central Asian countries



Source: Kochanova, Hasnain, and Larson, forthcoming, for the WDR 2016. Data at http://bit.do/WDR2016-Fig3_10.

Note: The figures show the impact of introducing informational and transactional e-procurement systems, after controlling for firm-specific characteristics and fixed effects. Informational systems provide only information on government contracts online; transactional systems also enable firms to submit bids online. The bars stand for the average effects in each country. Based on a sample of 25,961 firms (panel a) and 4,343 firms (panel b), from the World Bank Enterprise Survey.

The varied impact of e-filing, e-procurement, and one-stop centers reveals a broader, sobering trend: Many government digital technology projects are unsuccessful. They are either abandoned before completion or underused, wasting substantial public funds (box 3.5). A widely accepted explanation for this poor record is the big gap between the technological capability and the institutional capacity of the government, as measured by processes, objectives, values, staffing numbers, skills, and management systems and structures.[27]

Receiving user feedback

One potential catalyst for service improvements is user feedback on service quality. More than a decade ago, the private sector discovered customer relationship management—the use of digital technologies to integrate all aspects of a firm's interaction with a customer to improve personalized communication and provide real-time information so that customers can track the status of their service requests. Governments have only recently discovered this management approach, with most innovation in cities in the developed countries. Mobile phone apps like SeeClickFix and FixMyStreet, active in many municipalities in the United States and the United Kingdom, and internet call centers allow users to report service issues and enable governments to report back to citizens on fix requests through integrated back-end systems. They are now standard in Barcelona, Boston, Chicago, London, New York, Seoul, and Singapore.

Developing countries are following suit. Given the considerable inefficiencies in public sector delivery systems, the gains from embedding digitally enabled citizen feedback in management are potentially greater than in developed countries. These feedback channels come in many varieties. They can be for a limited set of services tied to particular agencies or for multiple services and issues, usually housed in a center-of-government entity, either local or national. They can be complaint portals that invite citizens to report service issues, or government-initiated ("proactive") feedback mechanisms through which government officials contact citizens to inquire about their service experience. Complaint portals and call centers for citizen feedback are spreading rapidly across developing countries, particularly in cities—Buenos Aires, Muscat, Rio de Janeiro, and Ulaanbaatar, to name a few. Proactive feedback mechanisms are more recent and thus limited in number—those in Albania and Pakistan are examples.

Two conditions are required for user feedback to have impact: Citizens must have an incentive to provide feedback, and the service provider must have the incentive and capacity to respond and resolve the complaint. Citizens are more likely to complain if they use the service frequently, if it is a private good (so there are no problems of free-riding), and if it is easy to identify the service failure. Governments are more likely to respond if the information provided by citizens on the service failure is specific and actionable, if it is clear who in government needs to resolve the complaint, and if the complaint also integrates with document management systems within the agency so that both the complaint and the response can be prioritized and tracked. Government responsiveness can further incentivize citizens to complain, creating a virtuous circle of feedback and responsiveness. For example, users of FixMyStreet—the platform in the United Kingdom that citizens use to report local road problems, which are then routed to the relevant local authorities—are 54 percent more likely to submit a second report if their first complaint was resolved.[28]

Household water supply and electricity are examples of private goods that citizens use daily and have an incentive to monitor. The responsibility for delivering these services lies clearly with a particular utility, and it is easy for citizens to know when the service is failing. MajiVoice is a complaint mechanism in the water and sewerage company in Nairobi, and there is a similar one in use in EDE Este, the electricity supply company for the eastern Dominican Republic. Given the limited internet use in the country, consumers initiate complaints mostly in person at the service desk in the utility or through phone calls, generating a ticket number as a tracking tool for both the customer and the utility. The customer receives an SMS message from the utility when the complaint is entered and another when the complaint is resolved. This tracking is possible because each complaint is registered on a dashboard that enables management to categorize the complaint, delegate the issue to a specific staff member on duty, and track resolution. The dashboard enables the utility regulator to track performance, and customers of EDE Este are also randomly contacted after the complaint is resolved to gauge their satisfaction with the service.

Initial results are impressive. Before MajiVoice was initiated, the Nairobi water company received on average 400 complaints a month. Since 2013, when MajiVoice was launched, the utility has been getting about 3,000 complaints a month, resolution rates climbed from 46 percent to 94 percent, and time to resolution dropped by 90 percent (figure 3.11).[29] Since its implementation in 2011, the feedback channel in EDE Este has also recorded rising resolution rates for

Box 3.5 The high failure rate of e-government projects

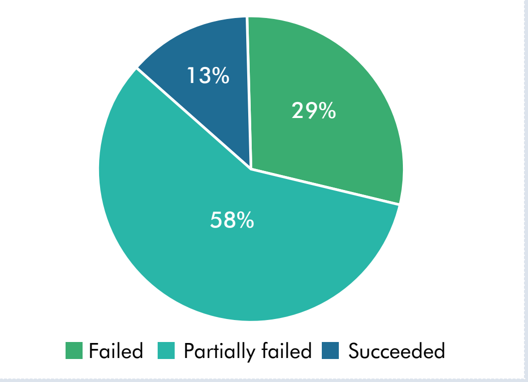
Despite spending more than $600 billion on IT over the past decade, the federal government has achieved little of the productivity improvements that private industry has realized from IT. Too often, federal IT projects run over budget, run behind schedule, or fail to deliver promised functionality.

—U.S. Office of Management and Budget 2010

Many public sector digital technology projects fail. Although the evidence is limited, various estimates from surveys of government officials, audit reports, and country cases suggest that about 30 percent of these projects are total failures, with the project abandoned before completion. Another 50 to 60 percent are partial failures, with significant budget and time overruns and only a limited number of the project objectives achieved. Fewer than 20 percent are successes.[a] In some cases, even if e-government projects are successfully implemented they may actually worsen outcomes as, without proper regulatory safeguards in place, automation makes it easier to perpetrate fraud and corrupt practices, and to erase records or avoid capturing them altogether, thereby eroding transparency mechanisms.[b]

Risky for the private sector, these projects do worse in governments. One survey of U.S. information technology projects found success rates of 59 percent in retail, 27 percent in manufacturing, and 18 percent in government.[c] Larger projects are more likely to fail than smaller ones, with success rates of only 13 percent on average (figure B3.5.1) and a skewed distribution, with a small proportion of projects accounting for a major chunk of budget and time overruns. One comprehensive review of more than 1,400 public sector information and communication technology (ICT) projects found that a sixth went over budget by 200 percent, posing “systemic” fiscal risks.[d]

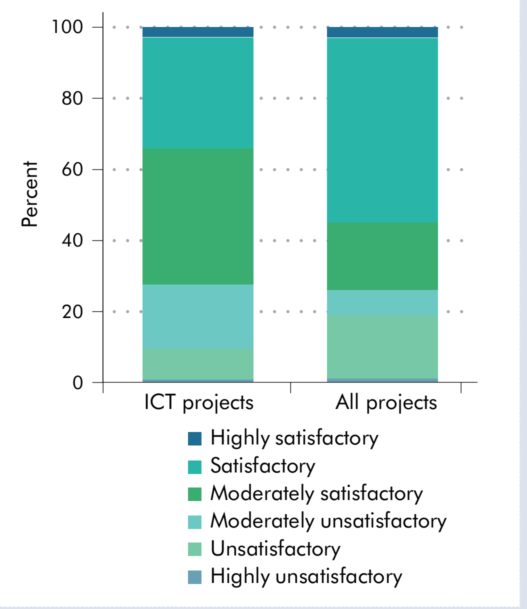
Figure B3.5.1 Success rate of large public sector ICT projects



Sources: WDR 2016 team, based on Standish Group 2014 and World Bank (2015a) Digital Governance Projects Database. Data at http://bit.do/WDR2016-FigB3_5_1.

Note: “Large” is above US$6 million. Data are for 2010 to 2014. ICT = information and communication technology.

Figure B3.5.2 Performance of World Bank–funded ICT projects



Sources: WDR 2016 team, based on Standish Group 2014 and World Bank (2015a) Digital Governance Projects Database. Data at http://bit.do/WDR2016-FigB3_5_2.

Note: Data are for 1995 to 2015. ICT = information and communication technology.

World Bank–funded projects have not fared much better: 27 percent of the roughly 530 information technology projects from 1995 to 2015 were self-evaluated by the World Bank as moderately unsatisfactory or worse, in line with all projects (figure B3.5.2). But far fewer were rated “satisfactory” or above, with 35 percent for ICT projects and 56 percent for all projects.

e-government scholars provide numerous explanations for these stark numbers. A widely quoted study blames a large gap between the regulatory, political, management, process, and skill realities in government and the ambitions

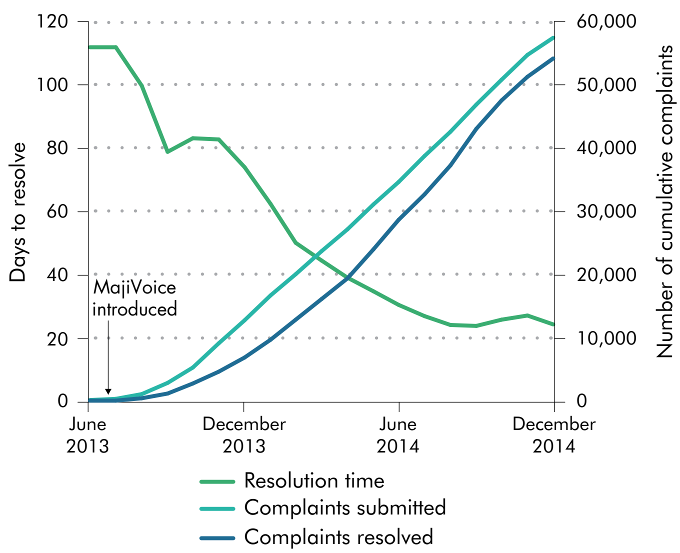
(Box continues next page)

Box 3.5 The high failure rate of e-government projects *(continued)*

of e-government projects.[e] Another points to the "dangerous enthusiasms" of technological infatuation and faddism in large IT projects.[f] Many studies also point to the rigidities in government procurement rules, IT vendors' lack of understanding of government processes, and a failure to understand the country context.[g] In the private sector, executives can choose vendors based on personal experience and jointly determined guidelines that are deliberately kept vague to allow flexibility during implementation. Ministers and senior officials, by contrast, are explicitly forbidden by government rules to exercise this level of discretion and instead must purchase on the basis of detailed specifications. Surveys of technology professionals and executives in both the public and private sectors underline user involvement, leadership support, and a clear statement of project requirements as critical factors for success.[h]

a. These estimates are based on the various reports issued by the Standish Group and Heeks 2008.
b. Lemieux 2015.
c. Standish Group 2014.
d. Budzier and Flyvbjerg 2012.
e. Heeks 2008.
f. Gauld and Goldfinch 2006.
g. Dunleavy and Carrera 2013; Fountain 2001; Heeks 2006; Bhatnagar 2009.
h. Standish Group 2014.

Figure 3.11 More complaints were resolved more quickly in the Nairobi water utility after the introduction of digital customer feedback



Source: World Bank 2015d. Data at http://bit.do/WDR2016-Fig3_11.

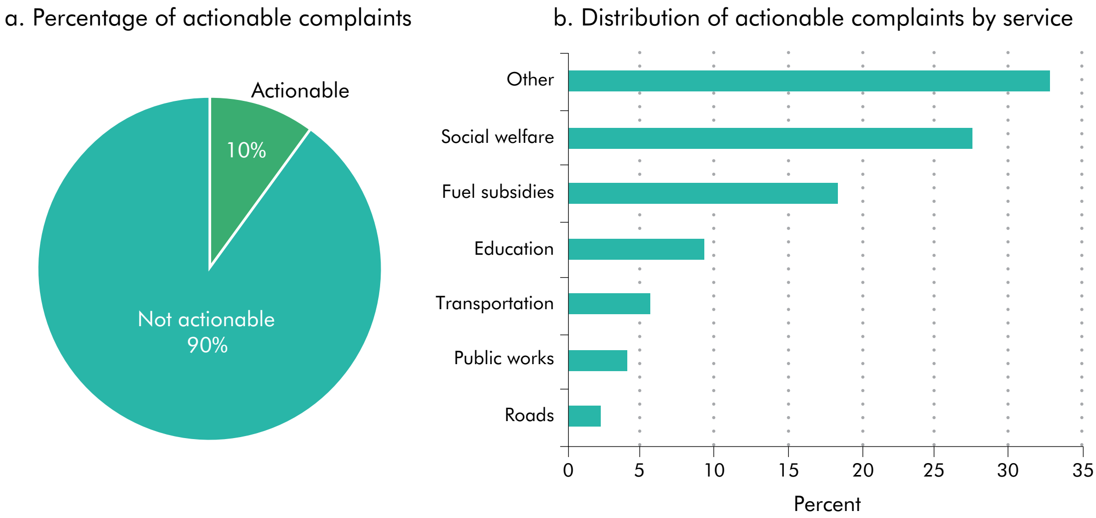
Note: Days to resolve represents the three-month trailing average; numbers of complaints are cumulative.

reported problems, improvements in customer satisfaction, and a reduction in reported corruption.[30] This improved tracking is also triggering improvements in human resource management. In EDE Este, the feedback is systematically used to inform sanctions (such as administrative procedures) and rewards (such as salary increases) based on worker performance. In the Nairobi utility, data from monthly management reports are also used as a basis for performance incentives for staff.

Property registrations, welfare payments, and licensing services are also private goods that are easy to monitor, and citizens have an incentive to give feedback on them. With multiple agencies usually delivering these services, citizen-initiated feedback is more likely to have impact if the services are consolidated in one-stop service centers that make it easier for citizens to provide feedback and for governments to integrate the feedback in administrative systems and to monitor the responsiveness of agencies. One-stop centers in Azerbaijan, in Brazil's Minas Gerais state, and in Moldova show how automating the service delivery chain with citizen feedback can drive service improvements.[31]

By contrast, it is much more difficult for citizens to determine the quality of education or curative health care and to attribute poor outcomes to the precise cause—whether, for example, their child's poor learning (to the extent that it is assessed through standardized tests) or their poor health is due to poor service providers, their own negligence, or environmental factors. Beyond issues like provider absenteeism, complaints are less likely to be actionable. And citizens have fewer incentives to complain about the weak provision of public goods like roads and municipal services because of free-riding.

Figure 3.12 Citizens using Indonesia's national feedback portal (LAPOR) have few actionable complaints, and these are mostly for private goods, 2015



Source: WDR 2016 team, based on 2015 LAPOR data. Data at http://bit.do/WDR2016-Fig3_12.

These problems are evident in general citizen feedback portals recently introduced in Botswana, Indonesia, and the Philippines. The government of Indonesia's complaint-handling system (LAPOR) allows citizens to submit reports on many issues, ranging from delays in welfare payments to damaged roads. It has received about 800 complaints a day on average from all over Indonesia since the portal's launch in 2012. Of these complaints, only 10 percent are specific and actionable (figure 3.12, panel a) and are forwarded to the relevant agency for resolution. Of these actionable complaints, 28 percent and 18 percent, respectively, are for private benefits like welfare payments or fuel subsidies; less than 5 percent are for public goods like roads and public works (figure 3.12, panel b).[32] The complaint portals of the governments of Botswana and the Philippines have similarly provided limited actionable information to the government, particularly on public goods.[33]

Citizen feedback portals are also likely to be disproportionately used by better-off, more educated, and more digitally savvy individuals, potentially biasing government responses. For example, most users of FixMyStreet in the United Kingdom are male, older, more educated, and less likely to be from an ethnic minority than the general population.[34] Similarly, the users of LAPOR are disproportionately from Jakarta, the largest city and the capital, than from the poorer and more remote regions in eastern Indonesia.

Government-initiated feedback can overcome these biases in citizen reporting and be more focused on acquiring actionable information. In Pakistan, under the Punjab Citizen Feedback Model, service providers record citizens' mobile numbers. A government call center sends SMS messages and voice calls to public service users to make targeted inquiries about satisfaction with 16 services, ranging from property registration to primary health care and potential incidents of corruption. The data are logged and tracked on dashboards.[35] This system has been deployed at a very large scale, with more than 7 million citizens contacted since 2012—250,000 a month on average—and about 1 million having provided feedback from across the province.[36] But the impact of the feedback on service delivery is unclear. Many officials have tried to subvert the initiative, as reflected in the high and steady proportion of invalid phone numbers recorded by service providers—40 percent for citizens registering property, a service particularly prone to petty corruption. The government has taken more than 6,000 administrative actions against officials based on the feedback. But given the protections afforded staff under civil service rules, the actions have been mostly warnings and formal apologies from the concerned official to the citizen, and only a handful have been suspensions or dismissals.

Governments in high-income countries are moving beyond user feedback to engage citizens in collaborative policy making. The northern European countries are on the vanguard in these moves to more direct democracy, as exemplified by Iceland's crowdsourced constitution, Estonia's e-legislation portal, and Reykjavik's digital participatory budgeting.[37] But even in these digitally and socioeconomically advanced countries, e-participatory policy making has engaged only a small, nonrepresentative subset of the population, has elicited limited government responsiveness, and is difficult to sustain. In Estonia, a global leader in e-services and e-voting, with high citizen use across all socioeconomic groups, only 8 percent of people polled had heard of http://www.osale.ee, the government's e-legislation and policy making portal.

Improving service provider management

Technology can improve systems that are already working . . . but it doesn't fix systems that are broken. There is no knowledge management without management.

—Kentaro Toyama, University of Michigan School of Information

User feedback is effective when providers and managers have the incentive and the ability to respond to citizens, which depends on strong relationships of accountability between policy makers and providers. By better monitoring of workers and facilities and through better organization and performance management in bureaucracies, digital technologies can strengthen accountability within the government by reducing information asymmetries between policy makers and service providers.

The absenteeism of teachers, doctors, nurses, and agricultural extension workers is pervasive in Africa and South Asia.[38] Estimates suggest that in India roughly one-quarter of government teachers and over one-third of government doctors in primary health centers are absent without a legitimate reason on any given day, with similarly alarming numbers in several African countries.[39] Physical monitoring of providers is costly, particularly in rural areas, and the monitors are just as likely to shirk as the providers or to collude with providers. Using mobile phones to record attendance—either with the photographs or thumbprints of the providers as evidence—and transmit data to a central database to generate monitoring reports can be a cost-effective solution to this seemingly intractable problem.

Evidence from impact evaluations in Haiti, India, Niger, Pakistan, and Uganda shows that digital monitoring can reduce absenteeism in general, but that technology on its own is not sufficient for curbing absenteeism among government providers, who are difficult to dismiss and discipline.[40] Technology must be accompanied by good management. In India, the monitoring of health workers did improve attendance, but many local governments did not use the data to sanction absent workers because of cumbersome civil service rules or for political reasons. In Uganda, absenteeism was reduced only by combining teacher incentive pay with monitoring technology. In Pakistan, smartphone-based monitoring of district health supervisors in rural clinics doubled inspections of health facilities and reduced medical worker absenteeism, but the results were highly contingent on the severity of patronage politics in a locality. In Haiti, the experiment failed because government teachers had not been paid for months and resented the additional unfairness imposed on them by digital monitoring. In Niger, by contrast, the experiment was conducted with contract teachers hired by a nongovernmental organization, and mobile phone–based monitoring by itself was sufficient to improve teacher effort and motivation as well as student learning outcomes.

Reducing absenteeism, while necessary, is not sufficient to ensure that doctors, teachers, and managers, once they show up to work, actually are motivated to perform well and to serve the public. Recent innovations in the private sector have extended these teacher monitoring technologies to the actual practice of teaching, through standard lesson plans and systematic monitoring of teacher activities by management. The initial results are promising, again conditional on the strong relationships of accountability that can exist in private schools (box 3.6). But applying these lessons to a government bureaucracy will be challenging. The typical developing country government bureaucracy is unable to recruit the best and brightest workers because of low pay and excessive influence by politicians. It promotes staff on the basis of seniority and not performance—in part because measuring performance is difficult and seniority is the only credible standard—and is unable to motivate workers to work hard and serve the public. For many providers, the reason for joining the public sector is job security, not promoting student learning or public health.

These weaknesses are evident from perception surveys of government workers in Indonesia and the Philippines. Many staff believe that the best university graduates prefer working in the private sector, that their coworkers are often not productive, that promotions are based on politics rather than merit, and that their coworkers in other government agencies cannot be trusted (figure 3.13). Anecdotal evidence

Box 3.6 Digitally enabled teacher management in private schools

Private schools targeted to the world's poorest have become a new model for education in developing countries with low-quality public education. Bridge International Academies (BIA) is an innovative for-profit private model operating in underserved communities in Kenya and Uganda that leverages standardization and technology to educate more than 118,000 children.

The BIA business and educational model is driven by a standardized set of curricular and managerial materials to keep classes consistent, students on task, and schools running smoothly. The core of these materials is an internet-enabled tablet computer, which downloads more than 3,400 lesson plans and teacher scripts at the beginning of each term. These plans include step-by-step instructions on how to prepare and present each lesson, homework assignments, and tests. BIA management tracks classroom progress—such as the speed of lessons and teacher attendance—with the tablet through automatic syncing. If a teacher falls behind in lessons, BIA managers in Nairobi and BIA's U.S. headquarters know immediately and can follow up with the teacher hundreds or thousands of miles away. In addition to teacher monitoring, student progress is tracked by teacher-inputted student test scores and progress measures. This automation gives BIA headquarters instant access to school data and helps BIA manage their academies.

In addition to classroom management, standardization and technology are leveraged to improve school administration. Each "academy manager"—akin to a head teacher or principal—receives a smartphone to use for communication and monitoring, and as a modem for the tablets. Academy managers follow standardized instructions on managing finances, personnel, and student and parent relationships, as well as on how to use a central payroll system, expense-processing system, standardized assessments, and evaluation tools. Even paying school fees is standardized and technology-enabled; tuition payments are made electronically with M-Pesa or through Equity Bank Kenya. The standardized instruction, school management, and assessment ensure that each student in a Bridge Academy receives the same education, regardless of location or instructor.

Initial evaluations show that this educational style may be effective. In 2013, a self-evaluation found that BIA students scored 0.32 standard deviations higher than peer students in public schools in reading fluency and comprehension, translating into an additional 16 words per minute and 252 additional learning days. In math skills, BIA students scored 0.51 standard deviations higher, equivalent to an additional 288 learning days. These findings need to be viewed cautiously, however, as the differences in outcomes may be entirely explained by differences in students between BIA and public schools.

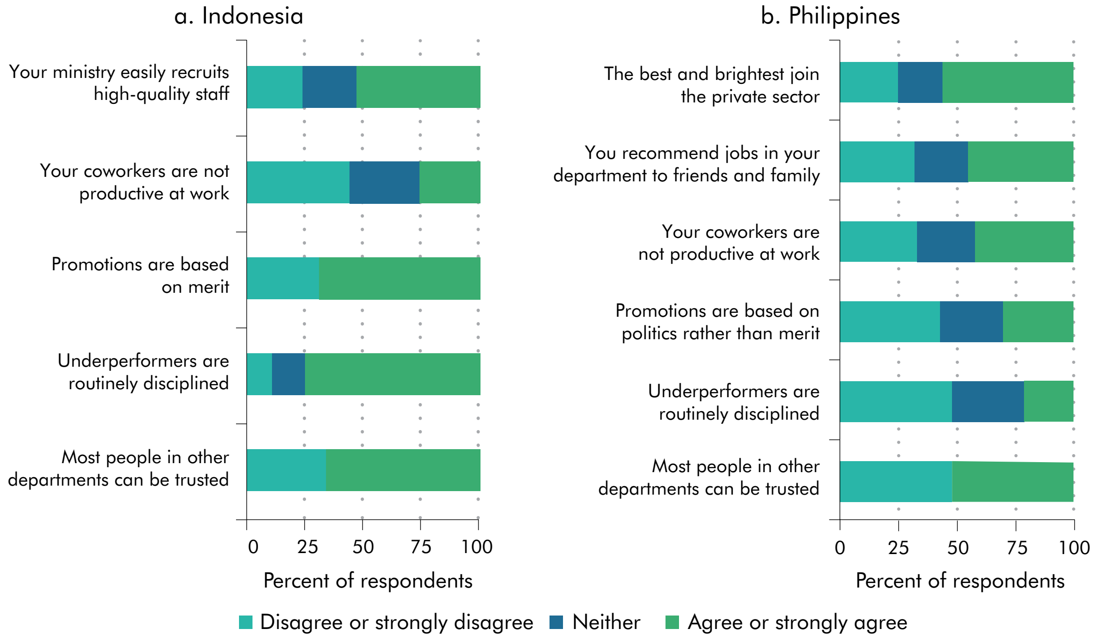
This type of private education is not unequivocally embraced. The scripted lesson plans are particularly controversial, with questions about the effectiveness of a script to create a dynamic learning environment for children to develop higher-order thinking skills. In addition, Bridge Academies rely on large class sizes and teachers with only a secondary education to keep costs low. Low-cost private education is also criticized because of the potential to undermine public education systems. Countries that rely on private education may not invest as heavily in their public systems, and private schools often attract the best students, further diminishing the public education system. Even so, in contexts where public schools are failing, a standardized private sector model may be a viable option for improving learning outcomes.

Sources: WDR 2016 team, based on Bridge Academies 2013; Heyneman and Stern 2014; Rangan and Lee 2010; Ross 2014.

suggests that these problems are even more severe in low-income countries. Studies of teacher and health worker management in South Asia and Africa reveal a fundamentally broken system, with pervasive problems of politicization, weak school management, low provider motivation, and shirking.[41] A recent survey of public schools in Tanzania revealed that 67 percent of the teachers who were present in the school did not show up in classrooms to teach. Nor did school principals hold them accountable: Three-quarters of teachers reported that they had never had a meeting with the head teacher to discuss their performance, and two-thirds of the head teachers had themselves been absent from school at least once in the last five days.[42]

The low productivity of some government bureaucracies reflects fundamental structural constraints that cannot easily be substituted for by technology. Where digital technologies can help is in monitoring goals and performance targets for organizational units and workers. For the private sector, firms that adopt

Figure 3.13 Government officials in Indonesia and the Philippines have generally low opinions of human resource management practices



Sources: World Bank surveys of government officials, 2011 and 2013. Data at http://bit.do/WDR2016-Fig3_13.

Note: The survey in Indonesia was conducted in 2011 and covered about 3,000 government officials; the survey in the Philippines was done in 2013 and covered 2,500 officials.

more structured performance management practices are more profitable, and digital technologies complement performance monitoring and performance incentives.[43] Goal-setting and performance incentives are difficult—but not impossible—in government bureaucracies. The multiple demands on a public organization, and the multiple interests it needs to serve, make it difficult to define goals, and performance incentives can trigger a host of perverse incentives. The key variable is the extent to which the tasks and outputs of agencies can be routinized and monitored.[44]

As MajiVoice and the EDE Este feedback systems show, eliciting citizen feedback on service quality, tracking complaint resolution, producing audit trails of worker effort, and offering performance incentives for staff can be a powerful combination for transforming government bureaucracies. This combination is also being used in one-stop service centers in many countries.

Digitally enabled performance monitoring is much more difficult for services that are highly discretionary and hard to monitor, such as teaching and curative health care, and for policy and regulatory functions. Assessing performance is necessarily more subjective and therefore conditional on the quality of management and level of trust in an organization—which can take years to build. There is little evidence, even in the OECD (Organisation for Economic Co-operation and Development) countries, that digital technologies have made any fundamental differences in the way government bureaucracies are managed, particularly for the better integration of policy making and service delivery across government. Even in New Zealand, known for its highly competent and innovative public administration, two-thirds of public officials surveyed were skeptical that digital technologies would induce greater collaboration and integration across government departments because the notion of a "joined-up government" conflicted with the annual agency-based budget appropriation process.[45]

In sum, these digitally enabled management improvements are isolated examples. Either they are pilots and experiments limited to a subset of activities, such as addressing absenteeism, that form the basic minimum required to improve teaching or health care, or they are limited to a few locales, sectors, or agencies and not taken to scale in the government as a whole. Developing country government bureaucracies now have a digital veneer over a largely unchanged structure, culture, and performance orientation.

Digital technologies too often fail to empower citizens

As discussed, digital technologies can be effective even in weak government bureaucracies in some areas—notably through digital identification, streamlining routine tasks, and citizen feedback for certain services that citizens have the incentive and capacity to monitor. But in general, to have an impact, e-government requires effective leadership by politicians and policy makers—to make the necessary changes to government rules and management practices, to overcome resistance from vested interests, and to respond to citizen feedback on service quality. Strengthening government capability requires a willing government. The question, then, is whether digital technologies can encourage good leadership by empowering citizens to hold policy makers and providers accountable.

Mechanisms for empowering citizens include

- *Free and fair elections* in government systems in which leaders are chosen in elections—ensuring that all legitimate votes can be cast and counted so that the poor in particular are not excluded from participating
- *More informed voting*—informing voters to increase electoral participation and reducing information asymmetries so that votes can be more accurately based on the performance of politicians
- *Citizen voice and collective action*—empowering citizens to individually and collectively mobilize to pressure policy makers and providers to improve services.

Emerging evidence suggests that digital technologies have made elections freer and fairer by improving voter registration and reducing errors in voting, and by better monitoring them to curb electoral fraud and violence. These technologies have also helped citizens vote out corrupt politicians, if the information comes from a credible source. But significant barriers to more informed voting remain, and digital technologies, by giving elites new ways of manipulating information to their advantage in election campaigns, can also disempower the poor. These disparities can be countered if traditional media bridge the digital divide, but such a role may be limited to providing information that is more salient and newsworthy, such as corruption scandals, rather than service delivery failures. Digital technologies, particularly social media, have galvanized citizen protests, but except where governments are willing and able, they have not sustained collective action and citizen voice to improve service delivery (table 3.2).

Freer and fairer elections

Is the growth of digital technologies spreading democratic ideals around the world, as many believe?[46] Democracy has indeed spread across the world, but so have election irregularities.[47] As the number of developing country democracies more than doubled from 1990 to 2012, the proportion of elections that were "free and fair" halved from almost 80 percent to under 40 percent over the same period (figure 3.14, panel a). In a free election, the electoral rules and their implementation leading up to an election enable all adult citizens to be registered, to exercise their right to vote, and to join political parties and to campaign

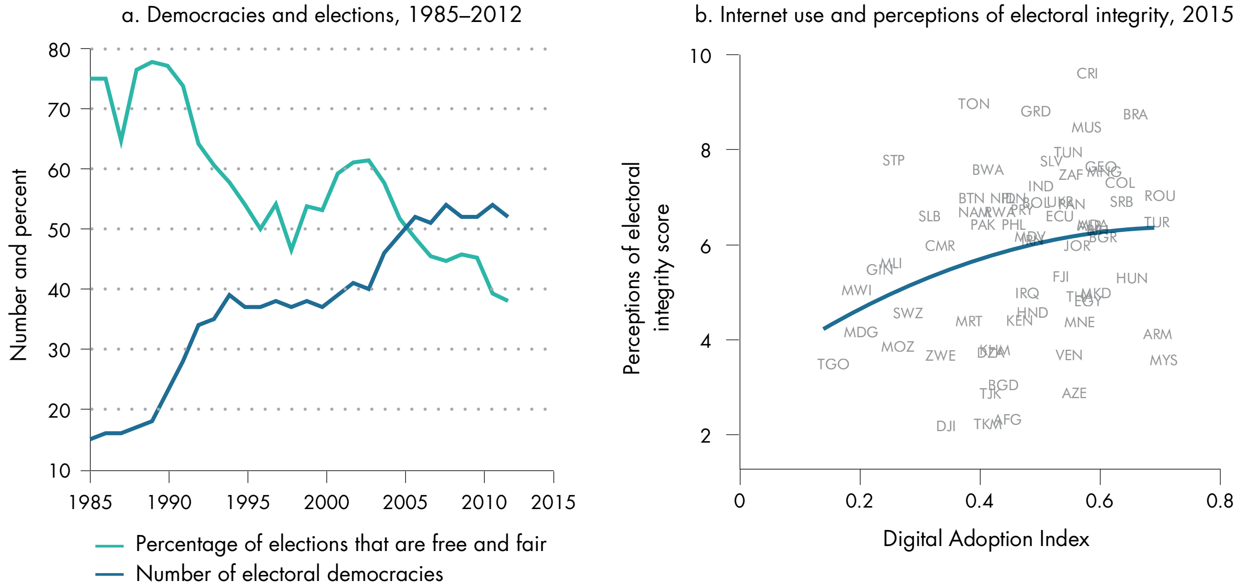
Table 3.2 The impact of digital technology on citizen empowerment: A scorecard

Channel	Impact of technology	Main problem to address	Do digital technologies solve the problem?
Free and fair elections	H	Lack of information; high transaction costs	• Yes, monitoring reduces errors and fraud in voting
More informed voting	M	Information asymmetries	• Yes, for blatant abuses of office; no, for less newsworthy public service failures • Increase ability of elites to manipulate information
Greater citizen voice	L	Collective action failures	• Effective only when governments are already willing to listen to citizens • Must be complemented by offline mobilization by civil society groups

Source: WDR 2016 team.

Note: Channels are arranged by degree of technology impact. L = low; M = medium; H = high.

Figure 3.14 Democracy has spread, but so have election irregularities—digital technologies can help make elections freer and fairer



Sources: WDR 2016 team, based on Polity IV 2015; Bishop and Hoeffler 2014; Perceptions of Electoral Integrity 2015. Data at http://bit.do/WDR2016-Fig3_14.

Note: The figures are limited to low-income, lower-middle-income, and upper-middle-income countries, for which election data are available. Election percentages are the five-year trailing average.

freely. In a fair election, all voters and all votes are treated equally on the day of the election.[48] Electoral irregularities can affect poor voters disproportionately. They may not be able to cast their votes because they lack proper identifying documents, or their votes may not be counted because of error or manipulation.

Digital technologies are helping make elections freer and fairer. Across nations, perceptions of the integrity of elections in developing countries are positively correlated with internet use (figure 3.14, panel b). Rigorous studies reinforce this cross-national correlation and demonstrate the powerful impact of digital technology in increasing electoral participation, particularly for the poor. In Brazil, pre-internet electronic voting machines significantly reduced voting errors in the 1990s, leading to the de facto enfranchisement of poor and less educated citizens, which in turn led to more pro-poor spending.[49] In Afghanistan, the monitoring of votes cast through cellphone photographs of vote totals in polling stations reduced electoral fraud in the vote aggregation process.[50] In Mozambique, SMS messages allowing citizens to report electoral irregularities increased voter turnout by 5 percentage points.[51] And although not evaluated, the use of crowdsourcing by Ushahidi and its successor Uchaguzi, combined with civil society monitoring, advocacy, and partnerships with government, has helped curtail election violence in Kenya (box 3.7).[52]

More informed voting

Improving the mechanical aspects of voting is a minimum requirement for electoral accountability. The more fundamental problem is that citizens are often uninterested and unengaged in politics, face significant informational barriers in assessing politician performance, or base their votes on tribal, ethnic, or clientelist factors and not the ability and performance of politicians.[53] This lack of engagement is understandable. Acquiring political information is costly, the sources of the information, like political parties, are often not credible, and the impact of an individual citizen's more informed vote is negligible to the outcome of an election. The question, then, is whether digital technologies change this calculus to result in a more engaged and informed citizenry—and more effective elections.

There is no shortage of popular opinion that the internet—by exponentially increasing transparency and forging connections among voters, particularly through social media—will strengthen accountability through greater voter engagement and participation.[54] These sentiments echo those of earlier generations about television, which was also viewed as nothing short of revolutionary for enhancing accountability. But television's impact has turned out to be much more mixed. In Sweden, the rollout of commercial television indeed improved citizen knowledge of

Box 3.7 Improving the integrity of elections through crowdsourcing and collaboration

Improving electoral integrity requires effective media, nongovernmental organizations, and partnerships between technologists, advocacy groups, and government watchdogs to gather, analyze, disseminate, and act upon relevant information. Consider the contrasting experiences of Ushahidi and Uchaguzi, two digital election-monitoring initiatives in Kenya. Ushahidi, one of the best-known digital platforms in the world, was launched in the aftermath of Kenya's tumultuous 2007 election and used "citizen reporters" to crowdsource and map incidents of violence after the election. While the platform galvanized considerable interest initially—with more 45,000 users in its first few months—many of the reports were not actionable, and there was limited response from the authorities.

Learning from this experience, Ushahidi and a group of journalists and civil society organizations launched its successor, Uchaguzi, to monitor Kenya's 2010 constitutional referendum. But this time, the effort combined citizen crowdsourcing with analysis by specialized civil society organizations with experience monitoring elections to provide actionable information to local and national government officials, in particular the Interim Independent Electoral Commission. This partnership was a success, with the government responding to a majority of the reports.

Ushahidi's implicit belief was that the platform would by itself be the agent of change. Uchaguzi—or "Ushahidi 2.0"—recognizes that the platform can work only if it amplifies existing institutions. The main lesson is that governments may be dysfunctional, but can only rarely be bypassed. As one of the founders of the initiative commented after the local police—infamous in Kenya for their venality and brutality—successfully responded to an online citizen report of a machete-armed mob gathering outside a local polling station, "We can't compel organizations to act. We can support institutions, but we can't replace them."

Sources: WDR 2016 team, based on interviews with Ushahidi management; Fung, Russon Gilman, and Shkabatur 2013; Wrong 2013.

politics and government policy and increased voter turnout.[55] In the United States, however, it reduced voter turnout and knowledge of policy issues by crowding out local radio and newspapers, previously the main source of political information.[56]

Digital technologies can certainly provide a variety of tools to improve the informational content of voting. For example, Voting Advice Applications are websites that enable citizens in several European countries to compare the platforms of competing political parties with their own preferences on salient issues; these increased voter turnout among youth in the Netherlands.[57] But the internet also offers a variety of other entertainment options that compete for people's time and can disengage them from politics. In Germany and Italy, the internet reduced voter turnout by crowding out television, a greater source of political information.[58]

The internet also provides political parties, bloggers, and opinion leaders with resources to shape public opinion. For example, a simple "I Voted" message on individuals' Facebook pages increased voter turnout by more than 300,000 in the 2010 U.S. midterm elections.[59] The "winner take all" feature of the internet economy is also replicated in the online news media landscape, as internet political opinion is dominated by a small group of bloggers and outlets that receive the bulk of search engine hits.[60] Finally, the internet can give voice to extreme opinions by enabling highly partisan media outlets to get sufficient readership and encouraging clustering of extreme views, particularly among the more politically organized and aware, potentially increasing polarization in politics.[61]

Given that the internet is the main source of news for less than 2 percent of the population in South Asia and Sub-Saharan Africa,[62] the informational effects of digital technologies are likely to be mediated through traditional media in those regions, as well as elsewhere in the developing world. A growing number of advocacy organizations in developing countries partner with media to provide voters with easy-to-understand information about politicians. For example, Mumbai Votes tracks legislators from Mumbai at all levels of government in India, reporting on their legislative activity and any court cases filed against them. The Fair Play Alliance of the Slovak Republic tracks campaign finance and procurement contracts to uncover corrupt relationships between businesses and politicians.[63]

For this digitally enabled political information to have impact, it must be easy to understand, be clearly attributable to a particular politician, and be credible. A good example is the uncovering of corruption by public officials if the information comes from a trusted source, such as an independent anticorruption commission or reliable media outlet. In 2003, the federal government of Brazil launched a national anticorruption program based on random audits of municipal governments by the national audit authority (the municipalities to be audited in a given month were chosen by lottery), with results publicly disseminated over radio, television, and print media. Voters punished incumbents who were found to be corrupt by not reelecting them. The effects were stronger in municipalities with local radio stations, pointing to the role of local media in informing voters.[64] These findings have been replicated in studies of municipal audits in Mexico, again pointing to the importance of a credible source for information on corruption (a national audit by an independent and competent institution) and local television and radio to disseminate that information for electoral accountability.[65]

By contrast, provision of information about failures in service delivery such as poor education or health care, or weak performance of legislatures—which is more complex and difficult to attribute to particular politicians—has been less effective.[66] Information campaigns over local radio on public health and primary education in rural Benin had no effect on the incentives of politicians to provide better health and education services or on provider responsiveness.[67] Informing Indian voters about the performance of their legislators in legislative activity had no effect on voting behavior; but informing them on spending by parliamentarians on physical infrastructure from funds allotted to them to spend on their constituencies did affect voting behavior, since this information was more salient to voters.[68] Similarly, providing information on legislator performance to voters in Uganda had no effect on parliamentarians' reelection rates.[69] The experience of Open Data Initiatives is also quite sobering. The mainstream media in Kenya, the Philippines, and Uganda have not been deeply engaged with the Open Data Initiatives, either in using data as a source of evidence in their reporting or in reporting on efforts surrounding open data. Journalists interviewed said there was no "scoop" in the open data story.[70]

Digital technologies can also reinforce socioeconomic disparities in voter participation and knowledge, particularly in developing countries. Internet voting has increased participation in some European countries by lowering the cost of voting, since votes can be cast from the convenience of one's home. In Estonia, where about one-third of voting is online, the share of internet voters has increased by more than 4 percentage points in almost every election since 2005, contributing to an overall increase in voter turnout (figure 3.15, panel a). Studies show no differences in the demographic characteristics of internet versus offline voters.[71] In Brazil, by contrast, internet voting on municipal budget proposals in the state of Rio Grande do Sul increased voter turnout by 8 percent (and these were new voters), but the online voters were more likely to be male, university educated, and higher-income (figure 3.15, panel b).[72] These changes in the demographic profile of voters have not yet changed policy preferences, perhaps because the offline participatory mechanisms to determine the budget proposals that are then voted on limit the range of options subject to the vote. But they show how the internet can be biased against certain groups.

Overall, then, the evidence suggests that digital technologies have helped curtail blatant abuses of political office, conditional on supportive institutions of accountability (such as independent audit or anticorruption bodies) and free media (to generate and help disseminate the relevant information to voters). Service delivery failures have not been salient enough to command the attention of even digitally enabled media to influence voting decisions by the poor.

Citizen voice and collective action

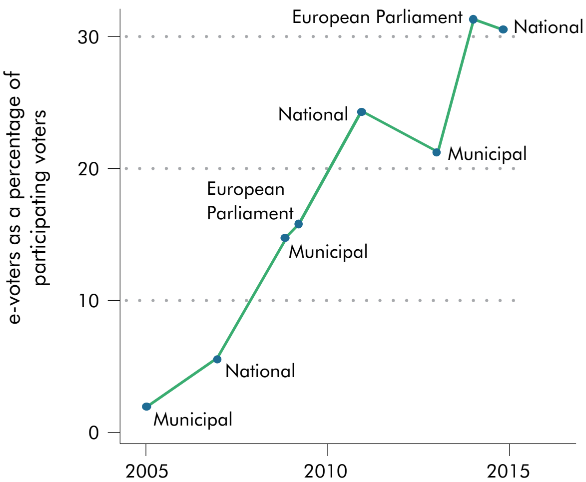
"Home run" cases in which a technological intervention almost by itself produces dramatic increases in accountability . . . are exceedingly rare . . . The greatest opportunities [for technology are in] amplifying NGO and governmental strategies of accountability.

—Archon Fung, Kennedy School of Government, and colleagues

One of the more widely held beliefs about the transformative power of digital technologies, particularly social media, is its ability to catalyze citizen voice and collective action to hold governments accountable. The internet promotes transparency by increasing the richness and customizability of the information for citizens. Less obvious—and unique to these technologies—is that they also enable citizens to generate their own information (user-generated content), which can be aggregated at low cost to provide col-

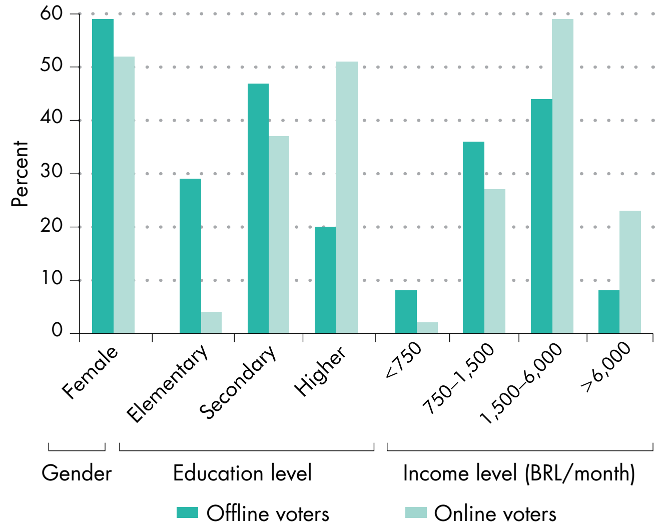
Figure 3.15 Internet voting can increase voter participation but can be biased toward more privileged groups

a. Increase in internet voting in various elections in Estonia, 2005–15



Source: WDR team, based on Vassil 2015, for the WDR 2016. Data at http://bit.do/WDR2016-Fig3_15a.

b. Profile of online and offline voters in a participatory budgeting vote in Rio Grande do Sul, Brazil, 2011–12



Source: WDR team, based on Spada and others 2015. Data at http://bit.do/WDR2016-Fig3_15b.

Note: BRL = Brazilian *real.*

lective voice through crowdsourcing or community mapping. Social media can facilitate collective action by generating peer pressure as individuals observe the behavior and actions of others, improving within-group monitoring, reducing free-riding, and enabling groups to better coordinate their actions around specific events such as protests.[73] These technologies also provide new platforms for citizens to engage with the government, lowering the costs to citizens of providing information, and enabling policy makers and service providers to seek information and track the feedback loop.

As a growing empirical literature shows, cellphones and the use of Twitter and Facebook aided protests during the Arab Spring in the Arab Republic of Egypt,[74] widespread demonstrations on social issues in Chile in 2011,[75] antiwar demonstrations in the United States,[76] and citizen mobilization across Africa, with the effect more pronounced in nondemocratic political systems where traditional channels for articulating interest were limited.[77] The same mechanisms also imply that digital technologies can trigger harmful collective action, like ethnic conflict.[78]

Social media have the unique ability to make scandals and highly emotive government abuses of authority "go viral" and trigger parallel physical citizen mobilization. But it is less clear that similar technology-enabled effects hold for collective action around the more mundane service delivery failures. Identifying the precise government failure is much more difficult for services—these after all are hidden from the public eye in classrooms, rural health centers, and in the substandard materials used to construct roads—just as is clearly attributing the failure itself to the actions of a particular individual or group of individuals. These failures only rarely become salient in flashpoint events like scandals or egregious abuses of public authority, such as the excessive use of force by the police or a patient dying because of poor care. And they cannot be addressed by the simple "stroke of the pen" actions that protests tend to mobilize around, such as jailing a corrupt politician. Instead, they require sustained reforms to improve government capability, which in turn requires sustained citizen voice and collective action.

Given these difficulties in monitoring service failures, it is not surprising that the large academic empirical literature on nondigital instruments of collective action—citizen and community report cards, complaint mechanisms, community monitoring of service providers—presents frustratingly mixed evidence of impact.[79] The main lesson is that the success of citizen collective action around service delivery failures depends on contextual factors, and each of the links in the causal chain between transparency, citizen action, and state action can break down if these factors are not aligned. How credible, salient, and comprehensible is the information to citizens?[80] How willing and able are citizens to act on the information individually or collectively? How effective are intermediary organizations—civil society, media, interest groups—to organize citizens or to lobby governments on their behalf? And most important, do state actors have the incentive and capacity for action, thereby "closing the loop"? Action and impact are more likely if the social accountability initiative is embedded in a citizen-state interface and synchronized with top-down government accountability initiatives.[81]

Digital citizen voice initiatives for improving service delivery have multiplied rapidly, but no rigorous studies have evaluated their impact. An organizing framework is needed to classify these examples and draw the necessarily tentative conclusions about what is likely to work and under what conditions.[82] The focus here is on digital channels that are initiated by civil society organizations (CSOs) and donors to pressure governments, and that publicize the inputs provided by citizens so as to expose the behavior of service providers to public scrutiny. This analysis excludes government-initiated portals, which are more accurately characterized as user feedback mechanisms to improve service quality, and not as citizen empowerment or accountability initiatives, and which were discussed earlier.

The analysis distinguishes 17 cases in 12 countries by whether the mechanism for expressing citizen preferences and views is individual or collective; whether the CSO or donor that led the initiative also had explicit partnerships with the concerned government; and whether there was also parallel offline mobilization accompanying the digital voice channel (table 3.3). Impact is measured in two ways: citizen

Table 3.3 Classifying the digital citizen engagement cases

Case	Location	Additional offline mobilization	CSO partners with government	Collective feedback	Impact: Citizen uptake	Impact: Government response
Por Mi Barrio	Uruguay	✓	✓		L	H
I Change My City	India	✓	✓		M	H
Lungisa	South Africa	✓	✓		L	H
Pressure Pan	Brazil	✓		✓	H	M
Rappler	Philippines	✓	✓	✓	H	M
Change.org	World	✓		✓	H	M
U-report	Uganda	✓	✓	✓	H	L
Huduma	Kenya				L	L
Daraja Maji Matone	Tanzania	✓			L	L
FixMyStreet	Georgia		✓		L	L
Check My School	Philippines	✓	✓		L	L
Barrios Digital	Bolivia				L	L
e-Chautari	Nepal				L	L
I Paid a Bribe	India		✓		M	L
Mejora Tu Escuela	Mexico				L	L
Karnataka BVS	India				L	L
Sauti Za Wananchi	Tanzania		✓		L	L

Source: WDR 2016 team, based on Peixoto and Fox 2015, for the WDR 2016.

Note: Examples are arranged by degree of government response. CSO = civil society organization; L = low; M = medium; H = high.

uptake, given that uptake can be considered a necessary condition for government responsiveness; and government action to resolve the service issue, which is the ultimate objective of the citizen voice initiative. The criterion for selecting the cases is simple availability of information. The examples have received media and donor attention, and some data are available on citizen use of the channel and on government response.

Of the 17 cases, 3 had high impact in terms of government responsiveness, 3 had medium impact, and 11 had low impact. All the high-impact examples involve partnerships between CSOs and government, suggesting that platforms that both channel citizen voice and link them to the government's internal work order systems to efficiently address the complaints are more likely to succeed. For example, Por Mi Barrio in Uruguay and I Change My City in India, two successful CSO platforms, are connected to existing government complaint systems. That enables urban residents to report problems using both the CSO and the government channel, with the complaints and government responses displayed on a map, thus informing and validating the citizen action and naming and shaming the nonperforming government units. But not all initiatives involving government-CSO partnerships led to high responsiveness. For instance, I Paid a Bribe (India) and Check My School (Philippines) both had low impact. Seen together, these findings seem to suggest that while collaboration with government is not a sufficient condition for success, it may well be a necessary one.

Another ingredient for success is effective offline mobilization, particularly because citizen uptake of the digital channels was low in most of the cases.[83] Online petitions on Change.org are more likely to be successful when sponsored by an organization, and citizen campaigns through Pressure Pan (Brazil) are three times more likely to succeed when supported by Pressure Pan staff.[84] Lungisa, a platform for Cape Town residents to report service delivery problems, involves significant follow-up by the CSO staff to ensure that the responsible government agency acts on the complaints. Rappler, a media and advocacy organization in the Philippines, combines media, technology, and the power of crowdsourcing to identify and amplify governance issues, with traditional citizen mobilization strategies using investigative journalists and social mobilizers. Rappler organizes community protests, the most dramatic one being the Philippines's first protests organized with social media against a corruption scandal involving congressional discretionary funds. The eventual result: The Supreme Court declared these funds unconstitutional.[85]

What stands out, though, is the high proportion of cases that have both low citizen uptake and low government response. Most of the cases that lacked partnerships between CSOs and governments were unsuccessful. Maji Matone (Tanzania), for example, received only 53 SMS messages during its first six months of operation, against an initial target of 3,000, and the mobile platform was abandoned. Other disappointments are Huduma (Kenya),[86] I Paid a Bribe (India), and Check My School (the Philippines). Despite high expectations, they have not generated much citizen uptake or government resolution of the reported problem—in some cases, despite government collaboration.

Uganda's U-report, perhaps the highest profile initiative, is an SMS-based platform that runs weekly polls with registered users (U-reporters) on issues ranging from child marriage to access to education, which are then both broadly disseminated and targeted to members of parliament for action. The platform has had considerable citizen uptake, but mostly by the more privileged groups. Of close to 300,000 U-reporters, nearly half have some university education, and one-quarter are government employees, raising questions about whose voices are being projected.[87] This high uptake has not led to any noticeable government action. Surveys of online political participation in the United States also find that better-off and more-educated citizens are more likely to participate in both online and offline political activities.[88]

In sum, the success of digital citizen voice is conditional on willing and able policy makers, a collaborative approach with government, and significant offline activism by strong civil society organizations so that the collective voice of citizens can pressure governments. However, digital platforms can also enhance unaccountable governments' capacity for surveillance and control (box 3.8).

The gap between technology and institutions

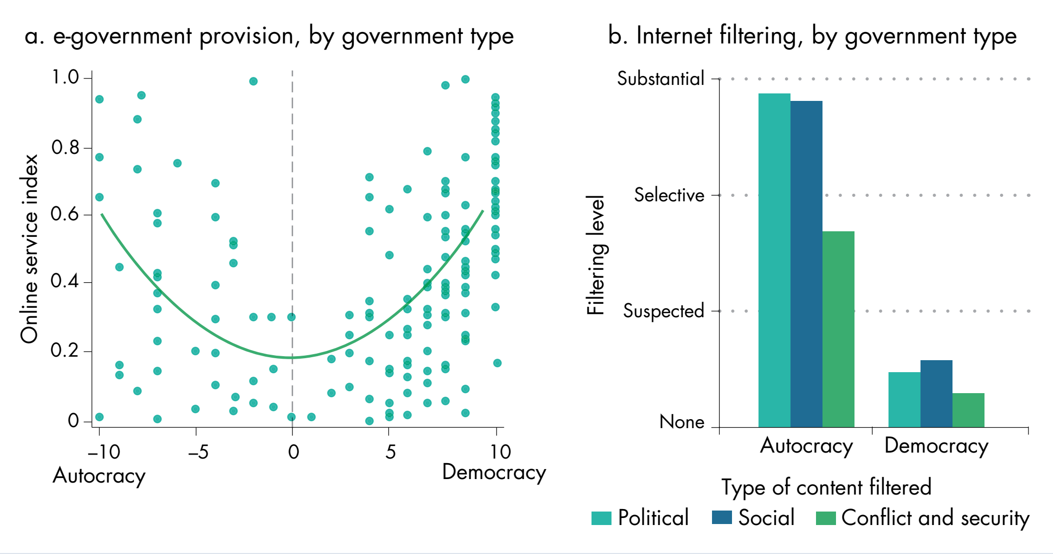
The internet largely, but not entirely, reinforces rather than replaces preexisting relationships of accountability between governments and citizens, and it complements rather than substitutes for existing government capabilities. The main explanation for the varying impact of digital technologies lies in the mismatch—or gap—between rapidly changing technology and slowly changing political and administrative institutions. Political institutions can

Box 3.8 Digital technologies can strengthen control

The internet presents a "dictator's dilemma" for autocracies. Restricting the internet can hurt economic development, but leaving it unfettered can threaten the government by increasing citizens' access to political information and facilitating collective action. Autocratic governments have responded to this dilemma in sophisticated ways, taking advantage of the tools that the internet itself offers to improve services while strengthening control.

Autocracies have invested in e-government, particularly in e-services. The relationship between online services and government type is U-shaped, with both more democratic and more autocratic governments scoring high on the United Nations' online service index compared to the ones in the middle (figure B3.8.1). This pattern suggests that improvements in basic service delivery can be independent of a country's political system.[a] Autocracies are, however, becoming more adept at monitoring the internet to censor criticism entirely or circumvent protests, to spread propaganda, or to learn about public grievances to improve government responsiveness while also intervening to prevent specific instances of collective action that challenge the government's power.[b] Digital technologies therefore provide opportunities for autocracies to improve service delivery while maintaining control.

Figure B3.8.1 Autocratic governments have promoted e-government while censoring the internet



Sources: WDR 2016 team, based on Polity IV 2015; UN 2014; Open Net Initiative 2013 data. Data at http://bit.do/WDR2016-FigB3_8_1.

Note: The Polity IV project defines government type based on characteristics such as competitiveness and openness of executive recruitment, constraints on the chief executive, and regulation and competitiveness of participation in the political process. The combined score varies from −10 for a pure autocracy to +10 for a pure democracy.

a. Corrales and Westhoff 2006; Rød and Weidmann 2015.
b. King, Pan, and Roberts 2013; Morozov 2012; Pierskalla and Hollenbach 2013; Shapiro and Weidmann 2013; Rød and Weidmann 2015. See also HRW 2015.

be distinguished by whether they are clientelist or pro-poor, and bureaucracies can be classified by whether they are patronage-based or performance-oriented.[89] These institutions, and their characteristics, matter because effective adoption of technology in organizations requires significant investments in skills and changes in working arrangements, and politicians and policy makers need to have the incentives to make these investments.

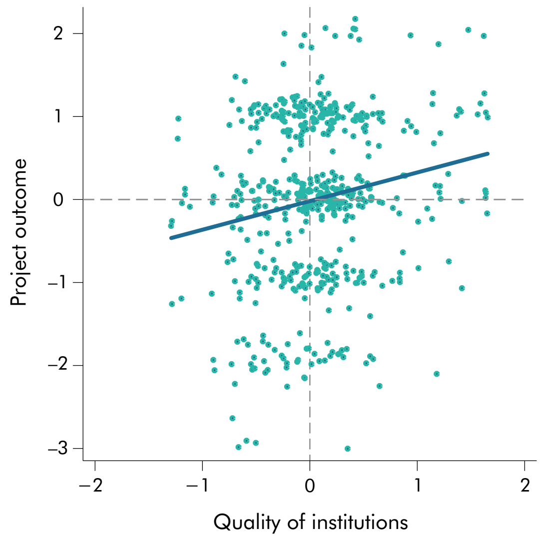
Bureaucracies can have a disincentive to reorganize their work to take full advantage of digital technologies. In the private sector, market competition forces firms to change and rewards them with higher profits for their investments. In contrast, in government, efficiency improvements can reduce an agency's budget and staff.[90] Adopting new technologies also requires learning new skills and changing processes, which can add to the workload, at least initially, with unclear career rewards in patronage-based civil service systems, particularly given the difficulties in measuring the productivity of government agencies. Ministries and departments compete against one another for scarce budgetary resources, leading to a silo mentality and resistance to horizontal collaboration. Most important, the automation of business processes and improved monitoring reduce bureaucratic discretion and opportunities for petty corruption in patronage-based systems.

In the absence of market competition, overcoming bureaucratic resistance to digital technologies requires strong political leadership. But political incentives may also not be aligned with digital technologies. Many e-government projects take a long time to implement and thus elicit little interest from political leaders whose preferences are governed by short election cycles. In clientelist political institutions, politicians are accountable largely to a narrow group of elites. Digital technologies, by promoting transparency and enhanced tracking and monitoring of resources, can curtail avenues for rent-seeking—"grand corruption," in contrast to the petty corruption of service providers—that underpin these informal political institutions. And citizens continue to face significant barriers to voice and collective action that digital technologies have not significantly ameliorated. Lifting these barriers depends more on the strength of an independent media, supreme audit and anticorruption agencies, and civil CSOs as sources of credible information and as intermediaries between the citizen and the state.

E-government projects funded by the World Bank are more successful in countries with stronger institutions (figure 3.16). While project performance varies considerably within countries, project outcomes across countries, as self-evaluated by the World Bank, are strongly positively linked to the quality of government institutions, as measured by the Worldwide Governance Indicators.

There is considerable evidence of the complementarity between technology and the organization of work in attaining productivity improvements in the private sector.[91] The few empirical studies that investigate these complementarities for government have similar findings. For example, investments in information technology by police departments in the United States lowered crime rates only when accompanied by significant organizational changes.[92] The mixed record of automation also underlines the

Figure 3.16 Digital technology projects funded by the World Bank are more successful in countries with higher-quality institutions



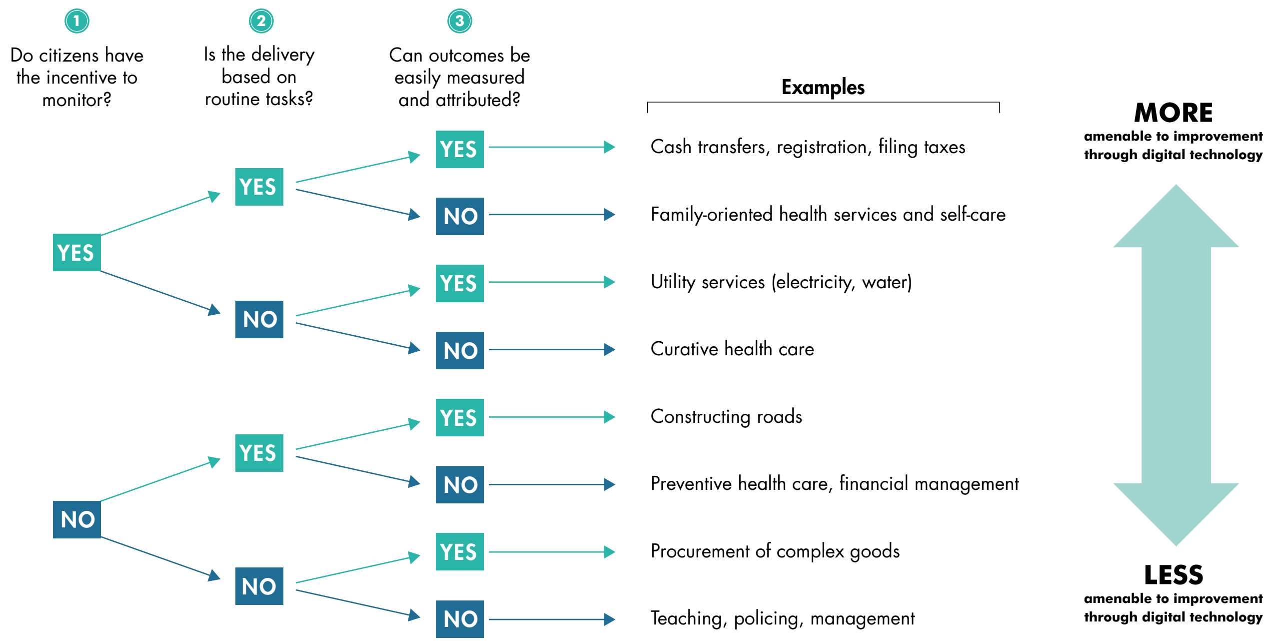
Sources: WDR 2016 team, based on World Bank (2015a) Digital Governance Projects Database; Worldwide Governance Index 2014; Denizer, Kaufmann, and Kraay 2013. Data at http://bit.do/WDR2016-Fig3_16.

Note: Each observation represents an e-government project, for a total of 530 projects. Quality of institutions is measured by the combined Worldwide Governance Index. Project outcomes are measured on a six-point scale based on assessments by the World Bank's internal evaluation unit. The graph controls for economic growth, project duration, and project size.

importance of these complementarities of skills, organizational changes, and issues specific to the public sector, such as procurement rules, as conditioning the impact of e-government.

The extent of the institutional dependence of digital technologies in achieving impacts varies by the type of service and activity, based on three factors: the degree to which citizens have an incentive to monitor the service and provide feedback; the extent to which the processes for the production and delivery of the service or activity are based on tasks that can be made routine and standardized; and the measurability and extent to which the outputs and outcomes from the task can be attributed to particular public actors or actions (figure 3.17). Services and activities that citizens have an incentive to monitor, and that are measurable and attributable to the efforts of specific government officials, are compatible with political incentives. Improving them yields immediate political benefits, as citizens care about these services, can assess the service improvement, and can attribute this improvement to actions by policy makers and providers. If their delivery is based on repeatable, routine tasks, these are more amenable to automation or digitally enabled monitoring. These services are less

Figure 3.17 Classifying public services and activities as to their amenability to improvement through digital technology



Sources: WDR 2016 team, based on Batley and Mcloughlin 2015; Pritchett and Woolcock 2002; Wilson 1989; World Bank 2003.

conditional on the strength of the initial institutions and relatively amenable to improvements through digital technology.

By contrast, services that citizens do not have an incentive to monitor and that are less measurable and attributable do not yield political benefits to politicians. If the delivery of these services is based on tasks that are highly discretionary, policy makers have less influence over the providers responsible for these services. These services and activities are much more dependent on the quality of existing institutions; improvements through the application of digital technologies are only incremental. This variation helps explain the differential impact of digital technologies across the elements of government capability and citizen empowerment summarized in the table 3.1 and 3.2 scorecards, and why digital technologies can substitute for poor institutions for certain activities and can only complement existing institutions for others.

Citizens and businesses have an incentive to monitor private goods or services that they use very frequently. These include the variety of registration and licensing services offered in one-stop centers; filing taxes; welfare payments; family-oriented health services and self-care such as neonatal health and patients' adherence to treatment schedules; and utility services like household water and electricity. The tasks to deliver some of these services, like cash transfers or filing taxes, are largely rule-based and clerical, or follow a standardized set of procedures, and ensuring the timely processing of work orders is enough to deliver the service. These features help explain the successful uses of digital technologies for welfare payments, water provision, property and business registration discussed earlier, including through citizen feedback on service quality. It also explains the success of various m-health initiatives. Automating these tasks does require breaking down departmental silos and changing administrative processes, but the quick, easily visible, and easily attributable service improvements to citizens can yield political benefits that even clientelist politicians might have an interest in supporting, though the political economy considerations vary by activity. The mixed impact of e-filing systems for example, reflects how these reforms can often conflict with elite interests and are likely more dependent on institutional complements.

By contrast, teaching, policing, and management are tasks for which no "user manual" can be written, since providers are confronted daily with unique circumstances and must exercise significant judgment on how to respond.[93] As a result, these tasks are particularly susceptible to problems of asymmetric information. As discussed, it is difficult for digital technologies to make a difference beyond addressing basic problems of provider absenteeism. Citizens also often lack the incentive or capacity to monitor these services, either because they are public goods (for example, security), or are less visible (classroom teaching or government administration). These difficulties in measurability, and therefore "attributability," also make it hard for citizens to hold providers and politicians accountable for performance through elections—beyond deterring electoral fraud and voting out corrupt politicians. They also make it difficult for citizen collective action to be effective in the absence of a strong civil society or willing governments to partner with. These are services and activities where institutions matter much more for outcomes. Digital technologies cannot replace weak institutions.

Between these two extremes are the mixed cases where digital technologies can improve some aspects of the service or activity. Roads and other public infrastructure, financial management, and government procurement are activities with low incentives for citizens to monitor because the service is a public good, or not visible to citizens; however, the measurability and attributability of outcomes may be high, and the delivery process may have some elements that can be automated (such as construction). E-procurement of complex goods, such as e-government systems, cannot entirely remove discretion in the evaluation of different bids, but it does establish audit trails and performance indicators. Curative and preventive health care are private and public goods, respectively, and so differ in the citizens' incentive to monitor (although vaccinating children is a preventive measure that parents are likely to have an incentive to monitor). But the highly discretionary nature of clinical services and the difficulties in measuring the outcomes of treatment render curative health care more difficult to improve through the application of technology than preventive health campaigns that follow more relatively standardized procedures (such as control of communicable diseases).

The future of public services

This varying interaction between institutions and digital technology provides entry points for reform in different country contexts to improve public service delivery. This institutional perspective does not imply that digitally enabled reforms must wait for a country's institutions to improve to have impact. Digital technologies can also strengthen institutions. In countries with clientelist and patronage-based institutions, technology can substitute for weak initial institutions for certain services, and in the process also help improve those institutions. That has been evident in the example of MajiVoice in Kenya, where automation quickly transformed a patronage-based water utility to a performance-oriented one, and in the examples of institutional transformation triggered by digital identification. Moreover, the considerable heterogeneity of institutions within countries, varying by sector and locale, creates many openings for innovations that are specific to a given context.[94]

How should this institutional heterogeneity be classified to help guide policies? Under clientelism, policies are more likely to be adopted if they generate immediate and highly visible service improvements to citizens without reducing the rents of vested interests. In patronage-based bureaucracies, reforms are more likely to succeed if they do not require significant changes in administrative processes or much collaboration across agencies, or threaten the bureaucracy with staffing and budgetary reductions. Under pro-poor political institutions, there can be greater political ownership in reforming bureaucracies to strengthen government capability, and in transparency and accountability initiatives. Performance-oriented bureaucracies have the incentive to engage with ambitious initiatives, including the long-duration and less visible administrative automation that often elicits little enthusiasm from politicians.

More generally, the variation in institutional dependency by the nature of the service and activity opens reform possibilities and can be a guide for policies in different country contexts, as discussed in chapter 5.

Notes

1. The 2004 World Development Report, *Making Services Work for Poor People*, underlined that service delivery failures are largely about failures of accountability and weak government implementation capacity, not about poor policies or lack of resources. It showed how relationships of accountability—between citizens and policy makers, between policy makers and service providers, and between citizens and providers—determine outcomes. Unaccountable politicians target policies and public spending to a narrow set of elites rather than providing public goods to benefit the general population. Managers and providers are unresponsive to policy makers and to citizens, often using their positions to extract rents. And poor citizens are unable to organize collectively to pressure policy makers and providers to address service delivery failures. See also Pritchett, Woolcock, and Andrews 2010.

2. Based on the Online Service Index (OSI), published by the United Nations Department of Economic and Social Affairs. The OSI assesses the range and functionality of government-to-citizen (G2C) and government-to-business (G2B) services offered on the national website of each of the UN's 193 member states, from simple one-way provision of information, to two-way interaction, to integrated "one-stop" portals. This functionality is based on the standard three-stage classification of e-services in the literature. Informational services are basic websites where citizens can obtain information on government ministries and agencies, access archives, and download forms to apply for public services. Transactional services are chiefly two-way online communications for governments to share information and solicit feedback, and often on government websites that process financial transactions, such as electronic tax filing. Connected services are citizen-centric, whole-of-government services. Institutional reform and advanced technologies enable citizens to automatically receive benefits based on life-cycle or economic characteristics. They also allow agencies to easily share data to facilitate service delivery. And they encourage accountability through monitoring and feedback mechanisms. Depending on the intended beneficiary, these services can be classified as government-to-government (G2G), G2C, or G2B (UN 2014).
3. For this Report, the World Bank has developed two indexes to measure e-government. The Core Systems index measures the automation and integration of core G2G financial and human resource management systems, as well as revenue-related G2B and G2C systems, in 198 countries, drawing on a global dataset of e-government systems developed by the World Bank. The Digital Identification Systems index measures the presence and scope of digital identification systems in government that can serve as a foundational platform technology for myriad G2G, G2C, and G2B services, also drawing on a global dataset of these systems developed by the World Bank. These datasets were prepared by a World Bank team comprising Cem Dener, Sophiko Skhirtladze, Irene H. Zhang, and Doruk Yarin Kiroglu.
4. Reddick and Turner 2012; Gauld, Goldfinch, and Horsburgh 2010.
5. UN 2014.
6. Tomlinson and others 2013.
7. Agarwal and Labrique 2014.
8. World Bank 2012.
9. Kradt-Todd and others 2015.
10. Corbacho, Cibils, and Lora 2013.
11. Perez-Truglia and Troiano 2015; Bø, Slemrod, and Thoresen 2014. For a review of the literature, see Luttmer and Singhal 2014.
12. Ayres, Raseman, and Shih 2009.
13. World Bank 2015c.
14. World Bank 2015c.
15. Muralidharan, Niehaus, and Sukhtankar 2014.
16. See http://global.census.okfn.org/.
17. Chopra 2014; Sunstein 2013; Goldstein and Dyson 2013.
18. Bayern 2015.
19. These perceptions are based on the World Bank Enterprise Survey panel dataset (2008/09 and 2012/13) from the European and Central Asian countries.
20. Kochanova, Hasnain, and Larson, forthcoming.
21. World Bank 2015b; WDI.
22. Deloitte 2012; Yilmaz and Coolidge 2013.
23. World Bank 2014a.
24. Doing Business (World Bank).
25. Lewis-Faupel and others 2014.
26. Krishna 2015.
27. Heeks 2003.
28. Sjoberg, Mellon, and Peixoto 2014.
29. World Bank 2015d.
30. Peixoto and Fox 2015.
31. Presentation given at the World Bank on ASAN Xidmet centers by the government of Azerbaijan; Majeed 2014.
32. Based on data received from LAPOR.
33. Based on discussions with government officials.
34. Cantijoch, Galandini, and Gobson 2014.
35. Bhatti, Kusek, and Verheijen 2015.
36. WDR 2016 team based on data received from the government of Punjab.
37. Astrom and others 2013.
38. Chaudhury and others 2006.
39. Dhaliwal and Hanna 2014; Muralidharan and others 2014.
40. Duflo, Hanna, and Ryan 2012; Cilliers and others 2013; Callen and others 2014; Aker and Ksoll 2015; Dhaliwal and Hanna 2014; Adelman and others 2015.
41. WDR 2016 team based on data from the government of Punjab.
42. Oxford Policy Management 2015.
43. Bloom and others 2013; Aral, Brynjolfsson, and Wu 2012.
44. World Bank 2014b.
45. Kraemer and King 2006; Baldwin, Gauld, and Goldfinch 2012.
46. For example, Bill Clinton, former president of the United States, reportedly said that "in the new century, liberty will spread by cell phone and cable modem" (see http://www.techlawjournal.com/trade/20000309.htm).
47. Effective service delivery requires sound mechanisms for holding policy makers and bureaucracies accountable. Democracy is one, but not the only, political system for establishing strong relationships of accountability.

48. Based on data from Bishop and Hoeffler 2014. Six indicators relate to the freeness of the electoral process before election day: the legal framework, electoral management bodies, electoral rights, voter register, ballot access, and campaign process. Four indicators relate to the fairness of voting and events on or immediately after election day: media access, voting process, role of officials, and counting of votes. Each indicator has several criteria that must be met for it to be coded as "1" for the given election. If there is a sufficient body of data to conclude that the conditions are not met, the indicator is coded as "0." An election is considered free when at least four of the six relevant indicators are coded as "1." An election is considered "fair" when at least two of the four relevant indicators are coded as "1."
49. Fujiwara 2015.
50. Callen and Long 2015.
51. Aker, Collier, and Vicente 2013.
52. Fung, Russon Gilman, and Shkabatur 2010.
53. For a review of the literature, see Anderson 2007.
54. This "liberation technology" literature is considerable. See, for example, Diamond and Plattner 2012.
55. Prat and Stromberg 2005.
56. Gentzkow 2006.
57. Gemenis and Rosema 2014.
58. Falck, Gold, and Heblich 2014.
59. Bond and others 2012.
60. Hindman 2008.
61. Farrell 2012; Sunstein 2009.
62. Gallup World Poll, http://www.gallup.com/services/170945/world-poll.aspx.
63. Fung, Russon Gilman, and Shkabatur 2013.
64. Ferraz and Finan 2008.
65. Larreguy, Marshall, and Snyder Jr. 2014.
66. Keefer and Khemani 2003.
67. Keefer and Khemani 2011.
68. Banerjee and others 2011.
69. Humphreys and Weinstein 2012.
70. Bayern 2015.
71. Alvarez, Hall, and Trechsel 2009.
72. Spada and others 2015.
73. Diamond and Plattner 2012; Little 2015; Shirky 2008.
74. Acemoglu, Hasan, and Tahoun 2014.
75. Valenzuela 2013.
76. Bennett and Segerberg 2011.
77. Hollenbach and Pierskalla 2014.
78. Pierskalla and Hollenbach 2013.
79. Banerjee and others 2010; Björkman and Svensson 2009; Lieberman, Posner, and Tsai 2014; Olken 2007.
80. Fung, Graham, and Weil 2007.
81. Fox 2014; Grandvoinnet, Aslam, and Raha 2015.
82. Peixoto and Fox 2015.
83. Fung, Russon Gilman, and Shkabatur 2010.
84. Peixoto and Fox 2015.
85. Bayern 2015.
86. This is the Huduma citizen complaints portal based on the Ushahidi platform, not to be confused with the Huduma service centers recently established by the government of Kenya.
87. Berdou and Lopes 2015.
88. Schlozman, Verba, and Brady 2010.
89. World Bank 2003.
90. Fountain 2001.
91. Bresnahan, Brynjolfsson, and Hitt 2002; Brynjolfsson and Hitt 2000.
92. Garicano and Heaton 2010.
93. Lipsky 1980.
94. Banerjee and Duflo 2014.

References

Acemoglu, Daron, Tarek Hasan, and Ahmed Tahoun. 2014. "The Power of the Street: Evidence from Egypt's Arab Spring." NBER Working Paper 20665, National Bureau of Economic Research, Cambridge, MA.

Adelman, Melissa, Moussa Blimpo, David K. Evans, Atabanam Simbou, and Noah Yarrow. 2015. "Can Information Technology Improve School Effectiveness in Haiti? Evidence from a Field Experiment." Unpublished paper, World Bank, Washington, DC.

Agarwal, Smisha, and Alain Labrique. 2014. "Newborn Health on the Line: The Potential mHealth Applications." *Journal of the American Medical Association* 312 (3): 229–30.

Aker, Jenny C., Rachid Boumnijel, Amanda McClelland, and Niall Tierney. 2014. "Payment Mechanisms and Anti-Poverty Programs: Evidence from a Mobile Money Cash Transfer Experiment in Niger." Working Paper 268, Center for Global Development, Washington, DC.

Aker, Jenny C., Paul Collier, and Pedro Vicente. 2013. "Is Information Power? Using Mobile Phones and Free Newspapers during an Election in Mozambique." Working Paper 328, Center for Global Development, Washington, DC. http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2364162.

Aker, Jenny C., and Christopher Ksoll. 2015. "Call Me Educated: Evidence from a Mobile Monitoring Experiment in Niger." Working Paper 406, Center for Global Development, Washington, DC. http://www.cgdev.org/publication/call-me-educated-evidence-mobile-monitoring-experiment-niger-working-paper-406.

Alvarez, Michael R., Thad E. Hall, and Alexander H. Trechsel. 2009. "Internet Voting in Comparative Perspective: The Case of Estonia." *Political Science and Politics* 42 (3): 497–505.

Anderson, Christopher J. 2007. "The End of Economic Voting? Contingency Dilemmas and the Limits of Democratic Accountability." *Annual Review of Political Science* 10 (1): 271–96.

Aral, Sinan, Erik Brynjolfsson, and Lynn Wu. 2012. "Three-Way Complementarities: Performance Pay, HR Analytics and Information Technology." *Management Science* 58 (5): 913–31.

Astrom, Joachim, Hille Hinsberg, Magnus Jonsson, and Martin Karlsson. 2013. "Citizen Centric E-Participation: A Trilateral Collaboration for Democratic Innovation." PRAXIS Center for Policy Studies, Tallin, Estonia.

Ayres, Ian, Sophie Raseman, and Alice Shih. 2009. "Evidence from Two Large Field Experiments That Peer Comparison Feedback Can Reduce Residential Energy Usage." NBER Working Paper 15386, National Bureau of Economic Research, Cambridge, MA.

Baldwin, Norman J., Robin Gauld, and Shaun Goldfinch. 2012. "What Public Servants Really Think of E-Government." *Public Management Review* 14 (1): 105–27.

Banerjee, Abhijit, Rukmini Banerji, Esther Duflo, Rachel Glennerster, and Stuti Khemani. 2010. "Pitfalls of Participatory Programs: Evidence from a Randomized Evaluation in Education in India." *American Economic Journal: Economic Policy* 2 (1): 1–30.

Banerjee, Abhijit, and Esther Duflo. 2014. "Under the Thumb of History? Political Institutions and the Scope for Action." NBER Working Paper 19848, National Bureau of Economic Research, Cambridge, MA.

Banerjee, Abhijit, Selvan Kumar, Rohini Pande, and Felix Su. 2011. "Do Informed Voters Make Better Choices? Experimental Evidence from Urban India." Unpublished manuscript, Harvard University, Cambridge, MA. http://www.povertyactionlab.org/node/2764.

Batley, Richard, and Claire Mcloughlin. 2015. "The Politics of Public Services: A Service Characteristics Approach." *World Development* 74: 275–85.

Bayern, Jessica. 2015. "Investigating the Impact of Open Data: Case Studies of Kenya, Moldova, Philippines, and Uganda." Background paper for the *World Development Report 2016*, World Bank, Washington, DC.

Bennett, W. Lance, and Alexandra Segerberg. 2011. "Digital Media and the Personalization of Collective Action: Social Technology and the Organization of Protests against the Global Economic Crisis." *Information, Communication & Society* 14 (6): 770–99.

Berdou, E., and C. A. Lopes. 2015. "The Case of UNICEF's U-Report (Uganda)." World Bank, Washington, DC.

Best, Michael. 2013. *Cables, Commissions and Cybercafés: ICTs in Postconflict Liberia.* Washington, DC: World Bank.

Bhatnagar, Subhash. 2009. *Unlocking E-Government Potential: Concepts, Cases and Practical Insights.* New Delhi, India: SAGE Publications.

Bhatti, Zubair, Jody Kusek, and Tony Verheijen. 2015. "Logged On: Smart Government Solutions from South Asia." World Bank, Washington, DC.

Bishop, Sylvia, and Anke Hoeffler. 2014. "Free and Fair Elections: A New Database." Working Paper WPS/2014-14, Centre for the Study of African Economies, Oxford, U.K. http://www.csae.ox.ac.uk/datasets/free-fair-elections/.

Björkman, Martina, and Jakob Svensson. 2009. "Power to the People: Evidence from a Randomized Experiment on Community-Based Monitoring in Uganda." *Quarterly Journal of Economics* 124 (2): 735–69.

Bloom, Nicholas, Erik Brynjolfsson, Lucia Foster, Ron Jarmin, Ita Saporta-Eksten, and John Van Reenan. 2013. "Management in America." Discussion Paper 13-01, Center for Economic Studies, Washington, DC.

Bø, Erland E., Joel Slemrod, and Thor O. Thoresen. 2014. "Taxes on the Internet: Deterrence Effects of Public Disclosure." Discussion Paper 770, Statistics Norway Research Department.

Bond, Robert M., Christopher J. Fariss, Jason J. Jones, Adam Kramer, Cameron Marlow, Jaime E. Settle, and James H. Fowler. 2012. "A 61-Million-Person Experiment in Social Influence and Political Mobilization." *Nature* 489: 295–98.

Bresnahan, Timothy, Erik Brynjolfsson, and Lorin M. Hitt. 2002. "Information Technology, Workplace Organization, and the Demand for Skilled Labor: Firm-Level Evidence." *Quarterly Journal of Economics* 117 (1): 339–76.

Bridge Academies. 2013. "The Bridge Effect: Comparison of Bridge Pupils to Peers at Nearby Schools." EGRA-EGMA Evaluation Programme, Fall 2013 Results, Bridge International Academies, Mombassa, Kenya. http://www.bridgeinternationalacademies.com/wp-content/uploads/2013/01/Bridge-International-Academies_White-Paper_The-Bridge-Effect_Nov-2014_Website.pdf.

Brynjolfsson, Erik, and Lorin M. Hitt. 2000. "Beyond Computation: Information Technology, Organizational Transformation and Business Performance." *Journal of Economic Perspectives* 14 (4): 23–48.

Budzier, Alexander, and Bent Flyvbjerg. 2012. "Overspend? Late? Failure? What the Data Say about IT Project Risk in the Public Sector." In *Commonwealth Governance Handbook 2012/13: Democracy, Development and Public Administration*, edited by Commonwealth Secretariat, 145–57. London: Commonwealth Secretariat.

Bussell, Jennifer. 2012. *Corruption and Reform in India: Public Services in the Digital Age.* Cambridge, MA: Cambridge University Press.

Callen, Michael, Saad Gulzar, Ali Hasanain, and Yasir Khan. 2014. "The Political Economy of Public Employee Absence: Experimental Evidence from Pakistan." Working paper, Harvard University, Cambridge, MA.

Callen, Michael, and James D. Long. 2015. "Institutional Corruption and Election Fraud: Evidence from a Field Experiment in Afghanistan." *American Economic Review* 105 (1): 354–81.

Cantijoch, Marta, Silvia Galandini, and Rachel Gobson. 2014. “Civic Websites and Community Engagement: A Mixed Methods Study of Citizen Empowerment Initiatives.” APSA Annual Meeting paper. http://ssrn.com/abstract=2454315.

Chaudhury, Nazmul, Jeffery Hammer, Michael Kremer, Karthik Muralidharan, and F. Halsey Rogers. 2006. “Missing in Action: Teacher and Health Worker Absence in Developing Countries.” *Journal of Economic Perspectives* 20 (1): 91–116. doi:10.1257/089533006776526058.

Chopra, Aneesh. 2014. *Innovative State: How New Technologies Can Transform Government.* New York: Atlantic Monthly Press.

Cilliers, Jacobus, Ibrahim Kasirye, Clare Leaver, Pieter Serneels, and Andrew Zeitlin. 2013. “Improving Teacher Attendance Using a Locally Managed Monitoring Scheme: Evidence from Ugandan Primary Schools.” Policy Note 14/0186, International Growth Centre, London.

Corbacho, A., V. Fretes Cibils, and E. Lora. 2013. *More Than Revenue: Taxation as a Development Tool.* Washington, DC: Inter-American Development Bank.

Corrales, Javier, and Frank Westhoff. 2006. “Information Technology Adoption and Political Regimes.” *International Studies Quarterly* 50: 911–33. http://onlinelibrary.wiley.com/doi/10.1111/j.1468-2478.2006.00431.x/pdf.

Deloitte. 2012. “eTransform Africa: Modernising Government through ICTs.” Deloitte Consulting. http://siteresources.worldbank.org/EXTINFORMATIONANDCOMMUNICATIONANDTECHNOLOGIES/Resources/282822-1346223280837/Modernizing Government_Fullreport.pdf.

Denizer, Cevdet, Daniel Kaufmann, and Aart Kraay. 2013. “Good Countries or Good Projects? Macro and Micro Correlates of World Bank Project Performance.” *Journal of Development Economics* 105 (November): 288–302. http://www.sciencedirect.com/science/article/pii/S0304387813000874.

Dhaliwal, Iqbal, and Rema Hanna. 2014. “Deal with the Devil: The Success and Limitations of Bureaucratic Reform in India.” NBER Working Paper 20482, National Bureau of Economic Research, Cambridge, MA.

Diamond, Larry, and Marc F. Plattner. 2012. *Liberation Technology: Social Media and the Struggle for Democracy*. Baltimore, MD: John Hopkins University Press.

Duflo, Esther, Rema Hanna, and Stephen P. Ryan. 2012. “Incentives Work: Getting Teachers to Come to School.” *American Economic Review* 102 (4): 1241–78.

Dunleavy, Patrick, and Leandro Carrera. 2013. *Growing the Productivity of Government Services.* Cheltenham, U.K.: Edward Elgar.

EC (European Commission). 2014. Eurostat (database). European Commission, Luxembourg, http://ec.europa.eu/eurostat/data/database.

Falck, Oliver, Robert Gold, and Stephan Heblich. 2014. “E-lections: Voting Behavior and the Internet.” *American Economic Review* 104 (7): 2238–65.

Farrell, Henry. 2012. “The Consequences of the Internet for Politics.” *Annual Review of Political Science* 15 (June): 35–52. doi: 10.1146/annurev-polisci-030810-110815.

Ferraz, Claudio, and Frederico Finan. 2008. “Exposing Corrupt Politicians: The Effects of Brazil’s Publicly Released Audits on Electoral Outcomes.” *Quarterly Journal of Economics* (May 2008): 703–45. http://eml.berkeley.edu/~ffinan/Finan_Audit.pdf.

Fountain, Jane E. 2001. *Building the Virtual State: Information Technology and Institutional Change.* Washington, DC: Brookings Institution Press.

Fox, Jonathan. 2014. “Social Accountability: What Does the Evidence Really Say?” Working paper, Global Partnership for Social Accountability, Washington, DC.

Fujiwara, Thomas. 2015. “Voting Technology, Political Responsiveness, and Infant Health: Evidence from Brazil.” *Econometrica* 83 (2): 423–64.

Fung, Archon, Hollie Russon Gilman, and Jennifer Shkabatur. 2010. *Impact Case Studies from Middle Income and Developing Countries.* London: Transparency and Accountability Initiative, Open Society Foundation. http://www.transparency-initiative.org/wp-content/uploads/2011/05/impact_case_studies_final1.pdf.

———. 2013. “Six Models for the Internet + Politics.” *International Studies Review* 15 (1): 30–47. doi: 10.1111/misr.12028.

Fung, Archon, Mary Graham, and David Weil. 2007. *Full Disclosure: The Perils and Promise of Transparency.* Cambridge, MA: Cambridge University Press.

Garicano, Luis, and Paul Heaton. 2010. “Information Technology, Organization, and Productivity in the Public Sector: Evidence from Police Departments.” *Journal of Labor Economics* 28 (1): 167–201.

Gauld, Robin, and Shaun Goldfinch. 2006. *Dangerous Enthusiasms: E-Government, Computer Failure, and Information System Development.* Dunedin, New Zealand: Otago University Press.

Gauld, Robin, Shaun Goldfinch, and Simon Horsburgh. 2010. “Do They Want It? Do They Use It? The ‘Demand Side’ of E-Government in Australia and New Zealand.” *Government Information Quarterly* 27 (2): 177–86. doi: 10.1016/j.giq.2009.12.002.

Gemenis, Kostas, and Martin Rosema. 2014. “Voting Advice Applications and Electoral Turnout.” *Electoral Studies* 36 (December 2014): 281–89.

Gentzkow, Matthew. 2006. “Television and Voter Turnout.” *Quarterly Journal of Economics* 121 (3): 931–72. doi: 10.1162/qjec.121.3.931.

Goldstein, Brett, and Lauren Dyson. 2013. *Beyond Transparency: Open Data and the Future of Civic Innovation.* San Francisco: Code for America Press.

Grandvoinnet, Helene, Ghazia Aslam, and Shomikho Raha. 2015. *Opening the Black Box: Contextual Drivers* *of Social Accountability Effectiveness*. Washington, DC: World Bank.

Heeks, Richard. 2003. "Most eGovernment-for-Development Projects Fail: How Can Risks Be Reduced?" iGovernment Working Paper 14, Institute for Development Policy and Management, Manchester, U.K. http://unpan1.un.org/intradoc/groups/public/documents/NISPAcee/UNPAN015488.pdf.

———. 2006. "Understanding and Measuring E-Government: International Benchmarking Studies." Unpublished paper, University of Manchester, Manchester, U.K.

———. 2008. "Success and Failure Rates of eGovernment in Developing/Transitional Countries." http://www.egov4dev.org/success/sfrates.shtml.

Heyneman, Stephen P., and Jonathan M. B. Stern. 2014. "Low Cost Private Schools for the Poor: What Public Policy Is Appropriate?" *International Journal of Educational Development* 35 (March): 3–15.

Hindman, Matthew. 2008. *The Myth of Digital Democracy*. Princeton, NJ: Princeton University Press.

Hollenbach, Florian, and Jan Pierskalla. 2014. "Voicing Discontent: Communication Technology and Protest." APSA Annual Meeting paper.

HRW (Human Rights Watch). 2015. "Human Rights Watch Submission." Background note submitted to the *World Development Report 2016* team, Human Rights Watch, Washington, DC. https://www.hrw.org/sites/default/files/supporting_resources/hrw_submission_re_wdr_2016_internet_for_development.pdf.

Humphreys, Macarten, and Jeremy Weinstein. 2012. "Policing Politicians: Citizen Empowerment and Political Accountability in Uganda: Preliminary Analysis." Working paper, Columbia University, New York.

International Budget Partnership. 2014. "Open Budget Index." http://internationalbudget.org/opening-budgets/open-budget-initiative/open-budget-survey/.

Keefer, Philip, and Stuti Khemani. 2003. "Democracy, Public Expenditures and the Poor." World Bank, Washington, DC.

———. 2011. "Do Informed Citizens Receive More . . . or Pay More? The Impact of Radio on the Government Distribution of Public Health Benefits." Policy Research Working Paper 5952, World Bank, Washington, DC. https://openknowledge.worldbank.org/bitstream/handle/10986/3236/WPS5952.pdf?sequence=1.

Kelly, Tim, and David Souter. 2014. *The Role of Information and Communication Technologies in Post-Conflict Reconstruction*. Washington, DC: World Bank. http://www.infodev.org/infodev-files/final_report_10_feb.pdf.

King, Gary, Jennifer Pan, and Margaret E. Roberts. 2013. "How Censorship in China Allows Government Criticism but Silences Collective Expression." *American Political Science Review* 107 (2): 1–18.

Kochanova, Anna, Zahid Hasnain, and Bradley R. Larson. Forthcoming. "Does E-Government Improve Public Sector Capability?" Background paper for the *World Development Report 2016*, World Bank, Washington, DC.

Kradt-Todd, G., Erez Yoeli, Syon Bhanot, and David Rand. 2015. "Promoting Cooperation in the Field." *Current Opinion in Behavioral Sciences* 3 (June): 96–101. doi:10.1016/j.cobeha.2015.02.006.

Kraemer, Kenneth L., and John Leslie King. 2006. "Information Technology and Administrative Reform: Will E-Government Be Different?" *International Journal of Electronic Government Research* 2 (1): 1–20.

Krishna, Gunjan. 2015. "Improving Service Delivery through the Use of Digital Technologies: A Case Study of Karnataka e-Procurement." Background paper for the *World Development Report 2016*, World Bank, Washington, DC.

Larreguy, Horacio, John Marshall, and James M. Snyder Jr. 2014. "Revealing Malfeasence: How Local Media Facilitates Sanctioning of Mayors in Mexico." NBER Working Paper 20697, National Bureau of Economic Research, Cambridge, MA.

Lemieux, V. 2015. "One Step Forward, Two Steps Back? Does E-Government Make Governments in Developing Countries More Transparent and Accountable?" Background paper for the *World Development Report 2016*, World Bank, Washington, DC.

Lewis-Faupel, Sean, Yusef Neggers, Benjamin A. Olken, and Rohini Pande. 2014. "Can Electronic Procurement Improve Infrastructure Provision? Evidence from Public Works in India and Indonesia." NBER Working Paper 20344, National Bureau of Economic Research, Cambridge, MA.

Lieberman, Evan, Daniel Posner, and Lily Tsai. 2014. "Does Information Lead to More Active Citizenship? Evidence from an Education Intervention in Rural Kenya." *World Development* 60: 69–83.

Lipsky, Michael. 1980. *Street-Level Bureaucracy: Dilemmas of the Individual in Public Service*. New York: Russell Sage Foundation.

Little, Andrew. 2015. "Communication Technology and Protest." *Journal of Politics* 78 (1). http://www.jstor.org/stable/10.1086/683187.

Luttmer, Erzo, and Monica Singhal. 2014. "Tax Morale." *Journal of Economic Perspectives* 28 (4): 149–68. doi:10.1257/jep.28.4.149.

Majeed, Rushda. 2014. "A Second Life for One-Stop Shops: Citizen Service Centers in Minas Gerais, Brazil, 2003–2013." Innovations for Successful Societies, Princeton University, Princeton, NJ.

Morozov, Evgeny. 2012. *The Net Delusion: The Dark Side of Internet Freedom*. PublicAffairs.

Muralidharan, Karthik, Jishnu Das, Alaka Holla, and Aakash Mohpal. 2014. "The Fiscal Cost of Weak Governance: Evidence from Teacher Absenteeism in India." NBER Working Paper 20299, National Bureau of Economic Research, Cambridge, MA.

Muralidharan, Karthik, Paul Niehaus, and Sandip Sukhtankar. 2014. "Building State Capacity: Evidence from Biometric Smartcards in India." NBER Working Paper 19999, National Bureau of Economic Research, Cambridge, MA.

Olken, Benjamin. 2007. "Monitoring Corruption: Evidence from a Field Experiment in Indonesia." *Journal of Political Economy* 115 (2): 200–49. http://economics.mit.edu/files/2913.

OMB (U.S. Office of Management and Budget). 2010. *25-Point Implementation Plan to Reform Federal Information Technology Management.* OMB, Washington, DC.

Open Net Initiative. 2013. https://opennet.net/.

Oxford Policy Management. 2015. "EQUIP-Tanzania Impact Evaluation." Briefing Note 2, Oxford Policy Management.

Peixoto, Tiago, and Jonathan Fox. 2015. "When Does ICT-Enabled Citizen Voice Lead to Government Responsiveness?" Background paper for the *World Development Report 2016,* World Bank, Washington, DC.

Perceptions of Electoral Integrity. 2015. https://dataverse.harvard.edu/dataverse/PEI.

Perez-Truglia, Ricardo, and Ugo Troiano. 2015. "Tax Debt Enforcement: Theory and Evidence from a Field Experiment in the United States." Meeting Paper 134, Society for Economic Dynamics.

PIAAC (Programme for the International Assessment of Adult Competencies). 2014. OECD, Paris, http://www.oecd.org/site/piaac/.

Pierskalla, Jan H., and Florian M. Hollenbach. 2013. "Technology and Collective Action: The Effect of Cell Phone Coverage on Political Violence in Africa." *American Political Science Review* 107 (2): 207–24.

Polity IV. 2015. http://www.systemicpeace.org/polityproject.html.

Prat, Andrea, and David Stromberg. 2005. "Commercial Television and Voter Information." Discussion Paper 4989, Centre for Economic Policy Research, London.

Pritchett, Lant, and Michael Woolcock. 2002. "Solutions When the Solution is the Problem: Arraying the Disarray in Development." Center for Global Development, Washington, DC.

Pritchett, Lant, Michael Woolcock, and Matt Andrews. 2010. "Capability Traps? The Mechanisms of Persistent Implementation Failure." Center for Global Development, Washington, DC.

Rangan, V. Kasturi, and Katherine Lee. 2010. "Bridge International Academies: A School in a Box." Harvard Business School, Cambridge, MA.

Reddick, Christopher, and Michael Turner. 2012. "Channel Choice and Public Service Delivery in Canada: Comparing E-Government to Traditional Service Delivery." *Government Information Quarterly* 29 (1): 1–11. doi: 10.1016/j.giq.2011.03.005.

Research ICT Africa. 2014. Household surveys. Capetown, South Africa. http://www.researchictafrica.net/home.php.

Rød, Espen Geelmuyden, and Nils B. Weidmann. 2015. "Empowering Activists or Autocrats? The Internet in Authoritarian Regimes." *Journal of Peace Research* 53 (3): 1–14.

Rodriguez, Camila, and Sebastian Monroy-Taborda. Forthcoming. *Targeted Public Transit Benefits in Bogotá.* Background note for the *World Development Report 2016,* World Bank, Washington, DC.

Ross, Terrance. 2014. "Is It Ever Okay to Make Teachers Read Scripted Lessons?" *The Atlantic.* http://www.theatlantic.com/education/archive/2014/10/is-it-okay-to-make-teachers-read-scripted-lessons/381265/.

Schlozman, Kay Lehman, Sidney Verba, and Henry E. Brady. 2010. "Weapon of the Strong? Participatory Inequality and the Internet." *Perspectives on Politics* 8 (2): 487–509.

Shapiro, Jacob N., and Nils B. Weidmann. 2013. "Is the Phone Mightier Than the Sword? Cellphones and Insurgent Violence in Iraq." *International Organization* 2: 247–74.

Shirky, Clay. 2008. *Here Comes Everybody: The Power of Organizing without Organizations.* London: Penguin Group.

Sjoberg, Fredrik, Jonathan Mellon, and Tiago Peixoto. 2014. "The Effect of Government Responsiveness on Future Political Participation." Unpublished paper, World Bank, Washington, DC.

Spada, Paolo, Jonathan Mellon, Tiago Peixoto, and Fredrik Sjoberg. 2015. "Effects of the Internet on Participation: Study of a Policy Referendum in Brazil." Policy Research Working Paper 7204, World Bank, Washington, DC.

Standish Group. 2014. "Chaos Report." http://www.standishgroup.com/.

Sunstein, Cass R. 2009. *Republic 2.0.* Princeton, NJ: Princeton University Press.

———. 2013. *Simpler: The Future of Government.* New York: Simon & Schuster.

Tomlinson, Mark, Mary Jane Rotheram-Borus, Leslie Swartz, and Alexander C. Tsai. 2013. "Scaling Up mHealth: Where Is the Evidence?" *PLOS Medicine* 10 (2): e1001382. doi: 10.1371/journal.pmed.1001382.

Toyama, Kentaro. 2015. *Geek Heresy: Rescuing Social Change from the Cult of Technology.* New York: PublicAffairs.

UN (United Nations). 2014. "E-Government Survey 2014: E-Government for the Future We Want." UN, New York.

Valenzuela, Sebastián. 2013. "Unpacking the Use of Social Media for Protest Behavior: The Roles of Information, Opinion Expression, and Activism." *American Behavioral Scientist* 20 (10): 1–23.

Vassil, Kristjan. 2015. "Estonian E-Government Ecosystem: Foundation, Applications, Outcomes." Background paper for the *World Development Report 2016*, World Bank, Washington, DC.

Wilson, James Q. 1989. *Bureaucracy: What Government Agencies Do and Why They Do It.* New York: Basic Books.

World Bank. Various years. Doing Business (database). World Bank, Washington, DC, http://www.doingbusiness.org/.

———. Various years. Skills Towards Employability and Productivity (STEP) household surveys (database). World Bank, Washington, DC, http://microdata.worldbank.org/index.php/catalog/step/about.

———. 2003. *World Development Report 2004: Making Services Work for Poor People*. Washington, DC: World Bank.

———. 2012. "eTransform Africa: The Transformational Use of Information and Communication Technologies in Africa." World Bank, Washington, DC.

———. 2014a. "Impact Evaluation of E-Filing and In-Depth Study of Risk-Based Audits in Tajikistan." World Bank, Washington, DC.

———. 2014b. "Pay Flexibility and Government Performance: A Multicountry Study." Working Paper 88486, World Bank, Washington, DC. http://documents.worldbank.org/curated/en/2014/06/19630016/pay-flexibility-government-performance-multicountry-study.

World Bank. 2015a. Digital Governance Projects (database). World Bank, Washington, DC, http://data.worldbank.org/data-catalog/dg-projects-database.

———. 2015b. Global E-Government Systems (database). World Bank, Washington, DC, http://data.worldbank.org/data-catalog/pfm-systems-eservices-dataset.

———. 2015c. ID4D (Identification for Development database). World Bank, Washington, DC, http://data.worldbank.org/data-catalog/id4d-dataset.

———. 2015d. "MajiVoice: A New Accountability Tool to Improve Public Services." World Bank, Washington, DC.

Wrong, Michela. 2013. "Geeks for Peace." *New York Times*, February 28. http://latitude.blogs.nytimes.com/2013/02/28/geeks-for-peace/?_r=0.

Yilmaz, Fatih, and Jacqueline Coolidge. 2013. "Can E-Filing Reduce Tax Compliance Costs in Developing Countries?" Policy Research Working Paper 6647, World Bank, Washington, DC.

SECTOR FOCUS 3

e-health

Providing rural health care is a major challenge in countries with large rural populations. For example, in Ethiopia, more than 80 percent of the population lives outside of urban areas and more than 30 percent of the rural population is poor. Since 2003, the Ethiopian government has trained and deployed over 40,000 Health Extension Workers (HEWs) to serve rural and other hard-to-reach populations. However, HEWs are often isolated and lack the capacity to prioritize urgent but unpredictable antenatal and postnatal care.

To improve information flows, the World Bank, the African Development Bank, and Addis Ababa University developed the FrontlineSMS platform.[1] HEWs can register pregnant women and newborns and receive automated short message service (SMS) reminders to notify them of key appointments and to track the stock of essential medicines. An evaluation showed that by using existing mobile networks and low-cost feature phones, the system improved the ability of health workers to deliver services and improve health outcomes. More women had skilled assistance with their delivery, more women delivered in health centers, and more women received antenatal care. The system improved HEWs' capacity to respond in a timely manner and shows that in a context where internet coverage is low, mobile phones can be an effective way to improve health system performance.[2]

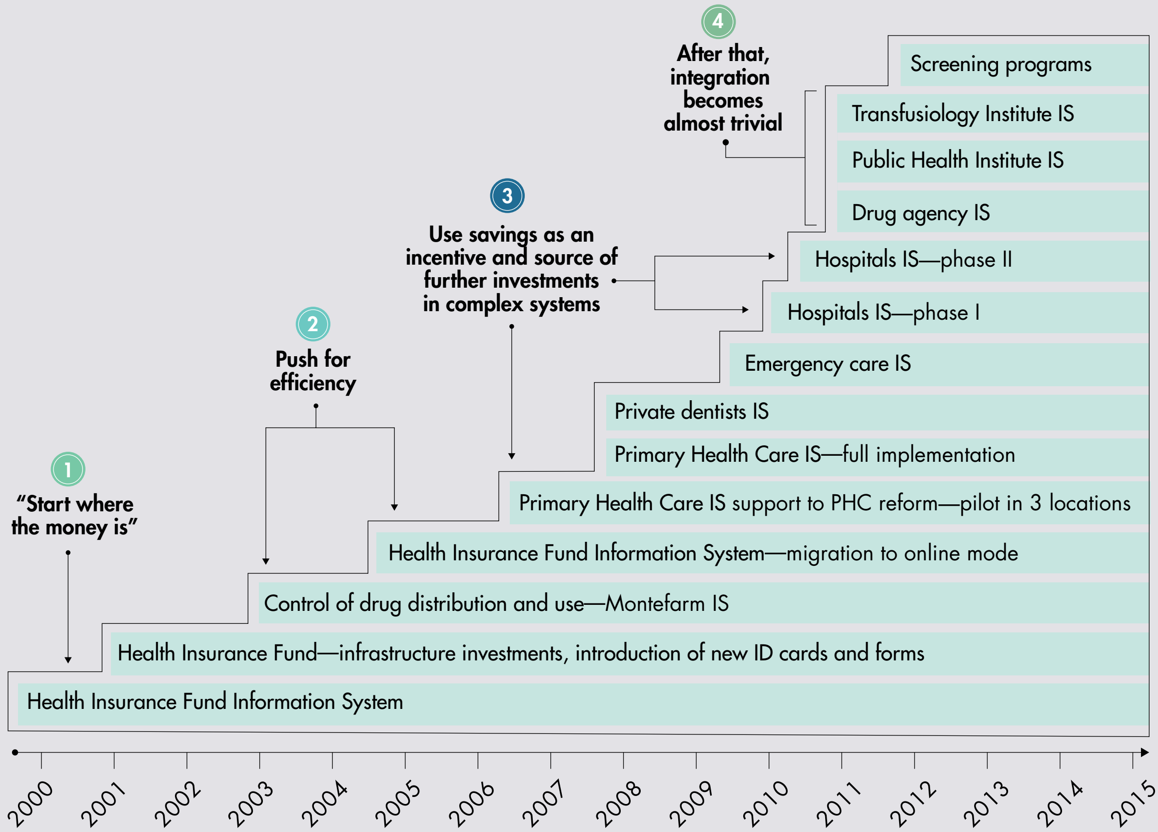
The internet and associated technologies have the potential to expand health services in developing countries, increase health system efficiency, and lead to better patient outcomes. E-health encompasses the full range of uses of information and communication technologies (ICTs)—from traditional administrative reporting systems to broader Health Management Information Systems (HMIS) to telemedicine, electronic medical records, clinical decision support, and patient portals—and a full range of technologies, including internet and mobile applications.[3]

Public health and clinical care cannot be delivered safely, with high quality and in a cost-effective manner, without seamless, sustainable, and secure data and information exchange at all levels of the health system. By 2011, 93 of 112 health systems in countries surveyed by the World Health Organization (WHO) had already adopted some form of an e-health or m-health (mobile phone–based) approach, mostly for information programs, emergencies, and telemedicine. Yet overall, deployment has been slow. Too often data are captured in a way that cannot be shared as needed because of interoperability issues or a lack of standards regarding the exchange of health information. Sometimes data are captured multiple times in multiple ways, leading to duplication, inaccuracies, and delays. Often they are not captured at all.

Low- and middle-income countries can do better. First, they can build on the emerging experience of developed countries and adapt systems to local conditions to benefit from e-health without repeating others' mistakes. For example, Montenegro chose "strategic interoperability" as a leading principle in developing its e-health system (figure F3.1). This includes integrative and long-term investment planning and phased implementation; central development for common resources such as shared codebooks and key registries of insured persons, drugs, health professionals, and health institutions; shared

This sector focus was contributed by Dominic S. Haazen, Zlatan Sabic, and Adis Balota.

Figure F3.1 Sequencing of e-health development in Montenegro



Note: IS = information system; PHC = primary health care.

information system infrastructure; and central development of key applications, including electronic health records, e-prescriptions, and e-referrals. Implementation sequencing "starts where the money is" (the Health Insurance Fund Information System) and progresses along the elements of e-health development, taking efficiency and monetary incentives into account. Most business processes are now computerized, serving 340 locations and 4,600 users, including general practitioners and nurses in primary and emergency care, hospitals, pharmacies, and private dentists. Systems are integrated and optimized by use of shared resources. Routine reporting systems provide complete and reliable data. Information is used to make policy-making and management decisions, and efficiency has improved throughout the system.[4]

Second, the absence of "legacy systems" can be an advantage. Countries can now make use of cloud computing to lower system costs and mobile technology to expand services to even the poorest and most remote locations. The potential value of e-health can arguably be greater in poorer countries, since it expands the reach and impact of the often very small number of highly trained physicians, assists clinical staff in rural and remote areas in making better diagnoses and treatment decisions, and helps make the best use of limited health care funding.

There is early evidence to suggest that e-health solutions, while costly to implement, can bring significant cost savings. This is because the implementation of human resources information systems, logistics management information systems, clinical decision support tools, digital payments, financial management information systems, and SMS reminder systems can address a variety of health system problems, including system inefficiencies, overuse of procedures, inappropriate hospital admissions, corruption and fraud, and missed appointments.

Effective country ownership, good governance, and strong institutional and human capacity are core to e-health planning and implementation. This includes a strong legal basis for managing health-related data with appropriate safeguards.[5] In addition to ensuring that health workers are able to effectively use such systems, this also implies the need for strong health informatics training programs in order to develop a qualified e-health workforce. National planning, enterprise architecture, standardization, and interoperability are essential for successful e-health implementation.

User-centered health care systems should leverage the unique capacity of citizens to contribute information and feedback. This enables health systems to connect with clients when and where needed, but clients can also access information and care, at their convenience.

Replacing paper-based patient registers with electronic registers should help improve local health care quality and inform management decision making. Similarly, increasing the use of e-health and m-health approaches and tools can support improved decision making by frontline providers, including GPS-enabled tools and harnessing the revolution that smartphone access to broadband content will bring about in developing countries. In this regard, more emphasis is needed to expand and improve the use and functionality of open-source software platforms (for example, OpenMRS, OpenLMIS, and iHRIS); develop new open-source platforms (for example, for health insurance and training); and support open-source frameworks (for example, OpenHIE).[6]

Information and communication technology platforms (web, social media, SMS campaigns, direct access to personal data in electronic health records) can be leveraged to enhance accountability, transparency, and empowerment of citizens to be active contributors to governance in health and central to health care delivery.

Notes

1. Otto and others 2014.
2. Bilal and others 2011.
3. WHO and ITU 2012.
4. Case study of the Montenegro Health System Improvement Programme (MHIP) by Adis Balota; Montenegro Republican Health Insurance Fund; University of Montenegro, Podgorica; and Zlatan Sabic.
5. EU 2012.
6. See, for example, http://openmrs.org, http://www.village reach.org/impact/openlmis, https://opensource.com/health.

References

Bilal, N. K., C. H. Herbst, F. Zhao, A. Soucat, and C. Lemiere. 2011. "Health Extension Workers in Ethiopia: Improved Access and Coverage for the Rural Poor." In *Yes Africa Can: Success Stories from a Dynamic Continent*, edited by P. Chuhan-Pole and M. Angwafo, 433–43. Washington, DC: World Bank.

EU (European Union). 2012. *eHealth Task Force Report: Redesigning Health in Europe for 2020*. Brussels: European Union.

Otto K., M. Shekar, H. C. Herbst, and R. Mohammed. 2014. *Information and Communication Technologies for Health Systems Strengthening Opportunities—Criteria for Success, and Innovation for Africa and Beyond*. Washington, DC: International Bank for Reconstruction and Development/World Bank.

WHO (World Health Organization) and ITU (International Telecommunication Union). 2012. *National eHealth Strategy Toolkit Overview*. Geneva: WHO and ITU.

SPOTLIGHT 4

ENABLING DIGITAL DEVELOPMENT

Digital identity

Individuals need mechanisms to identify one another and to identify themselves to their communities and governments. While this point may be obvious, it is profoundly important for people's welfare. Simple mechanisms—familiarity, appearance, perhaps vouching by an elder—are sufficient in small, intimate communities. Wider societies and economies require more formal systems—traditionally physical tokens, such as a paper-based identification (ID) card that includes the signatures or representations of their holders, and is verified against documents stored in a central registry. But these formal systems are failing in the developing world. Nearly 2.4 billion people are not registered. They are usually the poorest and most marginalized members of society; about one-quarter are children.[1] They are excluded from a range of rights and services, such as health care, enrollment in school, social welfare, and financial services.

Identity should be a public good. Its importance is now recognized in the post-2015 development agenda, specifically as a Sustainable Development Goal (SDG) target to "promote peaceful and inclusive societies for sustainable development, provide access to justice for all, and build effective, accountable, and inclusive institutions at all levels."[2] One of the indicators is to "provide legal identity for all, including birth registration, by 2030." The best way to achieve this goal is through *digital identity (digital ID)* systems, central registries storing personal data in digital form and credentials that rely on digital, rather than physical, mechanisms to authenticate the identity of their holder. India's massive Aadhaar program, which has enrolled over 950 million people, has dispensed with the physical ID card altogether. Estonia has created an electronic legal representation of an individual. Through the use of personal identification numbers (PINs) to authenticate the holder against a digital card credential, people can access public services remotely and even sign legal documents and contracts with the same legal validity as if they were signed in person.

Contributed by Joseph Atick, Mariana Dahan, Alan Gelb, and Mia Harbitz.

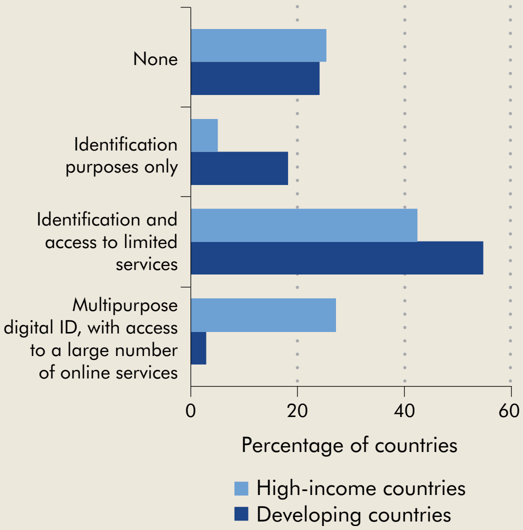
Country-specific use of digital identity

Most developing countries have some form of digital ID scheme tied to specific functions and serving a subset of the population, but only a few have a multipurpose scheme that covers the entire population. Eighteen percent of developing countries have a scheme that is used for identification purposes only; 55 percent have digital IDs that are used for specific functions and services like voting, cash transfers, or health; and only 3 percent have foundational ID schemes that can be used to access an array of online and offline services (figure S4.1). Twenty-four percent of developing countries have no digital ID system.

Although the concept of digital ID is universal, it plays somewhat different roles depending on the country context. In high-income countries, digital ID represents an upgrade from well-established, robust legacy physical ID systems that have worked reasonably well in the past. Belgium, Estonia, Finland, France, the Republic of Korea, and Singapore are some of the countries leveraging existing physical identity infrastructure to create digital ID ecosystems, enabling them to deliver public services more efficiently.

Low-income countries, by contrast, often lack robust civil registration systems and physical IDs and are building their ID systems on a digital basis, leapfrogging the more traditional physically based

Figure S4.1 Different types of digital ID schemes across countries



Source: World Bank ID4D database (various years). Data at http://bit.do/WDR2016-FigS4_1.

system. Identification, rather than e-services, is the main immediate goal. Such systems are being developed in Bangladesh, Guinea, and Kenya. One potential risk associated with leapfrogging to civil identification systems without a solid civil registration system is that in many cases the 0–18 population is excluded, and continues to be unregistered.

In middle-income countries, digital ID is strengthening and progressively replacing physical identity services while supporting the emergence of some e-services. Successful examples are found in Albania, India, Moldova, and Pakistan.

Evidence of impact

Evidence of the impact of digital ID is still largely anecdotal, but there is a growing body of research in at least three key areas—efficient management of social welfare programs, removing ghost workers from the government payroll, and improving the sanctity of elections.

Efficient management of social programs and welfare distribution

Digital IDs enable targeted cash transfers to bank accounts linked to a unique identifier. This ensures that those who are entitled to receive subsidies or benefits are actually getting them. For example, in India's fuel subsidy program, implementing cash transfers to Aadhaar-linked bank accounts to buy liquefied petroleum gas cylinders saved about US$1 billion per year when applied throughout the country.[3] This is just one of many subsidy programs in India that are being converted to direct transfers using digital ID, potentially saving over US$11 billion per year in government expenditures through reduced leakage and efficiency gains.[4] Other examples of the benefits of digital ID in reducing leakages for social protection or security programs, health insurance, and pension schemes due to duplicates, "ghost" beneficiaries, and corruption are occurring in Chile, the Arab Republic of Egypt, Ghana, Indonesia, Pakistan, South Africa, and Turkey.

Removing ghost employees from the government payroll

The budgets of many developing countries suffer from bloated civil service wages that leave little room for capital investments. For example, the public payroll occupies the bulk of the national budgets of Ghana, Uganda, and Zimbabwe, but weak systems imply that many individuals paid from the payroll do not actually work for the government, and may not even be alive.[5] Nigeria recently implemented a digital ID system for civil servants that enabled it to remove about 62,000 such ghost workers, saving US$1 billion annually, and providing a return on investment of nearly 20,000 percent in one year.[6] The impact of ghost workers is even worse in many other countries, ranging from 10 percent to as high as an estimated 40 percent in Zimbabwe, pointing to the substantial fiscal savings and efficiency gains from digital ID.[7]

Improving electoral integrity

Nigeria used digital IDs to prevent vote rigging in its 2015 elections.[8] The system enrolled about 68 million voters using biometrics (issuing voter cards that encoded the fingerprints of the rightful holder on a chip) and used card readers to authenticate voters, thus preventing 4 million duplicate votes. Although there were some operational challenges at the polls, the election was conducted successfully: all votes were cast, and it was difficult to rig or contest the results in the face of the transparency brought about by digital identity. However, other countries, such as Kenya and Somalia, have not reaped the same benefits from the biometric voter IDs.[9] Therefore, this remains an area of further research.

Developing effective digital ID schemes

Digital ID schemes rely on a backbone of connected systems, databases, and civil or population registries. These in turn have been established through a thorough enrollment process of the targeted population.

Many programs now include the use of both biometric data and traditional biographical data, as well as programs to eliminate duplicate enrollments to help ensure that each individual has only one registered identity and one unique identifying number.

The digital record is the basis for issuance of credentials, which may be cards equipped with bar codes or more advanced chip-based smart cards; they can also be single-function (and provide evidence only of identity) or multifunctional, with the card able to act as a bank card, driving license, and so on. India's Aadhaar program dispenses with the card altogether, providing remote authentication based on the holder's fingerprints or iris scan.[10] Online and mobile environments require enhanced authentication features—such as electronic trust services, which include e-signatures, e-seals, and time stamps—to add confidence in electronic transactions.

Mobile devices offer a compelling proposition for governments seeking to provide identity credentials and widespread access to digital services. In Sub-Saharan Africa, for example, more than half of the population in some countries is without official ID, but more than two-thirds of the residents in the region have a mobile phone subscription. The developing world is home to more than 6 billion of the world's 7 billion mobile subscriptions, making this a technology with considerable potential for registration, storage, and management of digital identity.

For a digital ID system to be effective, it must be rooted in an upgraded legal framework that considers the accessibility and protective measures of the system; clear definitions for the interconnectivity and interoperability with other (administrative or functional) registries; and coordinated investments throughout the country in information and communication technology (ICT) to develop a reliable and secure platform.

Digital identification systems may be developed in response to a specific application (elections, tax, social protection or security, pensions, health insurance, and the like), referred to as *functional schemes*.[11] Or they may be developed as universal multipurpose systems capable of supporting the entire range of needs for legal identity across all applications, known as *foundational identity schemes*. This distinction between functional and foundational systems is not immutable over time; often functional ones evolve to become foundational (in Bangladesh, Haiti, and Mexico, voter ID has become de facto national ID). No matter what the country context is, the priority should be to confer identity for all, either through a universal foundational scheme or through harmonization of the multitude of existing functional systems, so that in their totality they achieve full coverage.

Risks and mitigation

Digital ID schemes tend to be complex, are often politicized, and are subject to failure to deliver on high expectations. Risks associated with unsuccessful implementation can be mitigated by adopting guidelines that have emerged from the collective experience of digital ID schemes' rollouts around the world.[12] In this respect, several areas of focus emerge as critical:

- *Legal and regulatory concerns* about how to best determine the types, extent, and use of information collected under digital ID schemes; how to safeguard the privacy of personal data; and how to craft new primary legislation or rules to avoid unintended consequences such as inadvertent exclusions, onerous mandates that could deter individuals from accessing services, or increased rent-seeking involving registration or certificates.
- *Institutional and administrative concerns* about the institutional location of the civil and identification registries, and their interaction with functional registries or line ministries that need to verify or authenticate identities of beneficiaries or clients. The legal or foundational registries are traditionally located in the ministry of interior, justice, or home affairs; and more recently in special-purpose agencies independent of any line ministry (or loosely affiliated with one), and reporting to the center of government. Without effective coordination, there is a risk of a patchwork of competing schemes that would lack interoperability and consistency. The risk of exclusion would also be higher, as participation in functional IDs is a matter of program eligibility and not a birthright, as in foundational schemes.[13]
- *Technological concerns* about working with the private sector to develop a sustainable digital infrastructure that can reach remote areas and prevent exclusion; ensure interoperability and trusted authentication protocols for data exchange among different services and solution providers; and ensure data security, particularly in the use of biometrics, as well as the long-term accessibility and security of identity records.
- *Business models and procurement concerns* engendered by technology solutions that are tied to specific vendors; lack of open architecture anchored on modularity and open standards; lack of costing guidance

of various IT components; and absence of viable business models and digital ID–enabled services' uptake.
- *Country-specific and cross-border concerns* about what constitutes acceptable unique identifying credentials. This can differ across countries and applications, even as the world has taken steps to define standards for the mutual recognition of foreign citizens' credentials. Uses of digital ID schemes for tracking of ethnic groups and other nefarious purposes may be enabled by the recent advances in "big data" analytics that allow information to be collected and analyzed on an unprecedented scale.

Overcoming these challenges and barriers requires strong leadership, a supportive legal framework, interagency cooperation, mobilization of financial and human resources, and, critically, the trust of users. Incentives, technology, foreign assistance, and reforms will all be critical in achieving tangible results. Equally important is donor coordination at the global, regional, and national levels to ensure inclusive oversight and concerted global action.

Notes

1. World Bank ID4D global data set (April 2015). This number includes approximately 600 million unregistered children.
2. Dahan and Gelb 2015.
3. Barnwal 2015.
4. Banerjee 2015.
5. Public disclosures in media by finance ministers of several countries, monitored by Identity Counsel International and ID4Africa.
6. Gelb and Clark 2013.
7. Proceedings of Parliament of Zimbabwe, February 28, 2012.
8. Based on various reports in the Nigerian media.
9. Gelb and Clark 2013.
10. Dunning, Gelb, and Raghavan 2014.
11. This terminology was first adopted by Gelb and Clark (2013).
12. Gelb and Clark 2013.
13. For example, children are not eligible to register in voter rosters, while middle-income families are not included in poverty programs.

References

Banerjee, Shweta S. 2015. "From Cash to Digital Transfers in India: The Story So Far." CGAP Brief, Consultative Group to Assist the Poor (CGAP), Washington, DC. http://www.cgap.org/sites/default/files/Brief-From-Cash-to-Digital-Transfers-in-India-Feb-2015_0.pdf.

Barnwal, Prabhat. 2015. "Curbing Leakage in Public Programs with Biometric Identification Systems: Evidence from India's Fuel Subsidies." Columbia University School of International and Public Affairs, New York. http://www.columbia.edu/~pb2442/subsidyLeakageUID.pdf.

Dahan, Mariana, and Alan Gelb. 2015. "Role of Identification in the Post-2015 Development Agenda." Essays, World Bank and Center for Global Development, Washington, DC. http://www.cgdev.org/publication/role-identification-post-2015-development-agenda.

Dunning, Casey, Alan Gelb, and Sneha Raghavan. 2014. "Birth Registration, Legal Identity, and the Post-2015 Agenda." Policy Paper 46, Center for Global Development, Washington, DC.

Gelb, Alan, and Julia Clark. 2013. "Identification for Development: The Biometrics Revolution." Working Paper 315, Center for Global Development, Washington, DC.

World Bank. Various years. ID4D (Identification for Development database). World Bank, Washington, DC. http://data.worldbank.org/data-catalog/id4d-dataset.

SPOTLIGHT 4

4. Sectoral policies

5. National priorities

6. Global cooperation

PART 2

POLICIES

CHAPTER 4

Sectoral policies

Making the internet universal, affordable, open, and safe

Access to mobile phones is close to universal, and prices are falling in most countries, thanks to policies based on market competition, private participation, and light-touch regulation. But today's digital economy also requires universal access to the internet—at broadband speeds. First-generation policies for the information and communication technology (ICT) sector, aimed at universal access and affordability, have proved successful for phone service, and supply-side policies should also work well for the internet. But with more than half the world still offline, the benefits of the internet are unevenly distributed. Next-generation policies must also focus on demand-side issues of digital literacy, as well as privacy, cybersecurity, and internet governance, where a global consensus has yet to emerge.

In the last decade, all countries have benefited from the rapid spread of mobile communication networks. But only 15 percent of the world's citizens have access to affordable high-speed internet,[1] and the prices for service vary enormously. This reflects policy failures in some countries, such as regulatory capture, troubled privatizations, inefficient spectrum management, excessive taxation of the sector, or monopoly control of international gateways. To achieve better development outcomes, governments need to address these failures through open consultative policy-making processes involving the industry and users.

Developing countries are following a different route from developed ones. Most member-countries of the Organisation for Economic Co-operation and Development (OECD) benefited from initial state-led investment in their fixed telephone infrastructure, followed by private participation, and added mobile and internet networks later. But developing countries are jumping straight to mobile networks, built by the private sector. This may leave gaps in the backbone infrastructure, especially in rural areas, possibly requiring investment through public-private partnerships (PPPs) for the full benefits of high-speed networks to be enjoyed by all.

While availability, accessibility, and affordability remain concerns, the challenges facing internet stakeholders today are as much about how networks are used (demand) as how they are built (supply). Global interconnectedness introduces new vulnerabilities in areas where coordination mechanisms are weak, still evolving, or based on nongovernment models. Threats to cybersecurity are undermining confidence in the internet and increasing the costs to businesses and governments, resulting in economic losses as well as higher security spending. For privacy and data protection, different countries are taking quite different approaches, making it harder to develop global services. Ensuring safe and secure access will require greater international collaboration based on a multistakeholder model.

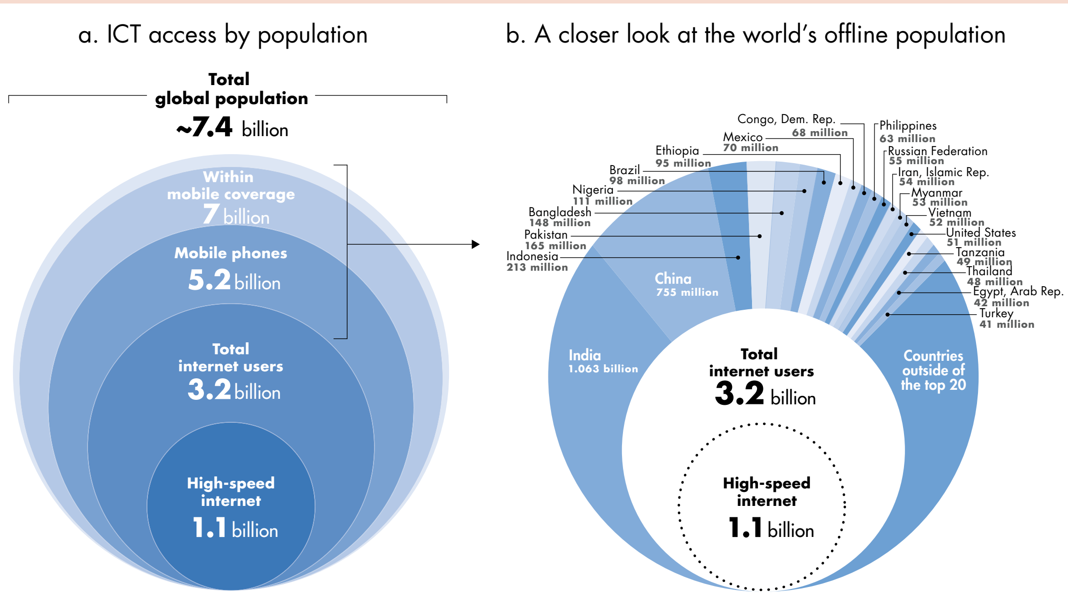
Converting connectivity into digital dividends will work best where an open access internet ecosystem allows content creation and applications development to thrive. ICT clusters tend to form naturally, and governments do not need to intervene to create them. But they can help clusters along and avoid stifling growth unintentionally through high tariffs or restrictions on openness. Most countries have found it useful to develop national ICT sector strategies for broadband, for e-government, and for local content. The process of developing these strategies, through multistakeholder consultations, can be just as useful as the strategies themselves—and ensures that targets are realistic and actionable. Policy challenges are summarized in box 4.1.

Box 4.1 Policy challenges for digital development

Offline, and missing out

Only around 15 percent of the world's population currently has affordable high-speed access to the internet (figure B4.1.1). Use of mobile phones, reaching almost three-quarters of the world's population, provides the main form of internet access in developing countries. But the lives of 2 billion people remain largely untouched by information and communication technologies (ICTs), and half a billion live outside areas with a mobile signal. The world's offline population is mainly in India and China, but more than 100 million people are also offline in North America, mainly in Mexico.

Figure B4.1.1 Global ICT access



Sources: World Bank 2015; Meeker 2015; ITU 2015; http://GSMAintelligence.com; UN Population Division 2014. Data at http://bit.do/WDR2016-FigB4_1_1.

Note: High-speed internet (broadband) includes the total number of fixed-line broadband subscriptions (such as DSL, cable modems, fiber optics), and the total number of 4G/LTE mobile subscriptions, minus a correcting factor to allow for those who have both types of access. 4G = fourth-generation; DSL = digital subscriber line; ICT = information and communication technology; LTE = Long Term Evolution.

Connected, but in the slow lane

Developed and developing countries are following different routes to the information society (figure B4.1.2). In the OECD (Organisation for Economic Co-operation and Development) countries, fixed-line networks came first, and now form the backbone for internet access. But most developing countries jumped straight to mobile networks without investing first in connectivity. The consequence for many users in developing countries is a second-class internet: slow, expensive, and rarely "always on."

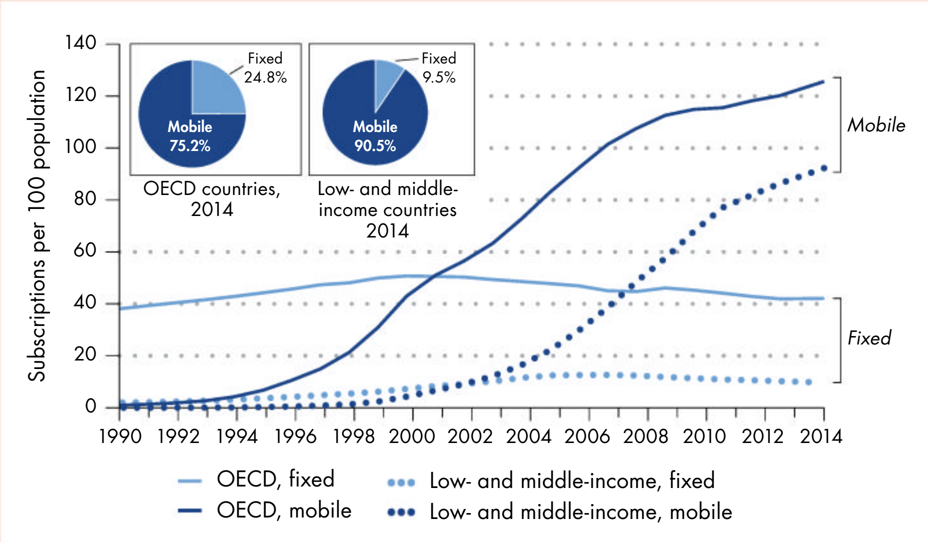
Megabucks for megabytes

ICT prices are falling globally, but large differences remain (map B4.1.1). Although Europe has some of the highest prices in the world for mobile calls and texts, prices are generally cheaper for data. North, South, and Central America have high prices for mobile data, in part due to bundling, but cheaper prices for fixed data. Northern Asia is generally cheaper than southern Asia. In Africa, prices are generally cheaper for mobile than for fixed-line data. Price differences reflect policy failures as much as market failures. Governments need to go further in liberalizing market entry, making available more spectrum, and encouraging investment to achieve more affordable prices.

(Box continues next page)

Box 4.1 Policy challenges for digital development *(continued)*

Figure B4.1.2 Network buildout (subscriptions per 100 population) in OECD and low- and middle-income countries, 1990–2014



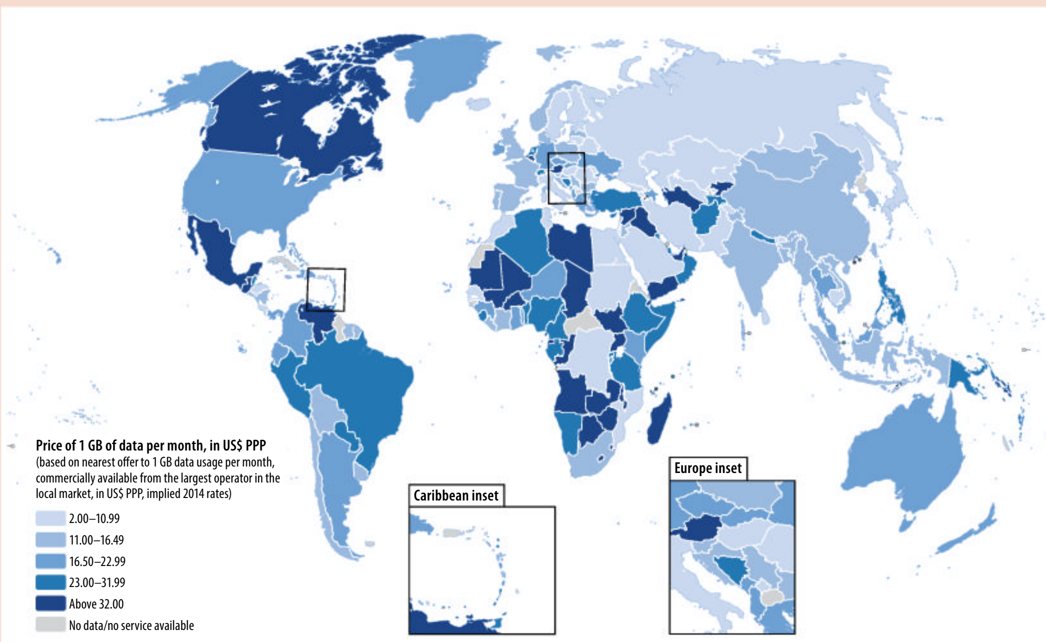
Source: Adapted from ITU World Telecommunication/ICT Indicators database. Data at http://bit.do/WDR2016-FigB4_1_2.

Note: OECD = Organisation for Economic Co-operation and Development.

Map B4.1.1 Price of mobile and fixed broadband services

US$, purchasing power parity, 2015

a. Mobile broadband services, price per gigabyte a month



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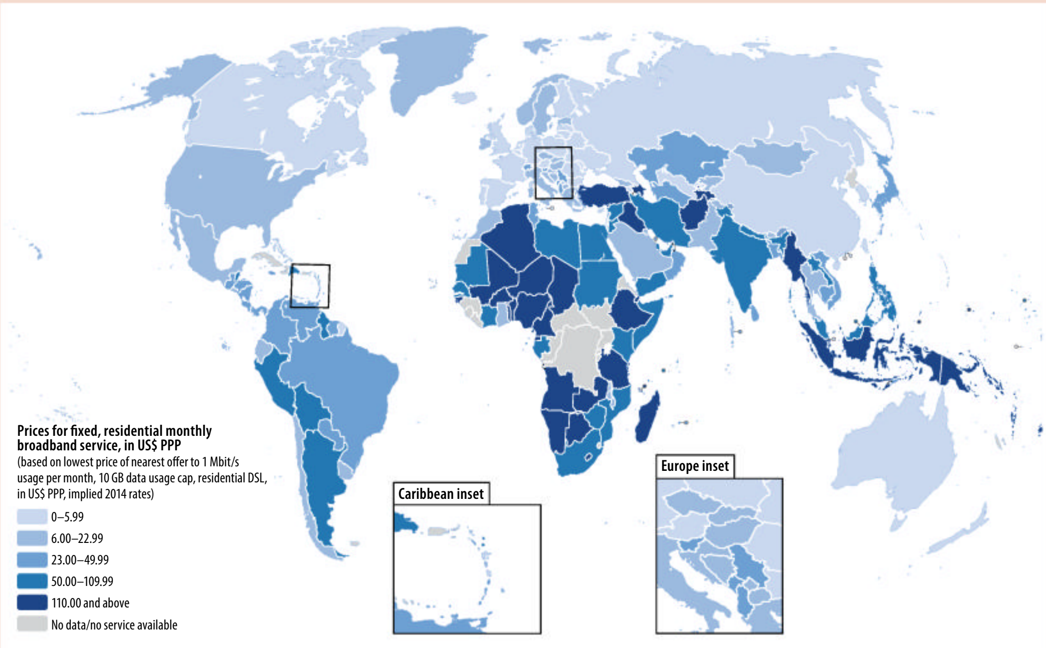
(Box continues next page)

Box 4.1 Policy challenges for digital development *(continued)*

Map B4.1.1 Price of mobile and fixed broadband services *(continued)*

US$, purchasing power parity, 2015

b. Fixed broadband services, residential, price per 1 Mbit/s



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Sources: WDR 2016 team, with additional data from Oxford Internet Institute, Google, http://blogs.oii.ox.ac.uk/roughconsensus/2014/02/could-you-afford-facebook-messenger-in-cameroon-a-global-map-of-mobile-broadband-prices/ and Plot and Scatter. Data and an interactive map of mobile broadband prices, as well as affordability measures, at http://bit.do/WDR2016-MapB4_1_1a and fixed broadband prices at http://bit.do/WDR2016-MapB4_1_1b.

Note: DSL = digital subscriber line; GB = gigabyte; Mbit/s = megabits per second; PPP = purchasing power parity.

Shaping the digital economy

Government policies and regulation of the internet help shape the digital economy. Particularly through their policies for the ICT sector, governments and regulatory agencies create an enabling environment for the private sector to build networks, develop services, and provide content and applications for users. Increasingly, governments seek to cooperate across borders on issues such as cybersecurity, privacy, and cross-border data flows.

Internet-enabling policies have evolved over time, especially those for the ICT sector (chapter 5 looks at complementary policies such as those for skills, regulations, and institutions). In the past, the government's main role was in building the fixed-line telecommunication network and acting as both owner and operator. That role is now pared back to policy maker and regulator, establishing an enabling environment for the private sector to do most of the work. For mobile networks and the internet, governments have been less directly involved, but many of them are seeking a more active role in shaping the digital economy. Broadband internet, in particular, is seen as a general-purpose technology,[2] essential for the competitiveness of nations,[3] and governments have invested more than US$50 billion in broadband networks since 2009 as part of stimulus packages.[4] Most also have national broadband plans.[5]

The internet has transformed telecommunication networks. In the same way that containerization revolutionized physical trade,[6] so the "packetization" of data has commoditized digital trade.[7] Networks have shifted from primarily carrying voice telephony to

Box 4.2 Is the internet a public good?

In considering what policies to apply to the internet, a key question is whether it is a public good. If it is, government intervention would be easier to justify. The internet does not have all the characteristics that economists conventionally associate with a public good—such as being nonexcludable (people can be prevented from using it) or nonrivalrous (a user who hogs bandwidth may impair the quality of service for other users). Even so, the internet provides public access to a vast library of useful information, it uses shared resources such as the spectrum, and it relies on network security; all of which may be considered public goods. Moreover, government intervention in promoting the internet may be justified because it has the characteristics of a general-purpose technology, like electricity.

A more accurate way of expressing the characteristics of the internet is that it is a private good with positive externalities (a club good). While the private sector can and should take the lead in providing internet networks and services, achieving universal and accessible internet is a legitimate public policy goal. The bulk of the investment required to achieve such a goal can come from the private sector, though many countries have invested public money to improve internet access by poor households and those living in remote areas. In a recent global survey, some 83 percent of users said they believe that affordable internet access should be a basic human right.[a] Several governments have followed Finland's lead in defining access to the internet at broadband speeds as a legal right and a goal of universal access policy.[b] High-speed, affordable broadband has been described as a foundation stone of modern society.[c] But it is something that more than five-sixths of the global population still lacks.[d]

a. The Global Survey on Internet Security and Trust (2014), conducted by the Centre for International Governance Innovation and Ipsos, a market research company, polled over 23,000 internet users in 24 countries; see https://www.cigionline.org/internet-survey.
b. World Bank/ITU, ICT Regulation Toolkit at http://www.ictregulationtoolkit.org/en/toolkit/notes/PracticeNote/3270.
c. UN Broadband Commission 2014, 8.
d. ITU 2014.

now providing a wide array of multimedia applications, with internet protocol (IP) as the shared language.[8] Fixed-line networks continue to be important in the developed countries, but in the developing world, especially in Africa, mobile networks are now the main means of delivering services. As the uptake of ICTs grows around the world, the policy focus is shifting from solving supply-side challenges (basic access and affordability) to addressing demand-side dilemmas (how to ensure that networks are open and safe).[9] Policy decisions intended to facilitate the take-up and safe use of ICT products and services will shape the digital economy and wider developmental outcomes.

In broad terms, services in sectors regulated by governments account for just under half of the US$4.2 trillion in revenues generated by the global ICT sector (telecom services, TV services, and internet), with the rest (hardware, software, and computer services) largely unregulated. Services delivered directly over the internet account only for just over 7.5 percent, but they are the fastest growing segment, having more than doubled since 2010 to reach an estimated US$309 billion in 2014.[10] Separate regulations have been traditionally applied to telecom and TV services, with the former focused on carriage (transmission) and the latter on content. Internet regulation has some characteristics of both, but with generally a much lighter touch than either telecom or TV regulation. Indeed, some would argue that internet regulation by government is neither helpful nor necessary, particularly if older models of regulation are applied.[11] But the trend is toward greater government control, not less—even in the United States, where the regulatory body recently proposed to regulate the internet as a common carrier telecommunication service—to preserve the concept of net neutrality, or treating all "bits" of information alike, irrespective of their content or value.[12] As this chapter shows, all governments have been obliged to consider which policies are most appropriate for the internet, and their answers vary widely (box 4.2).

Supply-side policies: Availability, accessibility, and affordability

The supply side of the internet is conditioned by rules on market competition, shaped by the respective roles of the public and private sector, and mediated by the degree to which regulation of the sector is independent of government and the operators. A useful framework for analyzing supply-side policies is to consider the value chain that stretches from the point where the internet enters a country (the first mile), and passes through that country (middle mile), to reach the end user (last mile). As a general rule, the market works best closest to the end user (last mile). Public-private partnership is more likely to be needed in the first and middle miles, or where customers live in areas that are difficult to serve. In addition to the visible elements of the network, certain hidden elements are vital to ensuring the integrity of the value chain—call them the "invisible mile" (table 4.1). (This framework is used a bit later in this chapter.) The goals of supply-side policies differ between countries, but the general objective is to ensure that the internet is universally available, accessible, and affordable.

Market competition

Today's internet runs on yesterday's legacy networks. In the OECD countries, and some others, the same copper networks built in the 1960s and 1970s to carry voice telephone calls and cable TV (the last mile) have now been upgraded and repurposed to stream movies and social media, carried over IP-based networks. Farther away from the user (the middle mile), the networks are more likely to be newer, and based on fiber, but the wired access networks that connect users were largely built in an era of government-run monopolies. All but a handful of countries had state-owned public telephone and telegraph companies (known as PTTs) when they were building out their networks.[13]

Outside the United States, which followed a different path of private investment, market competition in telecommunications began in the 1980s, with new market entrants arriving in the United Kingdom (1981),[14] the Republic of Korea (1982),[15] and Japan (1985).[16] In the European Union (EU), a coordinated process was set in motion by a Green Paper on telecommunications liberalization in 1987 and a Full Competition Directive in 1996, setting a timetable for full liberalization of the telecommunications sector by January 1, 1998.[17] The EU is now committed to achieving a single digital market by 2020.[18] Globally, some 69 countries[19] made commitments to liberalize telecommunication markets and allow foreign investment in their telecommunication sectors as part of the World Trade Organization (WTO) Basic Telecommunications Agreement in February 1997, when these countries accounted for some 93 percent of global telecommunications revenue.[20]

From these different market opening moves, a policy consensus emerged around three basic ingredients—market competition, private participation, and independent regulation of the ICT sector.[21] In developing countries, the main push toward market growth came in the 1990s with the arrival of digital (second-generation, or 2G) mobile communication services, which allowed for competition, often for the first time. Worldwide, only a handful of countries, including Djibouti, Eritrea, and Ethiopia in the Horn of Africa region, still maintain state-run monopolies in the provision of mobile services and the internet, and they have generally not fared as well as their neighbors. Mobile penetration is only half the level in the countries that have retained monopolies than in Kenya, which has had mobile competition since 2000, or in Sudan, since 2005. The cover photo of this report shows migrants in Djibouti straining to receive cellphone signals from Somalia, where competition in the telecom sector is fierce and prices are much lower (box 4.3).[22] A study of Sub-Saharan Africa showed that telecom revenue averaged 5.6 percent of GDP in liberalized economies, but only 3.5 percent in nonliberalized ones, and was growing twice as fast in liberalized economies.[23]

The recipe of competition, private participation, and independent regulation worked so well for mobile telephony that, as of June 2015, there were more than 7.5 billion subscriptions worldwide—more than the human population.[24] The same recipe should also largely work well for internet services, to extend access to the 4 billion or so people now without affordable service. But there is a wrinkle. For network operators, extending internet access may cannibalize revenues from existing voice and text services, at least in the short term. This is one outcome of market entry by third-party content and service providers that ride "over-the-top" (OTT) of the operator's IP-based networks:

- For telephony, voice over internet protocol services, such as Skype and Viber, substitute paid voice calls with calls made "free of charge" over the internet.[25]
- For text (short message service, or SMS), which had been highly profitable for mobile operators,[26] instant messaging OTT services such as WhatsApp and WeChat provide a more attractive substitute for a fraction of the price.
- For video (such as cable or satellite TV), streaming services like Netflix and YouTube—which together account for almost half the traffic delivered to users in the United States[27]—offer low-priced content and give more freedom to consumers to watch content when and where they like, on multiple devices.

Table 4.1 A policy framework for the supply of internet service

	The first mile (the point at which the internet enters a country)	The middle mile (the national, intercity internet backbone of a country)	The last mile (the connection between users and their nearest internet point of presence)	The invisible mile (other, less visible network components and potential bottlenecks)
Network components	International internet access, including submarine cable landing stations, satellite dishes, domain name registration	National backbone and intercity network, including fiber backbone, microwave, IXPs, local hosting of content	Local access network, including local loop, central office exchanges, wireless masts	Nonvisible network components, including spectrum, border crossings, databases, SIM cards, cybersecurity
Market competition	• Authorization of satellite dishes • Designation of domain name registry and registrars • Licensing of competing international service providers and orbital slots • Authorizations for landing stations, and access (co-location) to international gateway facilities	• Licensing/authorization of nationwide facilities-based operators and service providers • Interconnection arrangements • Infrastructure sharing arrangements • Cross-sectoral participation (such as cable TV and alternative infrastructures) • Licensing mobile virtual network operators	• Licensing/authorization of local facilities-based operators and service providers • Authorization of mobile virtual network operators • Authorization of value-added network service providers, including for mobile money • Unbundling the local loop	• Market mechanisms (such as auctions and resale) for spectrum assignments, especially for 3G and 4G bands • Arrangements for access to essential network facilities, including national numbers, address database
Public-private partnership	• Privatization/ liberalization of international gateway • Development of government data centers • Participation in international cable and satellite consortia • Regulation of legal intercept	• Privatization of the incumbent operator • Industry consultation on a network master plan • Establishment of national and local IXPs • Local hosting of content, including government data center	• Dominantly private operation and ownership, with PPP approach where market fails (as in rural areas) • Stakeholder consultation on a national broadband plan • Universal service obligations (as for emergency services and accessibility for disabled)	• Negotiation of transit and access to virtual landing stations (for landlocked countries) • CSIRTs at national and institutional levels • Open access to short code numbers, as for SMS
Effective regulation	• Open access to international facilities • Open to foreign ownership and investment • Avoiding excessive import and excise taxes • National representation at relevant national and regional bodies, such as ITU, ICANN, and WTO	• Coordinating rights-of-way for linear infrastructures • Safeguards on significant market power • Open access rules for national backbone • Promotion of local content and hosting	• Open access rules for local loop and central office exchanges • Coordination of planning permission for public works among operators and utilities, and authorizations for construction of wireless masts • e-waste recycling guidelines	• Spectrum management, including arrangements for allocation of bands and refarming • SIM card registration arrangements • Data protection and privacy guidelines

Source: WDR 2016 team.

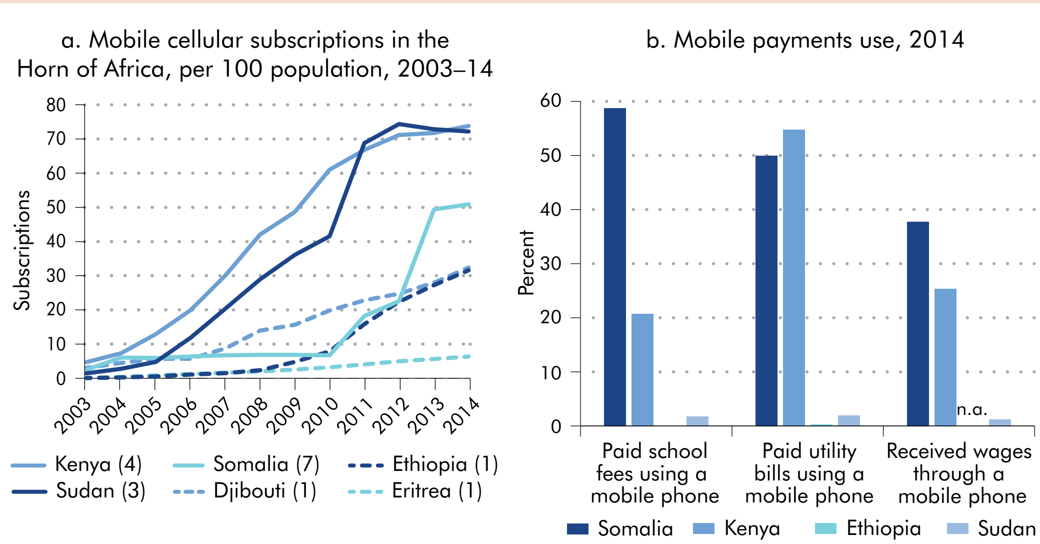
Note: Policy examples are indicative, not exhaustive. Policy actions shaded in ***red*** are particularly suitable for emerging economies, in ***green*** for transitioning economies, and in ***blue*** for transforming economies, but all are good options to pursue at any stage (see chapter 5 for classification of economies). 3G = third-generation; 4G = fourth-generation; CSIRTs = Computer Security Incident Response Teams; ICANN = Internet Corporation for Assigned Names and Numbers; IP = internet protocol; ITU = International Telecommunication Union; IXP = internet exchange point; PPP = public-private partnership; SIM = subscriber identification module; SMS = short message service; WTO = World Trade Organization.

Box 4.3 Fragile states, resilient digital economies

Somalia is emerging from 20 years of civil war, during which time its fixed telecom infrastructure was destroyed. Yet information and communication technologies (ICTs) are one of the bright spots in its economy. With seven mobile operators and multiple internet service providers (ISPs), Somalia has a higher rate of penetration than its monopolistic neighbors, despite the fact that it has the lowest gross domestic product per capita in the East Africa region (figure B4.3.1, panel a).

Telecommunications can play an important role in post-conflict reconstruction.[a] Not only does the sector generate jobs, entrepreneurship opportunities, and foreign currency from incoming phone calls, but using mobile phones to make payments or trade airtime also provides an attractive alternative to the local currency. In Somalia, few citizens have faith in the Somali shilling, and prefer U.S. dollars, but dollars are frequently in short supply. The World Bank's 2014 Findex survey showed that some 38 percent of wage-earning Somalis were paid via a mobile phone, compared with just 25 percent of Kenyans (figure B4.3.1, panel b), despite the popularity of M-Pesa, Safaricom's mobile money service, there.[b] Some 55 percent of Somalis used mobile phones to receive remittances; this has become indispensable recently as other financial channels, such as *Hawalas*, have been blacklisted as part of a crackdown on their suspected links with terror. Furthermore, telecom operators contribute to the national treasury, unlike the banking sector, which contributed nothing in 2014. Somalia has benefited since early 2014 from a fast connection to the global internet, following the completion of the EASSy undersea cable to Mogadishu, in which the International Finance Corporation is a stakeholder. The Shabaab terrorist organization has succeeded in blocking the use of mobile broadband in much of the country, because of traceability, but it still uses social media for recruitment and spreading its message.

Figure B4.3.1 Somalia's rising mobile economy



Sources: Adapted from ITU World Telecommunication/ICT Indicators and World Bank World Development Indicators, and World Bank Findex survey. Data at http://bit.do/WDR2016-FigB4_3_1.

Note: Figures in parentheses in panel a indicate the number of facilities-based mobile operators. n.a. = not available.

a. Kelly and Souter 2014.
b. http://go.worldbank.org/1F2V9ZK8C0.

Although network operators may be losing revenue from traditional voice, text, and video services, they benefit from the demand for data traffic generated by OTT services. But they face a heightened investment challenge to keep up with the service-quality demands of users, especially on mobile networks, where spectrum may be scarce. Cisco estimates that mobile data traffic grew 69 percent in 2014 and will continue to grow at 61 percent a year between 2014 and 2019.[28] Mobile operators in Africa, for instance, are having to spend on average one-quarter of their annual revenue on capital expenditure as they build out their networks, while in North America, where network buildout took place much earlier, the capital expenditure burden is just 15 percent of revenue.[29] But network operators in developing countries may find it a challenge to persuade users with low incomes to pay for higher data use, which has a lower perceived value than voice calls. Their users may employ OTT services primarily for reducing, rather than increasing, their monthly phone credit use. According to reports from the Global System for Mobile communications Association (GSMA), while average revenue per user in North America has remained steady at above US$65 per month since 2010, it has fallen in Africa from US$14 to below US$10.[30] So, African network operators are caught in a triple bind of rising user expectations (due to higher data usage) requiring higher capital expenditures, but declining user spending (due to OTT services).

For developing countries, the threat of diluting traditional revenue streams is particularly worrying because they are following a trajectory in their network buildout different from the one most developed countries follow. Figure B4.1.2 shows network buildout in developed (OECD) and developing countries (low- and middle-income). Both sets of countries show a similar pattern of mobile networks growing to overtake fixed-line networks in subscriber numbers, since 2001 and 2003, respectively, and fixed-line subscriptions declining thereafter. But the big difference is that OECD countries had already achieved universal fixed-line access (roughly, more than 90 percent household penetration) before 2001.

In developing countries, the decline in fixed-line access occurred before it had reached even one-quarter of the universal service level, and is now well below that. This is significant because wireless networks (using spectrum) are not fully substitutable for fixed networks (using copper or fiber), either in usage (which rarely offers flat-rate pricing, without data limits) or in performance (where speeds are generally lower). So, despite procompetitive policies that have encouraged infrastructure competition and allowed for the development of OTT services, many developing countries are stuck with a second-class internet that may fail to deliver the expected benefits, especially for business users.

Indeed, most developing countries are unlikely ever to attract, or generate, sufficient investment to extend a nationwide backbone (the middle mile) or create fixed-line networks in rural areas without some kind of public-private partnership. Some developing countries, such as the Democratic Republic of Congo or South Sudan, may never get a fixed-line access network, even in urban areas. An optimistic assessment is that developing countries are leapfrogging a whole stage of network development, but more realistically they may be missing an essential stage. Available evidence suggests that access to the internet from big-screen devices (PCs), with always-on flat-rate access, provides a bigger boost to economic activities than access from small-screen devices (mobile phones), which generally have use-based pricing.[31] As long as mobile operators dominate the provision of voice and internet services in developing countries, companies whose business models are based on long-term investment in fixed assets, without revenues from mobile services, will find it difficult to survive. That is why some degree of government intervention, through public-private investment, may be necessary in smaller developing countries to build up resilient international connectivity, and an open access backbone network, in order to retrofit the missing stages of network development.

Public-private partnership

After market competition, the next essential ingredient in the ICT policy recipe is private investment. Private companies have driven network investment throughout the world, especially in mobile networks. The biggest network operator of them all, China Mobile, which had over 800 million subscriptions at the end of 2014, is still majority state-owned.[32] But it is the partial exception, and its public shareholding is listed on the stock exchanges of Hong Kong SAR, China and New York. Network operators dominate the ICT sector in revenues and customer connections. But stock markets appear to prize internet companies that sell content and OTT services more highly than telecom operators that build networks. Alibaba, a Chinese e-commerce company that went public in September 2014, is valued at more than US$200 billion—a level similar to China Mobile, although it has only one-tenth the network operator's revenue.[33] Low market valuations for network operators, and the cannibalization of their voice and text revenues, make it harder for them to invest in network capacity, particularly in fiber backbone networks or fourth-generation (4G) mobile networks. Private investment in telecommunication networks in 2013 had fallen by almost one-third since its peak in 2008, suggesting that operators are finding it harder to justify capital expenditure at a time when future revenues are uncertain.[34]

One response is to revive public investment in the internet backbone. In the United States, the internet benefited from public funding from the 1960s until 1993, when the government began "privatizing" the internet by transitioning the role of the National Science Foundation to the private sector, including responsibility for registering domain names and managing network access points.[35] This process is due to be completed in September 2016, when the Department of Commerce is expected to transfer its oversight role for the Internet Corporation for Assigned Names and Numbers (ICANN) to the global multistakeholder community.[36] In other countries, too, the government took an early role in building out the national backbone infrastructure for the internet, as in the Republic of Korea (box 4.4). This role continues, for instance, in National Research and Education Networks (NRENs), where many governments subsidize the higher edu-

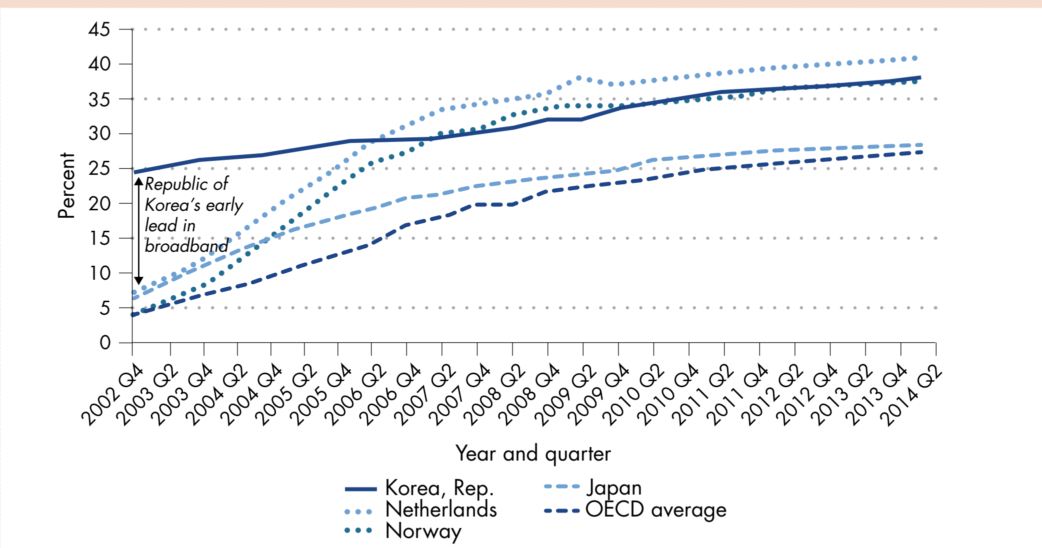
Box 4.4 How public-private partnership helped build the internet backbone in the Republic of Korea

Until other developed countries caught up around mid-2006, the Republic of Korea's fixed broadband penetration was well ahead of its competitors (figure B4.4.1 and table B4.4.1). In fiber-based ultrafast broadband, it is still ahead of the game. It has the highest percentage of fiber among fixed broadband connections (66 percent) of any country except Japan. Korea also leads in the "internet of things" and sensor technology (see spotlight 6).

One secret to Korea's success was a public-private partnership (PPP) that combined government funding and policy direction with private infrastructure investment and management. The Korea Information Infrastructure program, which ran from 1995 to 2005, and the Broadband Convergence Network that followed it from 2005 to 2014 saw government investment of just under US$1 billion in each phase. Private investment dominated in the initial phase, as the backbone network was established and larger cities were served. During this phase, government money was used mainly to purchase bandwidth for government's own needs. Since 2005, government spending has been proportionately greater, as network investment reached out to rural areas, where there was less incentive for the private sector to take the lead. The government of Korea has followed up with a program to upgrade network performance, through the Ultra Broadband Convergence Network, with around one-third of total investment coming from the government.

Figure B4.4.1 Broadband in the Republic of Korea and other selected economies

Broadband per 100 inhabitants, 2002 Q4 through 2014 Q2



Source: OECD Broadband Portal, http://www.oecd.org/sti/broadband/oecdbroadbandportal.htm. Data at http://bit.do/WDR2016-FigB4_4_1.

Note: The gap between the Republic of Korea and the two nearest countries of the Netherlands and Japan in 2002–04 indicates Korea's early lead in broadband. OECD = Organisation for Economic Co-operation and Development.

(Box continues next page)

Box 4.4 How public-private partnership helped build the internet backbone in the Republic of Korea *(continued)*

Table B4.4.1 Broadband investment program, Republic of Korea

US$ million and percent of total

Investment	Information infrastructure, 1995–2005	Broadband convergence network, 2005–14	Total, 1995–2014
Government	806 (2.4%)	981 (38.0%)	1,787 (5.1%)
Private	31,721 (97.5%)	1,599 (62.0%)	33,320 (94.9%)
Total (US$ million)	32,527	2,580	35,107

Sources: Kim, Kelly, and Raja 2010; World Bank and Korean Development Institute 2015.

cation community, such as Internet2 in the United States, SURFNet in the Netherlands, and KENET in Kenya.[37] Governments can also aggregate demand to negotiate lower bandwidth rates for universities and government departments, for example.

Effective regulation

After market competition and private participation, the third key policy ingredient is independent regulation: establishing ICT regulatory agencies that are independent of leading operators and of government departments. The International Telecommunication Union (ITU) records that some 159 of its 194 member-states (82 percent) had separate ICT regulatory agencies by the end of 2013, a doubling since 1998.[38] Effective regulation creates a level playing field for operators and helps promote market entry. Governance structures and mandates for regulators differ, but most have responsibility for spectrum management and for issuing and overseeing licenses for network operators. Most regulators are run on a cost-recovery basis, and some generate a significant surplus from license fees and spectrum auctions.[39]

Telecom sector regulation should work primarily in favor of the consumer—addressing market failure, fostering effective competition, protecting consumer interests, and increasing access to technology and services.[40] In particular, the regulator should seek to ensure that the benefits from technological change, greater efficiency and reduced costs, are passed on to consumers rather than appropriated in higher profits for private firms or extortionate taxes to governments. But even in the best of circumstances, regulatory agencies may lack sufficient high-caliber staff, or they may be captured by commercial or governmental interests. In the many countries where governments still hold a stake in the incumbent operator, true regulatory independence is rare. The worst case is where commercial and governmental interests coincide, in what is sometimes called "crony capitalism." In Tunisia during the Ben Ali regime, three telecom companies with ownership related directly to the Ben Ali family generated revenues of US$86.8 million, or 8.8 percent of total turnover from the sector in 2010, but they accounted for some 42.7 percent of total gross profit generated by the sector.[41] High demand for scarce spectrum also creates incentives for corruption. In India, the sale of 2G cellular licenses in 2007–08 was rigged to create an artificial scarcity that favored some companies over others, ending up in a scandal and a jailed minister.[42] Regulators bear a responsibility to protect consumers against such vested interests. They must also work closely with competition authorities to ensure that consolidation in the number of operators does not reduce true competition in the sector.

Where markets fail

By almost every measure, the policy recipe for promoting the supply side of the ICT industry, based on market competition, private investment, and independent regulation, has been tremendously effective in extending coverage, at least for mobile communications. The estimated 7.5 billion mobile subscriptions in use worldwide generate revenues of US$1.13 trillion a year, as of May 2015.[43] And some 95 percent of the world's inhabitants live within range of a mobile signal,[44] with two-thirds of them served by a 3G signal with theoretical access to the internet if they have a suitably equipped device.[45] Even in Africa, the region where mobile coverage is lowest, at just 88 percent in 2012, more-efficient markets could close all but 4.4 percent of the remaining gap, without needing a cross-subsidy.[46]

But that is not the whole story. Markets fail where the private sector underinvests—for instance, because the private return may be less than the social return. This appears to be happening in the ICT sector in at least three areas.

- *Remote areas.* Although only less than 5 percent of the global population remains unserved with cellular mobile coverage, that still represents almost half a billion people worldwide. Even where it is technically viable to serve these people, there may be little commercial incentive to do so. The costs of reaching them are high in relation to the commercial return, as they live mainly in rural locations with low population density, or in geographically remote areas (box 4.5). But the social costs of remaining unserved are high and growing, so universal service policies may be required.
- *Unattractive markets.* Competitive market entry may not take place even in markets that are nominally open to competition, especially in fragile or conflict-afflicted states, or in small island developing states.[47] A lack of scale and the failure to use competitive tendering for infrastructure investment, for instance, may also result in prices that are unaffordable for users.
- *Uneconomic services.* More worrying, even if basic services can be delivered, delivering more advanced networks suitable for carrying data services, such as high-speed internet, may not be economic. On mobile broadband networks, this requires third- (3G) or preferably fourth-generation (Long Term Evolution, LTE) networks, which need higher levels of investment and generally a denser network of base stations and masts.[48] Some developing countries have yet to launch mobile broadband. Even where services are launched, coverage can be low, reaching just 1 percent of the rural population in Zambia or 11 percent in Namibia, for example.[49]

To extend affordable access, governments have tried price controls, regulated prices, public facilities (such as telecenters), and mandated public pay phones. Public telecom operators use geographical averaging of tariffs to offer the same price to users in both urban and rural areas. Historically, they have also used profits from lucrative international and long-distance services to cross-subsidize loss-making local services. But with privatization and the shift to more competitive markets and IP-based networks, this became unsustainable.[50]

An alternative, followed by more than 70 countries, is a Universal Service Fund (USF) to channel payments by operators to fund infrastructure in rural areas or to provide access to libraries, schools, and hospitals. Some USFs have performed well, notably those that use competitive mechanisms to distribute funds, such as least-cost subsidies in Pakistan or reverse auctions in rural Chile.[51] But USFs generate funds that often remain unspent or go for unintended purposes. Unspent USFs amounted to more than US$11 billion in 2012, and in Côte d'Ivoire and Paraguay more than 0.6 percent of GDP. In several countries, USFs continue to fund basic fixed-line telephony long after user demand had shifted to mobile and broadband internet.[52]

By far the most successful measure to extend access is to license competing mobile service providers and internet service providers. Governments often include specific network rollout obligations in the license conditions of mobile operators, and these are frequently exceeded thanks to strong demand, at least for basic mobile telephony. But for advanced mobile networks, suitable for carrying data services such as high-speed internet, rollout into areas of sparse population density has been slower. For voice services, provision of coverage to rural areas by private investors could sometimes be justified by the volume of incoming calls. But for data services, although the direction of traffic might be similarly asymmetric, only the ability of the local population to pay for service justifies investment in network upgrading, as there is no payment for incoming traffic.

Given the increasing importance of broadband for modern life, better provision in rural areas could help revitalize the local economy in secondary towns and rural areas.[53] Here are some possible solutions for rural broadband:[54]

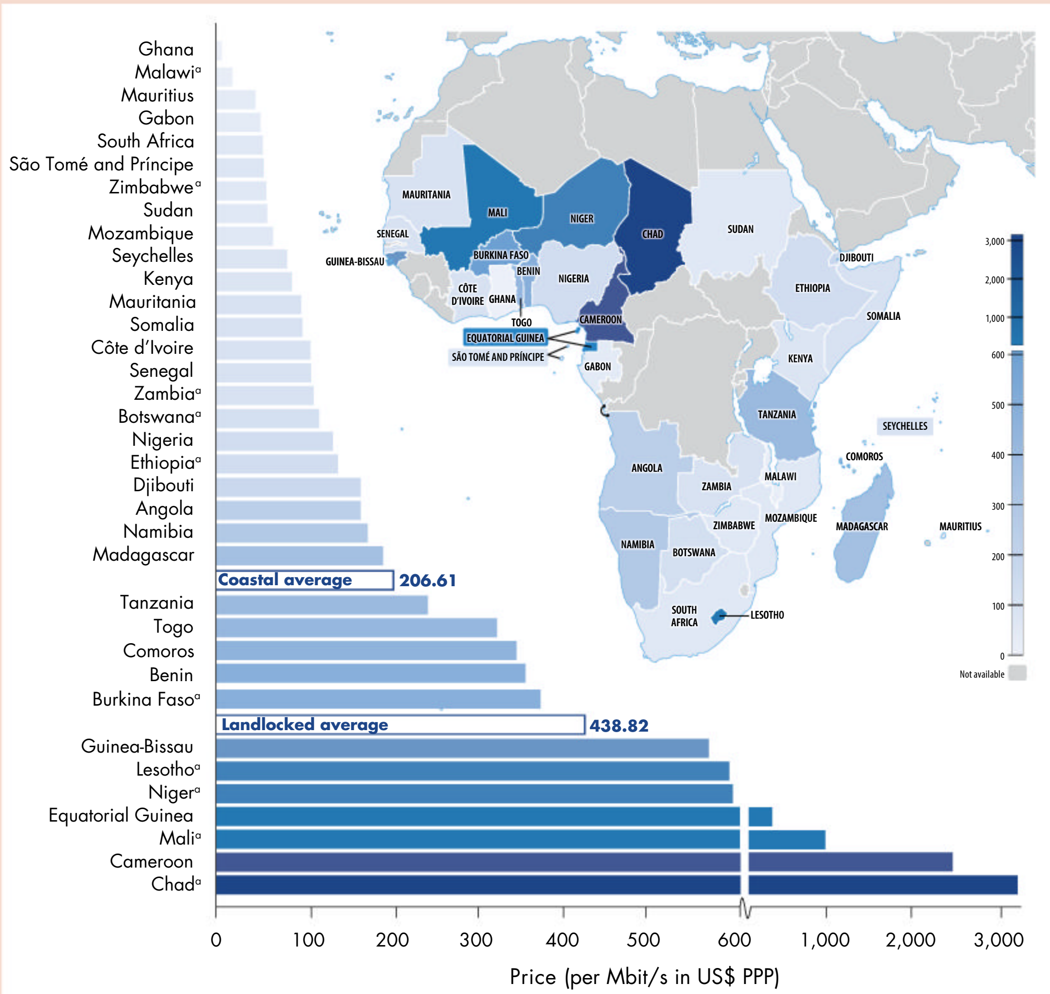
- *USFs can be repurposed to focus on broadband.* In the United States, since a 2011 decision by the regulatory body, the Federal Communications Commission (FCC), universal service subsidies have been channeled to the Connect America Fund, to the tune of around US$4.5 billion a year.[55] A similar initiative in Europe, using regional development funds, is the Connecting Europe Facility.[56] Already,

Box 4.5 The last (1,000) mile(s)

The "last mile" problem is a term commonly used in communications and transport economics to describe the relatively high cost of building the infrastructure to link to end users: the access network. Technological change, particularly the development of cellular mobile communications and data compression techniques, has greatly reduced infrastructure investment costs and is helping to solve the last mile problem, at least in urban areas. But a different problem, perhaps better described as the "last 1,000 miles," plagues remote rural communities. Specifically, what is the best way to bring the internet to areas "landlocked," far from the cable landing stations on the coast, or "sealocked," small islands with small populations that cannot justify an investment in undersea cable?

Where undersea fiber-optic cable is available, it will generally trump all other solutions in speed, performance, and cost. But for low-density, dispersed populations or remote islands, satellite offers a quick and easy alternative.

Map B4.5.1 The effect of geography on internet prices, Africa



IBRD 42012

Source: WDR 2016 team. Data at http://bit.do/WDR2016-MapB4_5_1.

Note: Price per Mbit/s in US$ PPP a month in 2014 Q4/2015 Q1 for fixed, residential broadband service. Mbit/s = megabits per second; PPP = purchasing power parity.

a. Indicates landlocked country; the gradient indicates greater cost.

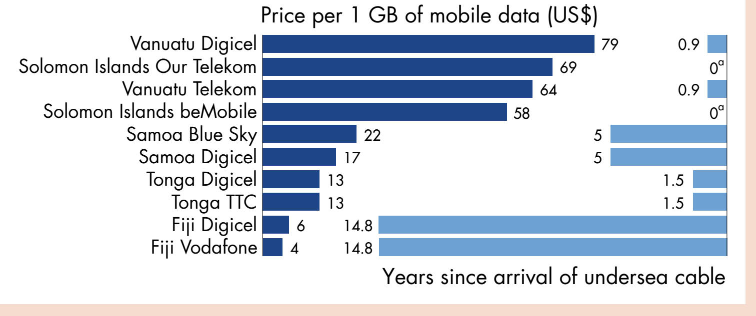
(Box continues next page)

Box 4.5 The last (1,000) mile(s) *(continued)*

Usage costs have come down, with the entry of new players, such as Avanti Communications[a] and O3B.[b] The Cook Islands, with fewer than 14,000 people spread over 15 inhabited islands across 2.2 million square kilometers of ocean, recently opted for a satellite network from O3B.[c] But satellite has the disadvantage of being more expensive than fiber-optic cable per unit of data, and, with older generations of satellite, suffers from higher latency (delay), which makes them unsuitable for real-time uses like video gaming. Even the Cook Islands are now considering an undersea cable.

Although satellite offers distributional advantages, it makes it hard to aggregate demand and therefore to negotiate lower bandwidth costs. South Sudan, for instance, has an estimated 3,000 very small aperture terminals (VSATs) serving its population of just over 10 million, who pay expensive retail rather than wholesale rates for the limited capacity provided. Geography matters. Landlocked countries generally pay higher prices for bandwidth than coastal countries. In Africa, for instance, being landlocked adds an average of US$232 to the monthly price for fixed broadband access (map B4.5.1). But history matters, too. In the Pacific, countries first reached by cable, such as Fiji, tend to have lower internet prices than those reached more recently (figure B4.5.1). Once served with fiber, small island states may find that they use only a tiny amount of the capacity available; Tonga, for instance, barely uses 10 percent. Moving to flat-rate pricing ("all you can eat") for bandwidth may be the best way to recoup the initial investment.[d]

Figure B4.5.1 The effect of history on internet prices, Pacific



Source: See http://www.theprif.org/index.php/news/53-media-releases/169-prif-ict-study. Data at http://bit.do/WDR2016-FigB4_5_1.

Note: Price, per gigabyte (GB) of data in US$ a month in 2014, for prepaid mobile broadband.

a. Cable to Solomon Islands under consideration.

a. http://www.avantiplc.com/.
b. http://www.o3bnetworks.com/.
c. http://www.islandsbusiness.com/2014/4/business-intelligence/cooks-opt-for-satellite-telecom-network/.
d. PRIF 2015.

from 2007 to 2014, some €14.7 billion (US$16.5 billion) had been committed to broadband networks under PPP funding, using EU structural funds, in more than 100 different projects in the European Union.[57] But few developing countries have this level of resources to commit.

- *Infrastructure sharing and mutualization*[58] *can also reduce costs for operators.* Infrastructure sharing refers to the operators sharing one another's network infrastructure, or at least some elements of it, such as wireless masts or cable ducts. They may also share infrastructure from other sectors, such as electricity or transport. Mutualization is slightly different, with a wholesale operator created to sell only to other operators and not directly to users. Increasingly, specialist wireless mast companies, like Indus or Reliance Infratel, two Indian companies, are emerging for wireless infrastructure, while cable backbone companies include Botswana's BoFiNet and the Burundi Backbone System. Sharing assets can improve management efficiency, though it may also lead to disputes.

- *Technological solutions are emerging that promise a fresh approach to rural broadband.* From drones to balloons to nanosats, there is no shortage of inventive solutions to providing wide area coverage. But these new technologies will need to leverage the physical and market infrastructure that the cellular mobile industry has built in order to become commercially viable and achieve scale. And efforts to bring new technology will have to be complemented by more efficient use of spectrum, such as spread spectrum and digital dividend spectrum, which releases for cellular commercial use the highly valuable spectrum (for instance, in the 700 MHz band previously used for terrestrial TV broadcasts), and in the "white spaces" between digital channels. These spectrum bands have wider coverage and are therefore ideal for rural areas.

Managing spectrum and other scarce resources

Managing scarce resources—such as numbers, rights-of-way, and especially spectrum—presents regulatory challenges. Policy makers are turning to market mechanisms, such as auctions, to deliver the best outcomes, and this can result in lower prices and higher growth, as in Guatemala (see box 4.6). More flexible approaches to spectrum sharing between services, use of spectrum-hopping technologies, and refarming of spectrum will also help. But demand for bandwidth, and thus also for spectrum, continues to grow rapidly, especially as video entertainment shifts from television sets to mobile devices. By 2020, around 2 GHz of total spectrum will be needed in major markets for cellular services.[59] Today, most developing countries have only around 500 MHz allocated, and some have less than 300 MHz.[60] Spectrum availability and allocation is one of the factors determining the future wealth of nations, and governments will have a vital role in maximizing the benefits from this resource.

The internet brings new challenges for allocating scarce resources, including domain names and the transition to longer (IPv6) addresses. While spectrum and numbers are regulated primarily by the public sector—internationally by the ITU and nationally by government ministries or regulators—domain names and IP addresses are controlled almost entirely by the Internet Corporation for Assigned Names and Numbers (ICANN), a California not-for-profit corporation, and the entities to which it subcontracts. The management of top-level domain names, such as .org and .com, IP addresses, and even country code domains, such as .za (South Africa), generally is not the provenance of government regulation. Their regulation is a complex matter, involving contract rights with private parties and not administrative fiat. But the natural shortage of attractive, or easy to remember, domain names creates opportunities for profiteering.

ICT prices are falling . . .

The trend toward declining prices in the ICT sector has been a long-term and predictable driver of growth. For hardware, it is encapsulated in the prediction made by Gordon Moore, the cofounder of Intel, in a 1965 paper that the number of transistors in an integrated circuit would double about every two years, with consequent improvement in price and performance.[61] For memory storage, this means that, in 2014, a typical price to store a gigabyte of data was just 3 U.S. cents, whereas 20 years earlier it was more than US$500.[62] Similar rates of progress are observable in the unit price of computer processing power and in the availability and price of bandwidth[63] (figure 4.1). Manufacturers have, to some extent, compensated for this by building greater functionality into devices for the same price. But as they have started to chase mass markets, device prices have also started to fall—since 2011 for smartphones, and earlier for older technologies such as laptops and televisions. Smartphones, with more computing power than NASA had at the time of the moonshots, can now be purchased for less than US$40 (although the typical cost is much higher), and it is forecast that, by 2020, 80 percent of adults around the world will own one.[64]

Predictable, rapid price declines create an interesting dynamic: it is possible to foresee, with reasonable accuracy, at what point services and devices will flip from narrow to mass markets, as the price of ownership and use falls. But there is a tendency to overestimate the effect of a technology in the short term and to underestimate its effects in the long.[65] This may in part explain why the initial impact of the internet caused a catastrophic swing in the markets, starting around 1997 and peaking in March 2000, since known as the dot-com bubble. The aspirations of many of the startups of the time—like Broadcast.com, an internet radio company, or Pets.com, an e-commerce supplier—simply could not be met by the slow-speed dial-up internet access available, and their business models were often unrealistic. The value of stock markets worldwide fell by some US$5 trillion in the 18 months that followed.[66] But that period of creative destruction also saw the birth of many of the giants that dominate the internet today, including Google and Tencent (both founded in 1998) and Alibaba (in 1999).

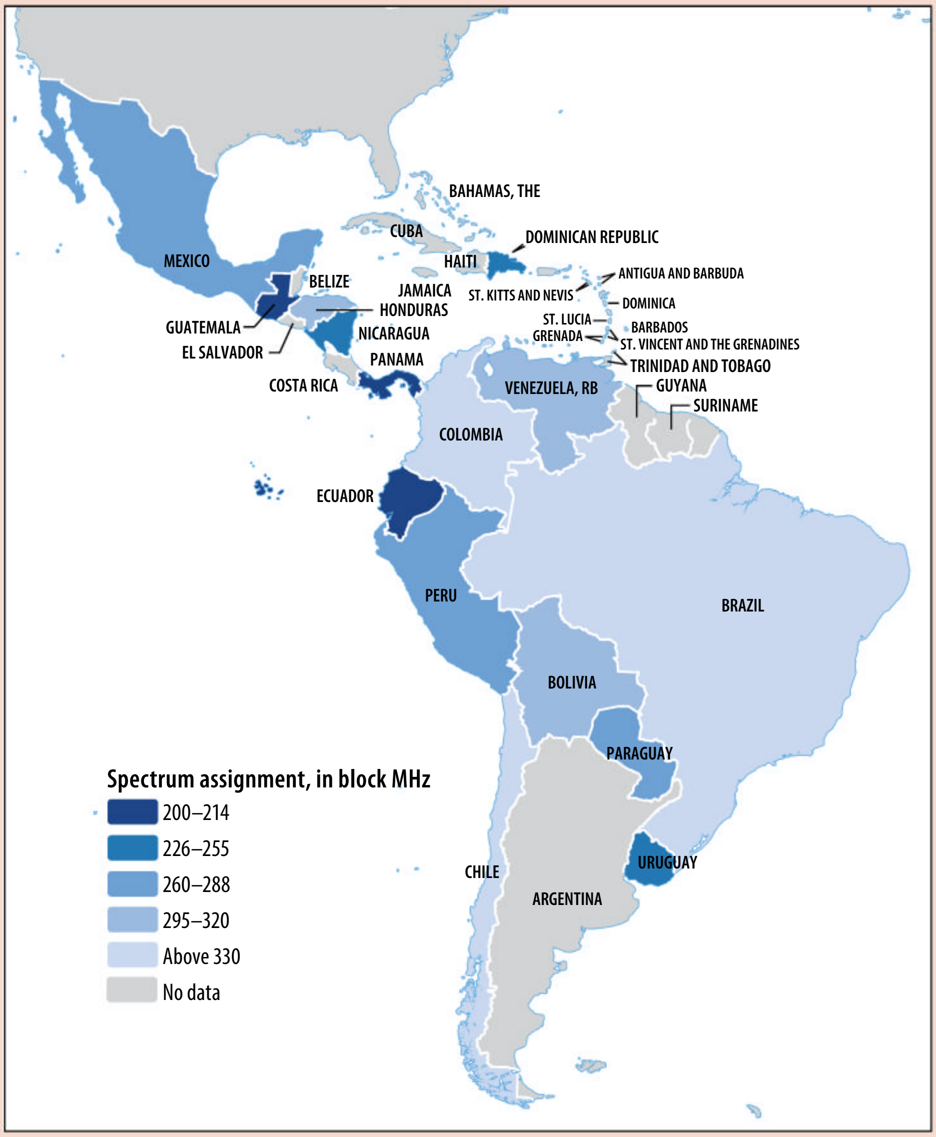
Perhaps the most sustained example of how falling prices drive market expansion comes with

Box 4.6 Guatemala: An early pioneer of spectrum auctions

In most countries, the management of the civil radio frequency spectrum was carried out on a "first come, first served" basis, with incumbent operators taking the lead. As countries separated the functions of operator and regulator, starting in the 1980s, spectrum management moved toward newly created regulatory agencies. But growing demand for using the airwaves for providing mobile communication services meant that supply soon exceeded demand.

Guatemala was one of the first countries to respond to the changing dynamics of the marketplace, and in its 1996

Map B4.6.1 Spectrum assignment in Latin America, in MHz blocks

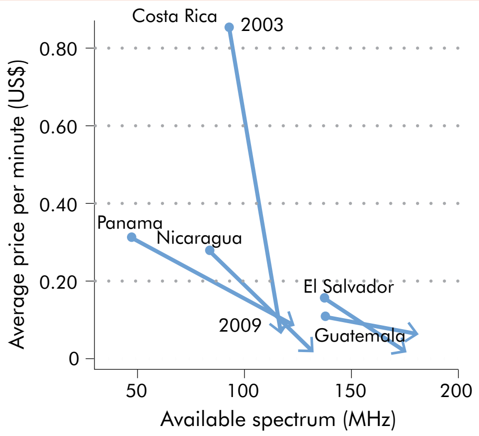


Source: Adapted from GSMA (unpublished spectrum database). Data at http://bit.do/WDR2016-MapB4_6_1.

(Box continues next page)

Box 4.6 Guatemala: An early pioneer of spectrum auctions *(continued)*

Figure B4.6.1 How greater spectrum availability led to lower prices in Latin America, 2003–09



Source: Adapted from Marino García 2015b. Data at http://bit.do/WDR2016-FigB4_6_1.

Note: The start of each arrow is a 2003 data point, and the end of each arrow is a 2009 data point.

General Telecommunications Law, recognized the economic value of the spectrum.[a] The law gave operators the right to request that any unallocated portions of spectrum be offered for sale, through auctions, and once awarded, it gave operators the right to use, lease, and resell the spectrum, creating a tradable market. Guatemala benefited from a faster reduction in prices for mobile services than the rest of the region (see figure B4.6.1). Other countries adopted similar policies, following Guatemala's early lead,[b] and indeed have now overtaken Guatemala in the spectrum allocated to mobile communications (see map B4.6.1).

a. Ibarguen 2003.
b. IDRC 2010.

mobile phone services. When the dot-com bubble burst in March 2000, there were fewer than 700 million mobile phone subscriptions (SIM cards)—but now, there are more than 7 billion, with over three-quarters in developing countries. That success story has come about, in part, because of the falling price of ownership and usage of mobile phones, particularly in South Asia, where it has been labelled the "budget telecom model,"[67] based on prepaid billing, very low entry costs, and extensive use of discounts. Six of the ten cheapest countries to use a mobile phone are in South Asia, where the cost of ownership is typically below US$5 a month (figure 4.2). Seven of the top ten most expensive countries are in Western Europe. On affordability, measured by the monthly price of a basket of services as a percentage of income, developed countries still do better, as might be expected, though the gap is narrowing.

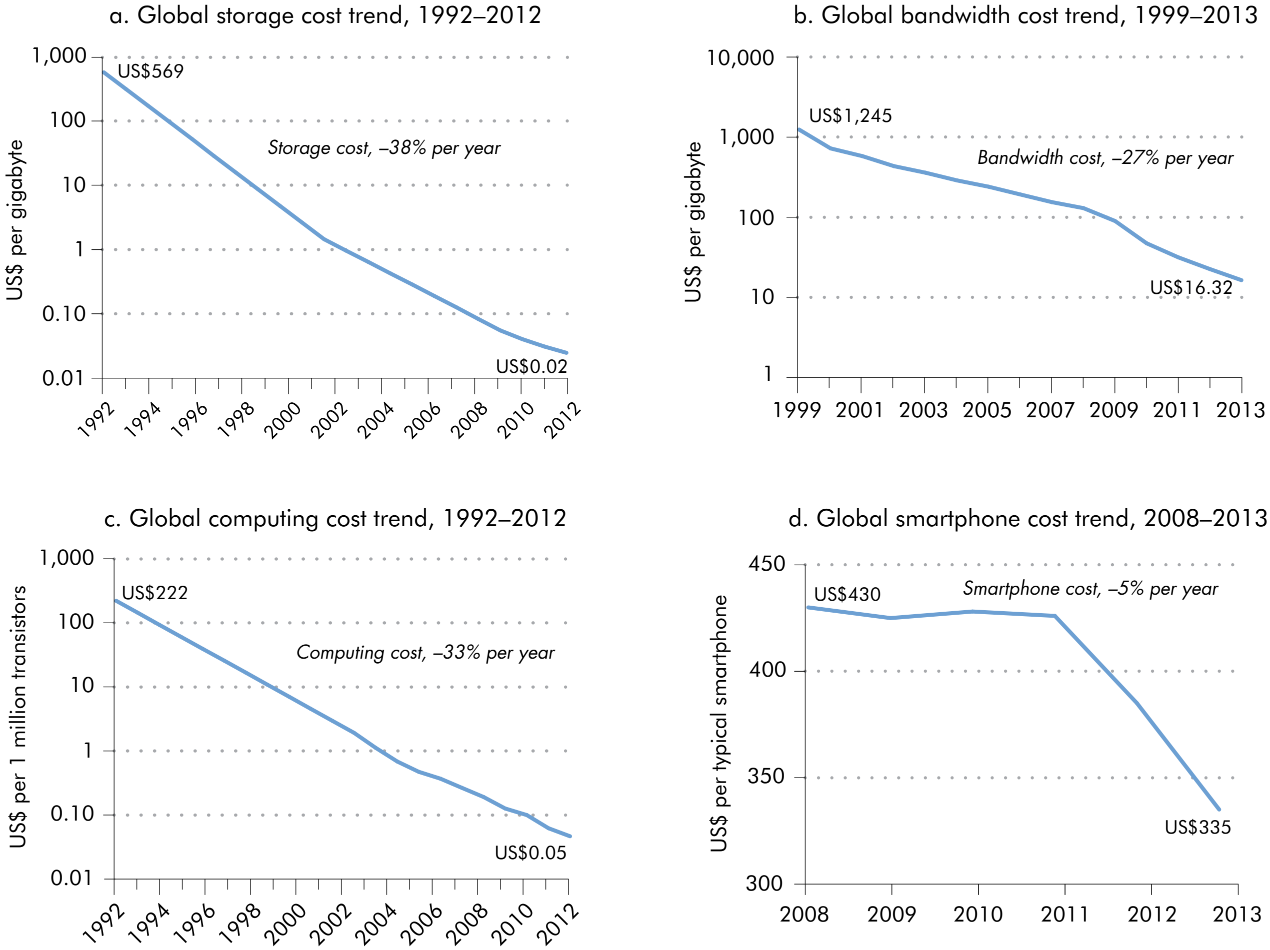
. . . but ICT prices still vary widely

Why do prices for ICT services vary so widely, by a factor of more than 40 for mobile cellular prices? Economies of scale seem to matter, with both India and China having prices below US$5 a month, while small island states, such as Vanuatu or the Marshall Islands, are generally more expensive than the global average, although there are many exceptions. But geography and population density appear to matter less than might be expected, with mountainous Bhutan and Nepal among the cheapest countries for mobile service, and the flat and densely populated Netherlands one of the more expensive. The practice of geographical averaging of pricing, applying the same price throughout a country, is still the norm—suggesting that, once basic coverage is established, rural areas are not necessarily more expensive to serve than urban ones. Mobile prices appear to be demand-driven rather than cost-based, with some of the cheapest prices in countries where the ability to pay is lowest.

Instead, to understand differences in ICT prices, it is necessary to look at policy and regulatory explanations. For mobile cellular services in Western Europe, larger operators found it profitable to set high rates for terminating each other's calls, and especially those from fixed-line operators. Higher prices for off-net calls locked in users, while high roaming charges drove profits. Regulatory interventions, to oblige operators to reduce termination and roaming rates, were only partially effective because operators simply absorbed lower interconnection payments by raising prices for outgoing calls in a "waterbed" effect.[68] In Canada and the United States, the unusual system of "both parties pay" pricing, where users pay both to receive and make calls with their mobile phones, should in theory obviate the problem of high mobile termination rates, in that "sender keeps all" is used (there are no payments between operators), which means there are no interconnection payments.[69]

But in practice, both appear among the most expensive countries for mobile calls, based on the

Figure 4.1 Prices are falling for computer processing, storage, bandwidth, and smartphones



Source: Deloitte Shift Index 2013; see http://www2.deloitte.com/us/en/pages/center-for-the-edge/topics/deloitte-shift-index-series.html. Data at http://bit.do/WDR2016-Fig4_1.

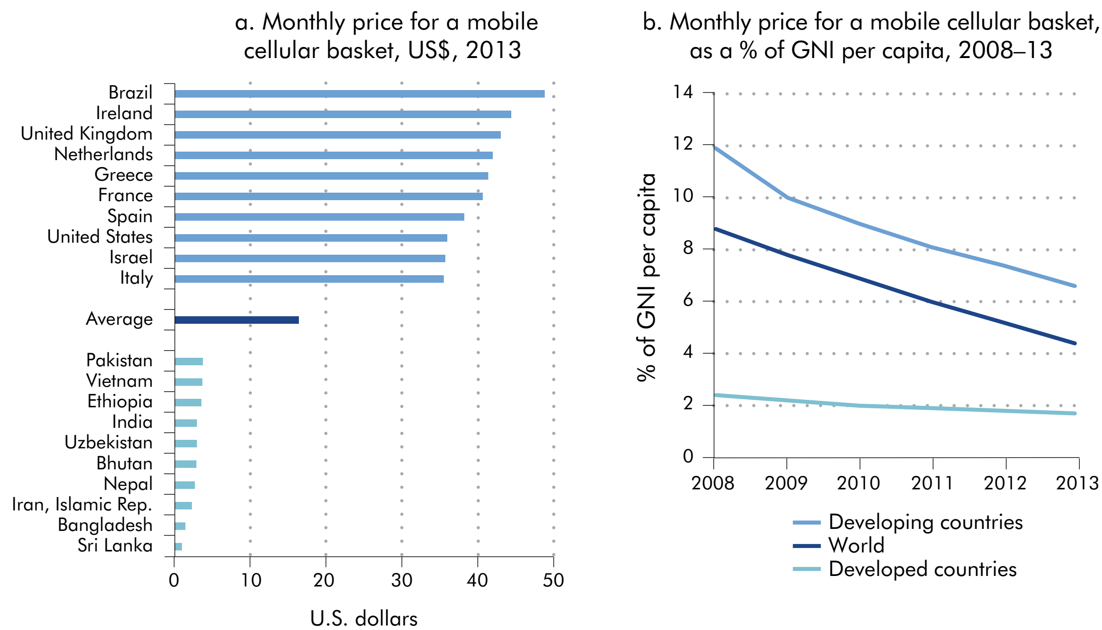
OECD low-user basket. Excessive bundling of different services, notably in North, South, and Central America, keeps prices for individual services high, and "locked" SIM (subscriber identification module) cards limit consumers' ability to choose among operators. Again, it is hard to escape the conclusion that operators are using demand-based, rather than cost-based, pricing, as operators in these countries have largely saturated markets. One more positive development is the dropping of mobile roaming charges in East Africa in October 2014, which led, for instance, to a 950-percent increase in traffic from Rwanda to Kenya compared with the previous month.[70]

Price differences between countries are even more evident for the internet. The range between countries for fixed-line broadband is almost 200-fold between Vietnam ($2.93 a month, for an entry-level price with a minimum speed of 256 kbit/s and monthly use of 1 gigabyte, GB) and the Central African Republic (US$584.97). For mobile broadband too, the range is more than 100-fold between Pakistan (US$1.48 for a GB of data a month, downloaded to a mobile handset) and São Tomé and Príncipe (US$169.38).[71] In contrast to mobile voice services, European countries, particularly in Scandinavia and Eastern Europe, are generally among the cheapest in the world, thanks to vibrant competition (see map B4.1.1). Mobile broadband in Europe does not suffer from the termination rates that keep prices high for voice calls and SMS.

What policy and regulatory options are available?

What can regulators do to address the shortfalls in availability and the wide price differences for internet

Figure 4.2 If you want to make a mobile phone call, go to Sri Lanka



Source: ITU 2014. Data at http://bit.do/WDR2016-Fig4_2.

Note: The basket of services used is based on the OECD low-user basket, which includes 30 outgoing calls a month (on and off-net, peak and off-peak), plus 100 SMS messages. Prices were sampled in the fourth quarter of 2013. Panel a is based on 167 economies, and panel b on a simple unweighted average for 140 countries with a complete data set. GNI = gross national income; OECD = Organisation for Economic Co-operation and Development; SMS = short message service.

prices worldwide? Table 4.1 offers some suggestions, based on applying the principles of market competition, public-private partnership, and independent regulation to the different phases of the internet supply value chain. The first step is benchmarking, to gather up-to-date price data to allow for comparisons, both within the country (between operators and over time) and between countries, using appropriate comparators. Price comparisons are tricky and generally require using a predefined basket of services and methodology, such as those used by the OECD[72] or ITU.[73] Operators often resist price comparisons, so it is essential to give the ICT regulatory agency a legal mandate for collecting, and publishing, relevant pricing and quality of service data (box 4.7).

Armed with data, the next step is to work out in which part of the value chain for the supply of internet the market may be failing. Table 4.1 suggests several distinct submarkets:

The first mile. This refers to the point at which the internet enters a country.

- *International connectivity*. The connection between a country and the global internet can be measured in bits per second per internet user. The global range is very wide—between 6.4 Mbit/s in Luxembourg to just 146 bit/s in the Central African Republic.[74] Governments can encourage a higher availability of international bandwidth, for instance, by liberalizing the market for satellite dishes, including very small aperture terminals, and allowing open access to submarine cables, satellite consortia, and landing stations. Government procurement can also lead in bringing down prices by aggregating demand among different services—all the universities in a region, for example—to negotiate better prices for bandwidth with international providers.
- *The international gateway* is the point at which a country connects to the global internet, and this can often become a bottleneck. Although the Arab Republic of Egypt liberalized its market for internet service providers in 1996, the incumbent, Telecom Egypt through its subsidiary TE Data, still has a legal monopoly over the international gateway and cable landing station, in Alexandria, at least until June 2016. Competitors pay as much for interconnection in Alexandria and backhaul to Cairo as they pay for international connectivity, resulting in some of the highest prices for internet in the region.[75] In such cases, regulating wholesale prices for connectivity,

Box 4.7 How better ICT data can lead to cheaper services

Better data on how information and communication technologies (ICTs) are used in developing countries can spur policy changes that benefit the poor and increase their digital access. In some parts of the world, one of the best ways to spur policy reform is to shame governments into action by comparing them to countries with better records. When a report from Research ICT Africa revealed that prepaid mobile prices were higher in South Africa than in 34 other African countries, pressure from the Parliament obliged the regulator to cut mobile termination rates, resulting in a wave of price cuts by mobile operators.[a] But such examples are rare, and there is an alarming lack of accurate and timely data on ICT use in the developing world. This makes it hard to understand the mechanisms by which greater information access among the poor drives economic opportunity. It also leaves important policy questions unanswered, such as whether new "free" internet services (or "zero-rated" services like "Facebook zero") drive the take-up of broadband or whether they deny access to the "free and open" internet.

In general, supply-side indicators (such as subscriptions, or domain name registrations) are better reported than demand-side use and applications data. The International Telecommunication Union has collected such data from its membership since the 19th century. But gaps in its database are increasing, as operators in more competitive environments have become more wary of releasing commercially sensitive data. National Statistical Offices could collect data on ICT use, but in developing countries they often lack the resources to carry out household surveys or do not have the know-how to collect policy-relevant data. A few donor agencies provide support, such as the funding of Research ICT Africa's household surveys by Canada's International Development Research Centre (IDRC)[b] or the funding of LIRNEasia's research on mobile phone usage at the base of the pyramid by the United Kingdom's Department for International Development (DFID).[c] The latter helped to persuade the government of Sri Lanka to forgo new mobile taxation policy.[d] But more should be done. Key areas for future action include:

- At the national level, ensuring that service licenses require operators to report data to regulators, and encouraging National Statistical Offices to include questions in their household surveys regarding ICT access and use
- At the global level, reigniting global coordination bodies, such as the Partnership for Measuring ICT for Development,[e] to compile, coordinate, and improve ICT data gathering
- Exploring the use of new data sources such as "big data," crowdsourced data, and social media to complement ICT access and usage statistics
- Creating mechanisms for telecommunications companies to share data, such as anonymized call records, for public research, policy, and planning purposes.

a. http://www.researchictafrica.net/docs/Fair_Mobile_Prices%20Q2-v04.pdf and http://www.researchictafrica.net/home_archive_reader.php?aid=118.
b. http://www.researchictafrica.net/home_archive_reader.php?aid=128.
c. http://lirneasia.net/projects/2010-12-research-program/teleusebop4/.
d. http://lirneasia.net/2007/10/lirneasias-policy-influence-on-mobile-tax -issue-in-sri-lanka/.
e. http://lirneasia.net/2007/10/lirneasias-policy-influence-on-mobile-tax -issue-in-sri-lanka/.

Contributed by Laurent Elder.

or structurally separating the supply of wholesale from retail services, could help.

The middle mile. This refers to the national, intercity internet backbone of a country.

- *The national backbone network*. The internet backbone network in a country provides backhaul from cable stations or satellite stations to major cities and towns. Ideally, it should include fiber-optic cables, but microwave and even copper links can also be used. The simplest step a government can take is to liberalize the market for building and operating backbone networks, and to encourage open access to the incumbent's network at the wholesale level. The risk is that the most popular routes—say, between the two main cities—are "superserved," while the rest of the country is underserved. So, many governments favor public-private partnerships to "direct" private investment, as in the Republic of Korea (see box 4.4). Governments can also help by making rights-of-way available to investors—and by requiring that all major infrastructure programs (such as roads, railways, pipelines, and energy distribution) include provision for an optical fiber link,[76] and follow the principle of "dig once, dig smart," by obliging contractors to anticipate future demand for fiber when digging trenches.[77]

- *The internet exchange point (IXP).* The IXP is where IP-based traffic is exchanged within a country. As of May 2015, there were some 446 IXPs around the world, but 87 countries still lacked a single one.[78] Average traffic handled by each exchange ranges from some 4.47 terabits a second on the Amsterdam Internet Exchange, founded in 1997, to just 21 kbit/s on the BurundiX IXP, founded in 2014. Setting up an IXP is one of the most cost-effective steps a country can take to enhance local connectivity. Research by the Internet Society shows that the Kenya IXP (KIXP), operating since November 2001 despite being initially declared illegal by the regulator, saves local internet service providers (ISPs) some US$1.5 million a year in reduced costs for international connectivity. And it reduces latency from 200–600 milliseconds to 2–10 milliseconds, on average, by exchanging traffic locally.[79]
- *Local hosting of content.* Promoting local hosting of content and creating a local cache for frequently used content from elsewhere can also enhance the efficiency of the network and reduce latency, increasing usage as users experienced shorter waiting times for websites to load. In Rwanda, 14 of the top 20 sites with Rwandese content were commercial sites, and all were hosted outside the country so that a typical website could save around US$100 a year and enjoyed a more reliable service. But this imposed additional costs of US$13,500 a year for local ISPs that had to bring the content back in over expensive international links—costs which are then passed on to users. Promoting local hosting, already required for government sites in Rwanda, could avoid this, and help improve service quality.[80]

The last mile. This refers to the connection between the user and their nearest internet point of presence (POP).

- *The local access network*. The most costly part of the network, and the hardest to duplicate, is the local access network, which connects the user to the nearest internet POP. In the early days, this was typically achieved through dial-up, using a modem, over ordinary copper telephone lines. Starting in the late 1990s, a technology called digital subscriber line (DSL) allowed that same telephone network to be used for always-on broadband connections, while cable modems offered the same facility for cable TV networks. In developing countries, where copper-based local access networks serve only a few areas, wireless-based access networks offer the most popular alternatives. Just over half the world's inhabitants live within coverage of advanced, third- (3G) or fourth-generation (4G) networks, but even second-generation (2G) networks can be adapted for slow-speed internet use.
- *Government policies to encourage the spread of fixed-line broadband networks* include permitting competing facilities, especially for intermodal competition (between cable, DSL, and wireless), and local loop unbundling (LLU), or mandating the incumbent to make local access lines available to competitors at wholesale prices. The widespread enforcement of LLU in Europe since 2000, following EU directives,[81] is one reason its average broadband prices are among the lowest in the world. LLU is most effective once a minimum level of penetration has been achieved; below that, it can act as a deterrent for investment.[82] LLU also offers a foothold for new entrants that can quickly offer nationwide service and then later develop their own infrastructure, as has been the case for free.fr, a new entrant in France.

The invisible mile. This refers to the other, less visible network components and potential bottlenecks.

- *Efficient spectrum management.* Critical at all stages of the internet supply chain but especially in the local access network, efficient management of the civil radio frequency spectrum includes increasing the amount of spectrum available, ensuring competitive access, encouraging sharing of essential facilities such as radio masts, and liberalizing the market for spectrum resale and leasing to allow the creation of mobile virtual network operators. In this sense, spectrum resale in the wireless world is the equivalent of LLU in the fixed-line world. Policy makers can also help by making more unlicensed spectrum available, especially for innovative uses such as cognitive radio (which hops between frequency bands to avoid interference), and by opening up underused government spectrum for commercial applications.
- *Over-the-top services.* Policies to encourage a wide range and diversity of OTT services can provide a wider choice to consumers at lower cost. Policies to encourage OTT growth include removing regulatory barriers to providing voice over IP and

mandating that operators provide access to essential facilities such as billing and app stores. Of course, OTT services introduce many regulatory issues of their own, not least the concept of "net neutrality." A recent consultation on net neutrality[83] by the Federal Communications Commission, the U.S. regulatory agency, attracted a record number of comments, around 4 million.[84] Ultimately, with support for net neutrality from the U.S. president, the FCC ruled in February 2015 in favor of regulating broadband internet as a public utility, although legal challenges could continue for years.[85]

- *Mobile money.* For developing countries, one of the most significant OTT services is mobile money, which is also fraught with regulatory challenges (see spotlight 2, "Digital finance").

Demand-side policies: Open and safe internet use

The internet is at once unique, complex, and one of the most used global communications media. It has different layers of infrastructure and applications, and different stakeholders are involved in its operation, use, and governance. What features affect the stability and security of the global internet to engender trust and therefore encourage use of the internet? What is the best way to balance stakeholder interests in these areas? This section addresses the creation of an enabling environment of "trust" for the internet to achieve its full potential.

Censorship and content filtering threaten the internet's utility as an engine of growth

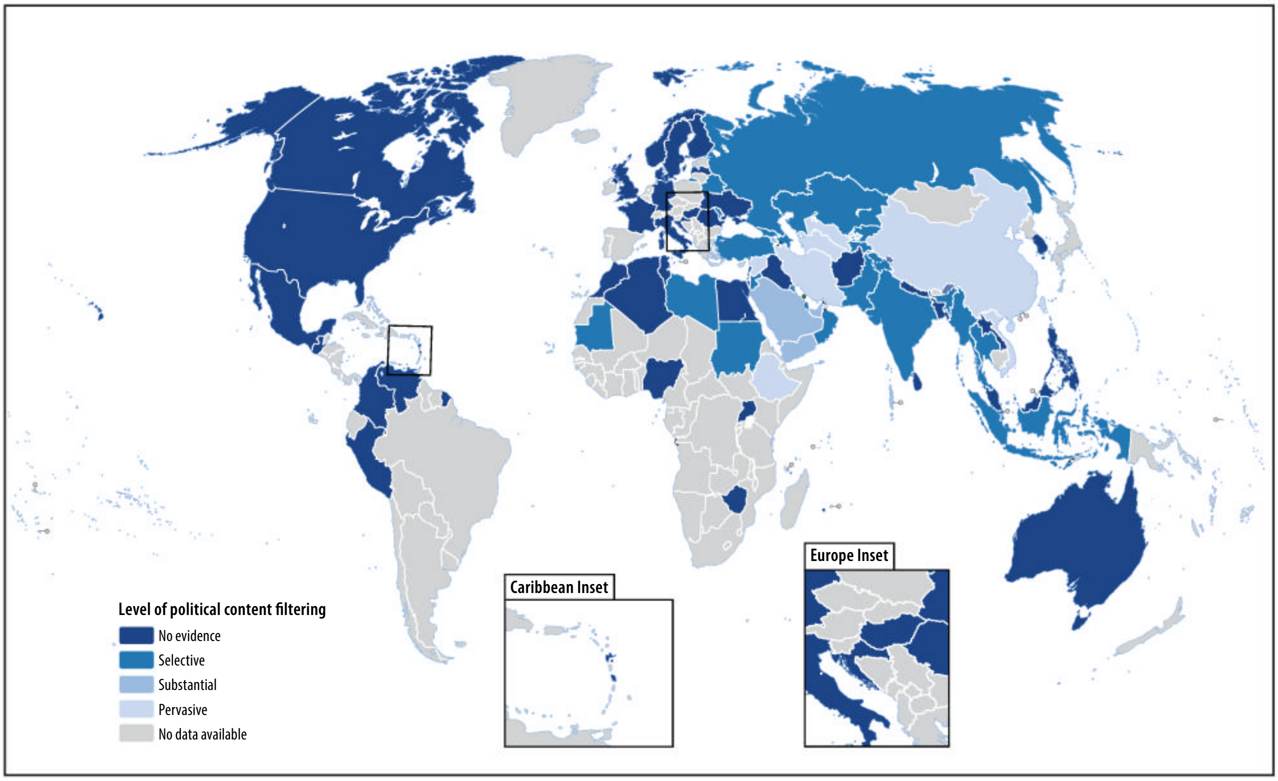
The internet thrives on open information exchange and freedom of expression.[86] One global view shows the range of internet filtering of political speech, from none to pervasive filtering (map 4.1).[87] Another shows, perhaps paradoxically, that concerns over freedom of expression are actually greater among users in countries that have more recently come online than among users from countries with a longer history of internet access.[88] One account of filtering blames filtering policies and software for poor internet performance (slow access speeds).[89] This is an example of a direct cost associated with filtering, but such filtering also leads to indirect costs from the drag on innovation that comes from self-censorship, and the resulting loss of freedom. In this discussion, "filtering" (or censorship of public content) does not include "surveillance" (or monitoring of private content).

Innovation also depends on the ability to protect and monetize intellectual property. Avoiding piracy will rely on striking the right balance between providing access to information and protecting intellectual property rights. Generally, the illegal distribution of copyright material tends to lessen when legitimate ways exist to access that material, for a fair price. Thus, contrary to expectations, peer-to-peer file sharing systems that blossomed in the early 2000s for free sharing of music, such as Napster and Kazaa, started to decline once legal alternatives, such as iTunes or Google Play, became available, without any noticeable impact on the quantity or quality of artistic output.[90] The action has now shifted to film and TV file sharing, but again the availability of legitimate commercial services, such as Netflix or Hulu, is progressively displacing illegal services as they are extended to more territories and have greater content coverage. But there remain large parts of the world where content is not available for download legally, because content licensing and copyright are so complex and fragmented that small markets are too often ignored (chapter 6).[91]

An issue that is more difficult to resolve surrounds the restriction, or filtering, of certain types of online content. Every country has different redlines on content it regards as dangerous or offensive. Germany has restrictions on hate speech, while Thailand monitors comments about its king. There are also certain absolute values, such as restrictions on child pornography. Such restrictions are understandable and justified where they represent a societal consensus adopted by an accountable government. The Supreme Court of India, for example, recently reconsidered its position on free speech issues, potentially lifting existing restrictions on online speech.[92] But few governments have the capability to enforce such content monitoring on their own. Instead, they must cooperate with the major websites and search engines, which then have to apply their own judgment. Google, for instance, publishes a transparency report that provides statistics on government requests to remove content, which have grown significantly since 2011.[93] In the six months ending December 31, 2013, Turkey submitted the most removal requests (895), followed by the United States (481).

Some governments try to block access to content directly, for instance by imposing national firewalls or restricting the use of certain internet applications, such as virtual private networks or voice over IP services. Google reports that, in the first nine months of 2015, six countries had experienced disruptions of

Map 4.1 Evidence of internet content filtering



Source: Open Network Initiative, http://map.opennet.net/filtering-pol.html. Data at http://bit.do/WDR2016-Map4_1.

traffic to its products—China, the Democratic Republic of Congo, the Islamic Republic of Iran, Pakistan, Tajikistan, and Turkey.[94] Excessive restrictions on use can increase the costs of doing business, particularly for international businesses, which may be dissuaded from investing.[95] In addition, inconsistent and complex content filtering requirements can make it difficult to offer internet services and applications that are global in nature. Policy makers in governments that impose such restrictions have to choose between the relative perceived advantages of controlling certain kinds of information and the economic costs, including lost opportunities, of maintaining such systems.

Cybersecurity: Trust in the internet will come from balancing the security of networks and information with the protection of individual rights

The term "cybersecurity" is a convenient shorthand for a very complex set of issues. It commonly refers to systems and actions aimed at securing data and communications over the internet and even the infrastructure of the internet itself.[96] It also sometimes includes "cybercrime." The more common threats to cybersecurity are malware, denial of service, and phishing attacks (attempts to acquire sensitive information online by someone who is masquerading as a trusted entity), but cyberincidents are increasingly perpetrated by disaffected insiders. So, cybersecurity usually refers to securing data and infrastructure in a civilian context; but acts that might previously have been considered civilian attacks are now being uncovered as acts of states against states via nonstate actor proxies, blurring the lines between acts of cybercrime and cyberwar or cyberterrorism. Threats to personal security online, such as online identity theft, are also growing. This may erode public confidence in e-commerce and e-government applications, and make internet use less attractive, thus suppressing its use for certain applications. Likewise, cybersecurity can include securing critical information infrastructure from acts of nature, such as developing backup facilities in alternative locations.

However defined, weak cybersecurity is a significant problem worldwide, with both the scale of financial losses, and the costs of preventing them, growing (box 4.8). New breaches of security over the internet are reported almost weekly. Reliable estimates of the size of the problem are hard to come by because of the definitional problem that compounds a lack of common indicators—and because firms and governments suffering cyberincidents are unwilling to disclose losses and thus to reveal vulnerabilities. Some of the published sources are based on flawed assumptions, and all reports raise as many questions as they answer. The growing centrality of the internet in daily lives around the world, and the increasing use of mobile devices, combined with the "internet of things" (see spotlight 6), appear to have increased exposure to cyberrisks.

Equally important, the incentives to deal with cyberrisks need realignment. For example, individuals sometimes do not take proper precautions to secure their devices or data, passing on the cost of security to society at large. Vendors of hardware and software are in a highly competitive environment and may push products to market at the expense of ensuring proper security features. Cybersecurity is expensive and complex (whether through incurring up-front costs of "prevention" or dealing with costs of restoring security in "recovery and resilience" regimes). It may be economically rational to accept some degree of insecurity for the convenience to transact online.[97]

That said, there are also various ways of identifying the costs involved, including direct and indirect costs, and two types of costs to be considered. First are the costs of the breach (actual loss) and of the remediation efforts to fix it. Second are costs associated with prevention and providing an environment of "trust," as well as understanding the incentives of actors to provide security. The methodology encapsulated in table 4.2 provides a systematic framework for more precisely evaluating "cybercosts" and identifying which stakeholders are most likely affected by particular costs. Aggregating the cumulative costs across all players and cost categories yields an estimate of the total direct, the total indirect, and the total implicit costs. This kind of assessment will be key for policy planning.

Public safety and security in the analog world is a public good, ensured by governments. In the cyberworld, governments also have an obligation, through their policies, laws, and institutions, to ensure the protection of data, communications, and critical infrastructure. One particularly vexing problem in government attempts to address cybersecurity is that much of the infrastructure, and most of the communications, are controlled by the private sector or other nonstate actors. Around the world, governments of both developed and developing economies are taking action at the national level to address cybersecurity concerns. But because of the global nature of the internet and the cross-border nature of cyberincidents, governments should be encouraged to do more to protect themselves and their citizens through cooperation at the international level, for instance by exchanging information on threats. Because of the role of nonstate actors in the provision of infrastructure and services, governmental efforts will have to involve public-private partnerships (working with a variety of nonstate actors beyond the private sector) and find ways of addressing and even overcoming jurisdictional boundaries and barriers. Technical solutions will help, as in combating spam, but these need to be backed by legal measures and enforcement. Collaboration and openness are key.

In the areas of cybersecurity, there are few obvious policy recommendations, and in these areas—

Box 4.8 The costs of cybercrime

Estimates of the costs of cybercrime abound, but many reports are based on weak evidence or overly simplified assumptions. Often the methodology is not disclosed, complicating an assessment of its validity. Damage, typically assessed at a highly aggregated level, is difficult to link to specific incidents. Furthermore, most estimates are developed by companies directly involved in the sector, which may have an interest to overestimate the risks. Nevertheless, the cost estimates are both high and growing:

- A 2014 study put the global costs of cybercrime at between US$375 billion and $US575 billion, or about 0.6 percent of global GDP.[a]
- A 2014 study showed the average per person cost of data breaches ranged from US$51 in India to US$201 in the United States, and had risen 15 percent in a year.[b]
- A 2013 study estimated that the global costs to consumers (excluding businesses) were around US$113 billion, and had risen by half in one year.[c]
- A 2008 study estimated that the global effects of malware were around 0.5 percent of global GDP.[d]

Source: Adapted from Bauer and Dutton 2015, for the WDR 2016.

a. CSIS and McAfee 2014.
b. Ponemon Institute 2014.
c. Symantec 2013.
d. Bauer and others 2008.

Table 4.2 A basic framework for assessing the costs of cybersecurity incidents

	Direct costs										Indirect costs						
Market players	Repair costs	Data loss	Security measures	Fraud	Patch development and deployment	Customer support	Abuse management	Investigation at the organizational level	Law enforcement	Cost of infrastructure	Lost productivity	Revenue loss	Confidentiality breach	Reputation-related revenue loss	Security countermeasures collateral impact	Slower ICT adoption	Slower ICT innovation
End users																	
Home	●	●	●	●	●						●		●		●		
Business	●	●	●	●	●					●	●	●	●	●	●		
e-commerce companies			●	●						●		●		●			
Infrastructure																	
Software vendors			●		●									●			
Internet service providers			●			●	●			●				●	●		
Hosting providers			●			●	●			●				●	●		
Registrars			●			●	●							●	●		
Computer emergency response teams								●									
Law enforcement									●								
Society at large																●	●

Source: Bauer and Dutton 2015, for the WDR 2016, citing Bauer and others 2008.

Note: ICT = information and communication technology.

perhaps more than others—governments can play a role in developing effective policies. The "perimeter security" paradigm that pervades today, born in an era of a few centralized mainframe computers, needs revisiting, putting users—not devices—at the center of the discussion, and thus implying a great role for capacity building.[98] Public policy could be used to change misaligned incentives to achieve security. Given the pace of technological change, these policies should be guidelines or principles, not prescriptive, and be technology neutral. They should encourage interoperability among regimes and legal systems to investigate and prosecute cybercriminals across jurisdictions and to avoid the creation of safe havens for cybercriminals. Finally, work could be done to develop a common set of indicators to measure the economic impact of cybercrime and other cyberrisks.

Protecting personal privacy and data online is essential in building trust in the internet

The other side of the "balance" is protecting privacy and data online.[99] One of the key drivers in the digital economy is the flow of personal data, of which an estimated 90 percent has been added in the last two years. Collecting and analyzing data about individuals is integral to how some of the largest companies in the world do business. For example, Facebook is a company with a US$230 billion capitalization largely through its sales of ads that reach Facebook users.[100] But data also allow small and medium companies to monetize their services.

The World Economic Forum (WEF) has identified data-driven enterprises as part of a strategy for economic development in developing countries.[101]

Protecting personal data online is key for the data-driven economy, since it will increase trust in the internet, and greater trust will foster more use. And privacy is not just a developed-country issue. Some studies show how concerns over maintaining privacy online have more to do with "awareness" of threats to privacy posed by the internet, rather than with relative economic development, debunking the notion that privacy is mainly a western preoccupation.[102] But the issue is not as simple as having and enforcing national laws that protect personal data. Data flows nowadays are global, and privacy regimes need to be interoperable with one another to really enable the internet to be an engine of innovation and economic growth.

Privacy concerns range from the personally sensitive (personal health information or precise locational information) to the seemingly trivial (search or browsing history). But even the most innocuous data can become harmful when used by third parties in unauthorized or unexpected ways.[103] Most internet users are willing to surrender personal data—or control over it—for more convenience (gift suggestions based on their past purchases), for possible gain (the chance to win a holiday), and to avoid payment (notably, when downloading and using free mobile apps). But few users have the means to challenge data use policies or even make the effort to read the small print.[104] Privacy online is also a balance. It may be economically rational to relinquish some degree of privacy for the convenience of transacting online. But beyond respecting users' choice in how they transact online, public policy choices involve determining what other measures are necessary to afford appropriate privacy protections. The key is to ensure that users are made aware of the risks of diminished privacy.

One of these privacy challenges[105] is the growing use of "big data."[106] Data mining has been routinely used, especially by social media and e-commerce companies, to create value. The business model of Twitter or Facebook, for instance, is to grant users free storage, communication, and functionality in return for privileged access to the content they create. Such companies then aggregate and analyze user-generated content to sell value to advertisers wishing to reach targeted audiences. This classic two-sided market approach can make for a more intelligent and convenient user interface, but at the risk of alienating users if they find the use of their data too intrusive.[107] Mobile call data records (CDRs), which record basic data like the time, duration, location, and direction of calls, can also be mined to extract trend information.[108]And many applications are potentially valuable, as in traffic analysis[109] or epidemiology.[110]

Like big data, the internet of things also poses new privacy challenges, notably in the ability it offers to develop detailed user profiles.[111] The number of connected devices in use worldwide is set to rise significantly as consumer goods companies, auto manufacturers, health care providers, and other businesses continue to invest in connected devices.[112] Data collected are generally anonymized, but users may be unwittingly relinquishing control of their personal data. Open data initiatives by governments raise similar concerns about "anonymization," data breaches, and unauthorized or unintended re-use.

Privacy concerns need to be balanced against other important issues such as transparency, freedom of expression, proportionality, and security.[113] There is tension between protecting the privacy of individuals and keeping them safe from terrorism or criminals. Law enforcement and national security agencies need access to CDRs, and legal call interception, to track criminals, but they should do this by having appropriate safeguards in place to seek authorization, and not by using blanket surveillance measures. The exposure of indiscriminate snooping by governments has, ironically, encouraged large internet content providers to make far wider use of encryption, and operating system manufacturers are following suit.[114] Outside the domain of law enforcement, legislation should give users more control of their data at the point of use (if not at the point of collection). Consider the Electronic Health Record System in Estonia, which is based on the principle that citizens own their own health records and can easily access them and transfer them between doctors.[115]

Privacy policy concerns also need to be balanced against countervailing public policy issues such as freedom of expression and government transparency in the internet context. A recent decision from the European Court of Justice,[116] popularly known as the right to be forgotten, highlights this debate. Users in Europe now have greater control of the data about them on the internet.[117] This right can be exercised against search engines, such as Google or Bing, and would include seeking to remove search results pointing to documents held elsewhere in the cloud. But the decision does not offer clear guidelines for applying the right. Beyond that, once something is online, it is virtually impossible to ensure that all copies are deleted. Complying with user demands to delete personal data will impose additional costs on businesses and governments.

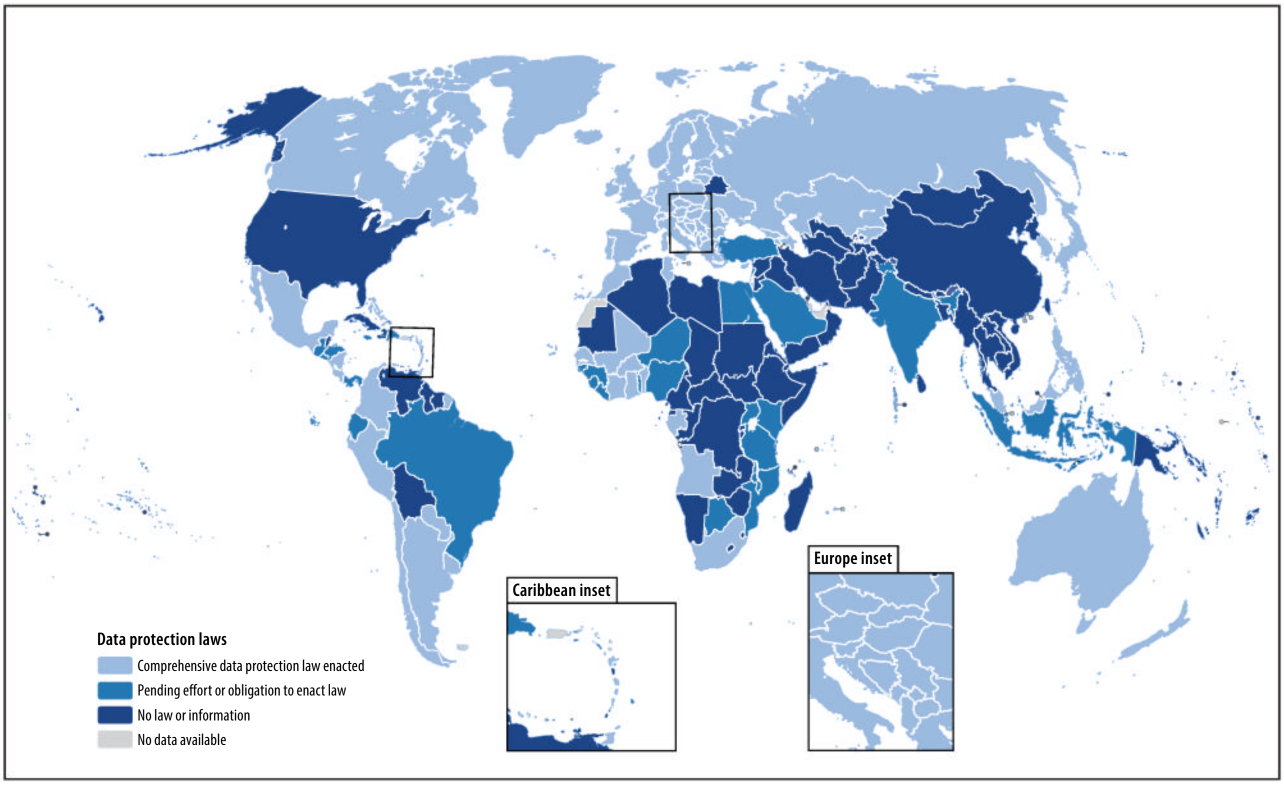
One sign of the growing awareness of public policy concerns is the surge in new privacy laws, even while there has been divergence among countries (such as in the European Union and the United States) in their approach.[118] According to the United Nations Conference on Trade and Development (UNCTAD), 107 countries had privacy laws or bills in place as of 2014, but only 51 of them were developing countries (map 4.2).[119]

At the international level the United Nations General Assembly has adopted a Resolution, introduced by Brazil and Germany, on the Right to Privacy in the Digital Age.[120] The Africa Union Convention on Cybersecurity includes data protection.[121] The OECD, in 2013, published its updated *Privacy Guidelines*, revising work originally carried out in the 1980s.[122] The Asia-Pacific Economic Cooperation followed up on its Privacy Framework with a cross-border privacy arrangement in 2010.[123] The European Union is conducting an overhaul of its data protection framework.[124] while the United States is also considering options.[125]

The data protection story is becoming more complex. There is some evidence of convergence: the newly proposed EU data protection framework includes a directive looking closely at the protection of data as they relate to security and defense issues, a long-standing concern in the United States about which Europe had been more hesitant. The U.S. administration unveiled a blueprint for a consumer privacy bill of rights that would address consumer privacy more comprehensively. At the same time, in reaction to the Edward Snowden revelations (discussed below), the European Court of Justice issued its opinion in the *Schrems* case effectively invalidating the "Safe Harbor" agreement reached between the European Union and the United States permitting the handling of European data in the United States.[126]

Different approaches, however, are making it difficult to develop truly global internet services and applications because local adaptations are required to comply with differing national privacy laws, imposing additional compliance burdens and costs on businesses (see chapter 6).[127] Diverging rules also stifle trade and innovation. In addition, the threat of "data nationalism"[128]—the idea that a country's data should be stored within its borders, recently embodied in a new Russian law, for example, that requires the local storage of the personal data of Russian citizens—has

Map 4.2 National data protection and privacy laws and bills



Source: UNCTAD 2015. Data at http://bit.do/WDR2016-Map4_2.

grown since the revelations by Edward Snowden about the U.S. government's surveillance of foreign internet traffic, which was subsequently declared to have been illegal.[129] That puts an additional burden on companies seeking to build services that rely on cloud-based networks.[130]

What is clear, however, is that getting the data protection and privacy piece of the puzzle right is, together with cybersecurity, a key element in engendering trust in and confidence in use of the internet. Even before "Snowden," users in countries of all regions were concerned that they should be careful about what they say online, as more and more perceived that their actions would be monitored.[131] While data protection and privacy are essentially matters of local law, a preponderance of privacy laws around the world are based on a common set of international, durable, and recognized principles. Moreover, interoperability of data protection regimes will encourage cross-border data flows and decrease the propensity for data nationalism. As discussed, data protection is not solely a preoccupation of advanced economies. Unlike investments in infrastructure, ensuring that good practice in data protection is part of the overall internet enabling environment makes sense for a country interested in the internet as a means of economic development.

Does net neutrality matter?

One of the more confounding issues around the internet today is "net neutrality." The term, euphemistically derived out of debates in the United States, has become a shorthand for a debate about the management and prioritization of scarce resources—notably bandwidth—over the internet. Thus the debate has pitted users and content providers against network providers.[132] In oversimplified terms, content providers want an "open" and "free" internet where every data bit, or IP packet, is treated equally, while network providers seek to charge higher rates for services chewing up more bandwidth. In the United States, the debate over net neutrality was mainly about the bandwidth consumed by video downloads. After announcing new rules in February 2015, opponents of the rules in the United States (mainly network providers) have claimed that compelling the openness of the internet imposes on their rights as a corporation to determine which content to make available. In other parts of the world, the debate over net neutrality is recognized as a matter of freedom of expression or access to information for individuals—a human rights issue.

So, depending on where one sits, the issue can be taken up as an issue of scarce bandwidth or of free speech. As with other resources where capacity is scarce, as on mobile networks, carriers attempt to use price discrimination to manage traffic. Network providers argue that regulators should grant them more flexibility to manage their traffic flows. But others argue that traffic management should not become an excuse to block certain traffic streams, content, or expression, to give preference to others, or to impede competition. The recent trend to develop services in which some basic content can be accessed free of data charges (such as Facebook's Free Basics or Internet.org), while other content is subject to data charges, would appear to be the antithesis of net neutrality and a distortion of markets.[133] Nevertheless, some defend the practice as a means of extending internet use in low-income countries.[134] In India, following protests, some participating organizations withdrew support to Airtel Zero and Internet.org, as the regulator indicated that these platforms do not provide equal treatment to all online services.[135]

An open and free internet is also a key contributing factor to innovation in the digital economy, making it critical to protect this openness. Care should be taken to ensure that users have the greatest possible access to internet-based content, applications, and services of their choice. But traffic management measures, while legitimate, should not reduce the enjoyment of fundamental rights and freedoms, particularly freedom of expression. The balance here should be carefully calibrated so that network operators continue to have incentives to build out and continuously improve networks and network capacity. Recognizing the balance to be sought in this debate, the Council of Europe in 2010 announced its policy on "net neutrality" (without calling it such), emphasizing the rights-based aspect of the issue.[136]

Much of the early debate on net neutrality in the United States was focused on the classification of the internet under the 1996 Telecommunications Act; in the rest of the world, the issues argued under the same moniker look at the impact of traffic management techniques, such as deliberately slowing (or "throttling") data streams, on human rights, and the continuing impact of the internet as a driver of innovation. Access to information is not solely a "developed" or "developing" country preoccupation. Not only is it a fundamental human right, inherent in Article 19 of the International Covenant on Civil and Political Rights,[137] it is also an essential element in the online innovation ecosystem, and therefore an economic development issue. In whatever form a country would wish to use the internet for development purposes, its public policies should ensure that technical management of internet traffic is not used to suppress a tool of innovation.

Promoting the digital economy

The internet as an open access ecosystem

Once the internet is widely available and affordable in a country, and public trust that the internet is a safe and open platform for doing business or storing personal information has been established, it can become an unrivaled platform for promoting entrepreneurial opportunity. Indeed, 9 of the top 20 people in the Forbes 2015 billionaires list made their money from the sector.[138] Initially, internet entrepreneurship was associated with the dot-com bubble of the late 1990s, but the networks of the day lagged behind the aspirations of entrepreneurs. As one subsequently said, "A lot of the business plans were deeply flawed, but a lot of the ideas would have worked had there been broadband."[139] Since 2008, when broadband crossed the threshold of 10-percent penetration worldwide, a new and more sustained period of internet entrepreneurship has developed.

The U.S. economy has so far been the main beneficiary of the internet as a source of innovation and entrepreneurship.[140] This success is exemplified by the Silicon Valley technology cluster. Many countries have tried to imitate it.[141] Few have succeeded. The ingredients of success for ICT clusters have traditionally included close collaboration between academia and industry, easy access to venture capital, high levels of government research spending, and a physical environment and climate that is attractive to footloose, highly paid workers. However, in recent years, certain cities with doubtful climates have also developed a vibrant tech entrepreneurship scene, notably Bangalore, Berlin, Hangzhou, London, Nairobi, and New York. This suggests that the internet is creating a new set of geographical preconditions for innovation districts that are more about density and bandwidth than about sunshine and golf courses.[142] Specifically, the serendipitous "collisions" between like-minded individuals that create innovative ideas are more likely to occur in high-density urban environments than in lower-density locales where high-technology industry has traditionally flourished.[143]

Governments are generally not very good at picking technology winners. Nor can they easily create technology clusters, which tend to grow organically, where the right conditions are in place, as firms draw upon the same talent pool and startups spin off from established enterprises. From the recent development of tech hubs and FabLabs—for instance, there are now more than 555 FabLabs across 77 countries[144]—it is unclear if all of them would have come up organically, though government involvement in most of them has been minimal (box 4.9 and map 4.3). But government policy can help to sustain an emerging technology cluster, for instance by instituting favorable tax regimes or liberal policies on awarding employment permits to skilled workers ("tech visas"). Israel shows how government can stimulate the growth of an ICT cluster once it becomes established (box 4.10). Government procurement can also help create opportunities for local companies to flourish without infringing commitments to free trade, for instance by unbundling large ICT projects into smaller components. But governments also can unwittingly undermine a local ICT sector, with lax rules on intellectual property protection or burdensome taxes on the import of ICT goods and components.

National ICT strategies

In recent years, it seems to have become ever more complicated to develop a coherent set of policies to regulate and promote a nation's ICT sector. Rapid technological change, coupled with disruptive changes in the supply side of the industry and growing challenges on the demand side, requires flexibility. But industry players demand predictability in policy setting and a level playing field. ICT users are becoming ever more vocal, and expertise that may once have been centralized is now dispersed throughout government. So, coordination becomes all the more important.

When countries take a conscious decision to develop a national strategy for broadband, or their ICT sector more generally, they are rewarded with

Box 4.9 Tech hubs in Africa

The recent development of tech hubs across Africa (see map 4.3) exemplifies how technology clusters create a snowball effect whereby initial preconditions for success generate additional, mutually reinforcing innovation drivers. Though nowhere similar in scale to Silicon Valley, technology clusters in Africa nevertheless demonstrate that close collaboration between academia, government, and the private sector can help develop a vibrant ecosystem that facilitates ongoing innovation and market entry. Tech hub clusters, such as in Cape Town, Lagos, and Nairobi, show that once a certain threshold is passed, new hubs and ongoing entrepreneurial activity can be stimulated through enhanced access to finance, services to entrepreneurs, and the demonstration effects of successful "first mover" startups. The development of Nairobi's tech cluster dates to the founding of iHub in March 2010. Growth has spread, first to the rest of the Bishop Magua Centre where it is located (including Nailab, m:lab East Africa, and the longer-established Ushahidi), and then to nearby Strathmore University (where iBiz and iLab are located) and along Ngong Road to the GreenHouse and 88 mph/Startup Garage.[a]

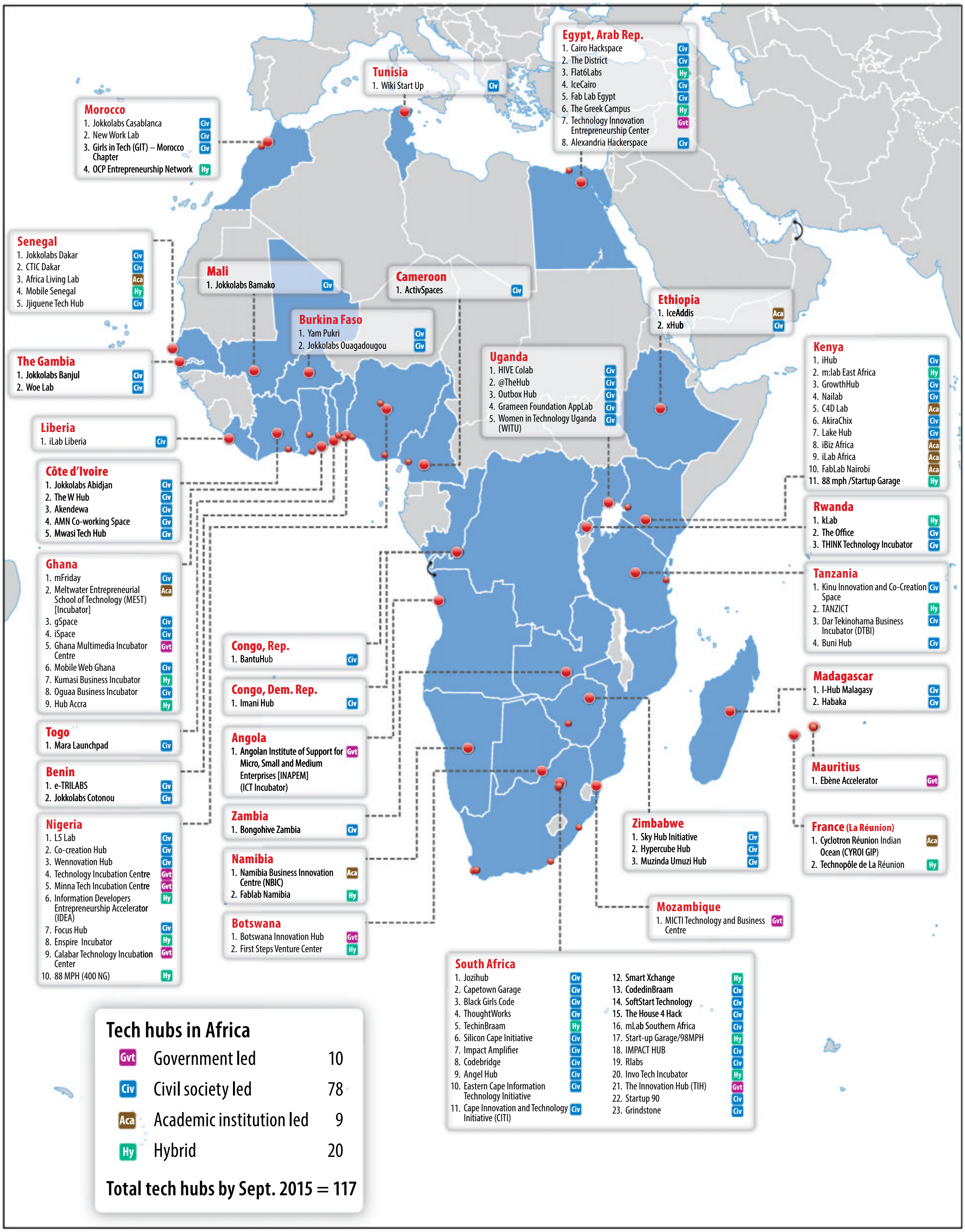
As with the creative destruction of the original dot-com bubble, many new startups, including some of the hubs themselves, have overestimated market demand for their products and services and ended up with short lifespans. Thus the turnover of hubs and incubators in Africa has been relatively rapid over the last five years,[b] but the growth path is still upward, with a net increase of around 15 percent since the start of 2014. Tech hub performance also depends on context-specific dynamics, and the situation of the local business community. However, the comparative success of certain clusters, while others remain stagnant, suggests that organic, multistakeholder ecosystems work better than initiatives led by government, the private sector, or academia alone.

a. Firestone and Kelly 2015.
b. http://www.gsmaentrepreneurshipkenya.com/GSMA_KENYA-AR2014-060214-WEB-SINGLE-PGS.pdf.

higher rates of service take-up.[145] As of mid-2013, some 134 countries had already developed national broadband plans, and a further 12 planned to do so. Once developed, plans need to be regularly refreshed and updated, ideally on a cycle of three to five years, according to the United Nations Broadband Commission, which has set a target that all countries should have a national broadband plan by 2015, with at least 40 percent of households in developing countries served with broadband.[146] National broadband plans are also more effective when they include specific benchmarks, or targets, that are relevant, measurable, realistic, and actionable. For example, Estonia has set a target that at least 100 Mbit/s broadband service should be available to each citizen by 2015.

What seems to be important is not so much the plans themselves, which vary enormously in quality and scope, but the consultation process for developing them and whether they can be easily implemented. In the same way that international internet governance has evolved toward a multistakeholder model, so too national strategies can benefit from ensuring that there is an opportunity for all stakeholders to express their views and that those views are reflected in policy making and regulation. In an era in which mobile subscriptions exceed the world's population, and with each internet user having within easy reach a vast library of global knowledge, ICT policy is too important to be left to the bureaucrats. Broad multistakeholder collaboration is the key. Equally important is the fact that digital development strategies need to be broader than they are today, strengthening the country's ICT infrastructure, but also the foundation underpinning its digital economy—an issue explored in the next chapter.

Map 4.3 African tech hubs



Source: WDR 2016 team. Interactive map and source data available at http://bit.do/WDR2016-Map4_3.

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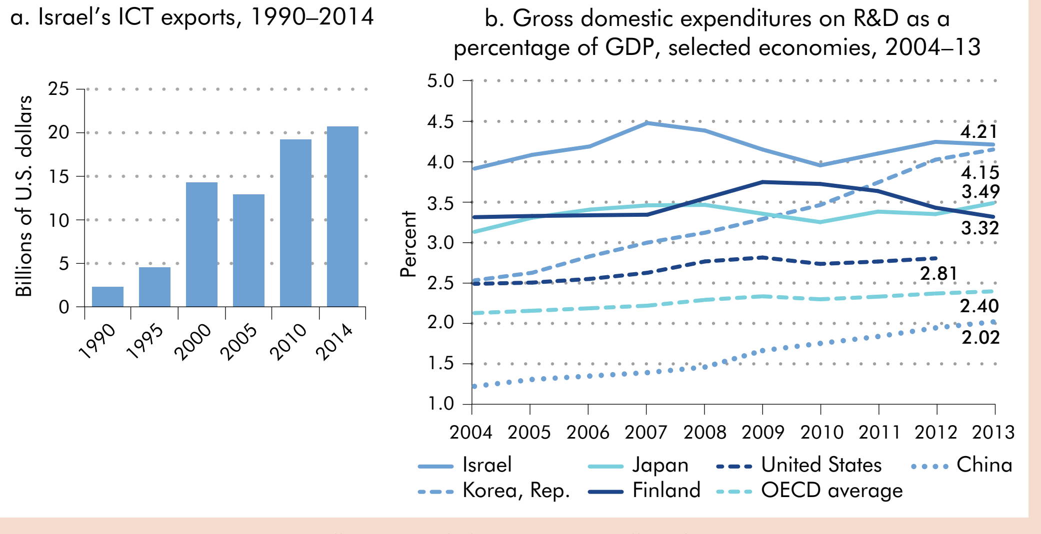
Box 4.10 Israel as a startup nation

The term "startup nation" was used to describe Israel in a 2011 best-selling book.[a] It takes as its starting point the 6,000 startups created between 2000 and 2010, more than twice the rate of the previous decade. In 2013, the information and communication technology (ICT) sector in Israel made up 16 percent of GDP and 26 percent of exports and employed 8.5 percent of its workforce.[b] It was also the fifth largest exporter of computer software and services in 2012, according to the World Trade Organization,[c] as ICT exports have increased almost tenfold since 1990 to over US$20 billion (figure B4.10.1, panel a).[d] A key ingredient in the success of the startup nation has been the role of the Israeli government, which designed its interventions so as not to hamper the emergence of the private sector.

Many Organisation for Economic Co-operation and Development (OECD) governments play an active role in funding innovation but Israel's program, from the very start in the late 1960s, has been particularly geared toward "sector-neutrality"—meaning that the government did not try to "pick winners." The program's design avoided crowding out private investment and stimulated additionality.[e] Recent programs have included the Tnufa program (since 2000), supporting entrepreneurs in the very first stages of development; Magneton (since 2001), supporting industrial/academic cooperation; the Public Technology Incubator Program set up in the early 1990s to help assimilate a wave of immigrants from the former Soviet Union; and the Yozma Fund, a venture capital fund set up in 1993 for technology companies. As a result, Israel consistently scores the highest level of gross domestic expenditures on research and development among OECD economies, although the Republic of Korea is catching up (figure B4.10.1, panel b).

But government support for firms in the ICT sector is not the whole story. Israel's government has promoted a high level of investment in education, and the sector has benefited from the innovativeness of the firm's themselves, which have been particularly successful in fields such as cybersecurity, mobile phone apps, and voice over internet protocol. Recent tech startups include Taboola (a content distribution and discovery platform), Silverbyte Systems (providing hotel management software), and Ceragon Networks (a wireless backhaul provider), while longer-established ones include Waze, which provides a location-based navigation app, and Wix, offering a cloud-based web development platform.

Figure B4.10.1 How Israel stays ahead in high-tech entrepreneurship



Source: OECD STI Indicators, available from http://www.oecd.org/sti/msti.htm. Data at http://bit.do/WDR2016-FigB4_10_1.

Note: In panel b, the percentages shown on the figure are for 2013, except for the U.S. percentage, which is for 2012. GDP = gross domestic product; ICT = information and communication technology; OECD = Organisation for Economic Co-operation and Development; R&D = research and development.

a. Senior and Singer 2011.
b. Getz and Goldberg 2015.
c. See https://www.wto.org/english/res_e/statis_e/its2014_e/its14_trade_category_e.htm.
d. Israel, Central Bureau of Statistics 2014.
e. Lach, Parizat, and Wasserteil 2008.

Notes

1. "High-speed internet" in this chapter is equated with fixed-line broadband service (such as digital subscriber line, cable modem, and fiber optics) and fourth-generation (4G) mobile services. Internet usage is much higher, at around 40 percent, but this is generally at slower speeds and is not necessarily affordable or "always on."
2. See chapter 1 and Kim, Kelly, and Raja (2010).
3. Markovitch 2013.
4. Qiang 2010.
5. UN Broadband Commission 2013.
6. Levinson 2007.
7. Internet protocol (IP)–based networks used packet-switching, a technology developed in the 1960s, that packages information into uniform chunks of digital data, or "packets," that can be used to transmit voice, text, video, or data. IP-based networks thus combine into a single network those functions that were previously handled by separate and distinct networks (Mathison, Roberts, and Walker 2012).
8. Wu 2010.
9. See Heeks (2014), notably figure 8 on the changing focus of ICT4D priorities over time.
10. IDATE 2014.
11. Cleland 2014.
12. Wheeler 2015.
13. The United States followed a different model of private ownership, but even there the monopoly of AT&T initially prevailed, as this was considered essential to achieving "universal service," a telephone in each home. An antitrust suit launched in 1974 eventually broke up AT&T into seven separate regional operators and a national long-distance and international carrier a decade later, opening the door for competition (Crandall 1991).
14. Harper 1997.
15. Cho 2002.
16. OECD 1999.
17. Ungerer 2000.
18. See http://ec.europa.eu/priorities/digital-single-market/.
19. The 69 World Trade Organization member countries that made commitments in telecommunications in 1997 have now risen to 108; see https://www.wto.org/english/tratop_e/serv_e/telecom_e/telecom_e.htm.
20. ITU 1997.
21. Wellenius and Stern 1995.
22. The cover photo illustrates a failing in all three ingredients for a successful digital policy: Djibouti Telecom is fully state-owned and enjoys monopoly status, contributing in part to its high prices for mobile service. But neighboring Somalia currently lacks a national communications act and sector regulator, which means that local operators function without internationally recognized licenses. Thus Somali migrants cannot roam in neighboring countries without changing their SIM cards.
23. Ampah and others 2009.
24. See https://gsmaintelligence.com/, although other sources such as Gallup World Poll show lower coverage.
25. ITU 2001.
26. See "WhatsApp Shows How Phone Carriers Lost Out on US$33 Billion," *Business Standard*, February 28, 2014, at http://www.business-standard.com/article/international/whatsapp-shows-how-phone-carriers-lost-out-on-33-bn-114022200022_1.html.
27. In the first half of 2014, Netflix accounted for 35 percent and YouTube 13 percent of internet data traffic to users in the United States, during peak periods on fixed networks, according to Sandvine (2014).
28. Cisco 2015.
29. Cisco 2015.
30. Regional average data from GSMA at www.gsmaintelligence.com.
31. Minges 2015.
32. Evans, Groves, and Croft 2014.
33. Stock market valuations change constantly, but on May 18, 2015, China Mobile had a market valuation of US$276.45 billion on revenue of US$103.21 billion, while Alibaba had a market valuation of US$217.26 billion on revenue of just US$12.26 billion, according to Yahoo Finance.
34. Investment in constant U.S. dollars fell to US$248 billion in 2013, down from US$357 billion in 2008, before the financial crisis, according to data on private sector investment in telecoms, sourced by the Public-Private Infrastructure Advisory Facility (PPIAF) and available at http://data.worldbank.org/indicator/IE.PPI.TELE.CDcountries/1W?display=default.
35. Office of Legislative and Public Affairs 2003.
36. The announcement of the transition was on March 14, 2014, by the National Telecommunications and Information Administration of the U.S. Department of Commerce, but the completion date was later delayed by one year to September 2016. For more information, see https://www.icann.org/resources/pages/process-next-steps-2014-10-10-en and http://www.ntia.doc.gov/blog/2015/update-iana-transition.
37. For more information on different national research and education network models, see the South-South Exchange of Research and Education Experience, at https://openknowledge.worldbank.org/handle/10986/12367.
38. See the regulatory information section of ITU's ICT Eye database, at http://www.itu.int/icteye.
39. As an example, the Communications Authority of Kenya, for the financial year ending June 30, 2012, records a surplus of around K Sh 7.0 billion (around

US$74 million) on income of K Sh 8.8 billion (US$98 million), a surplus of around 80 percent. This is over and above other taxes and other financial contributions from the sector. See the *Communications Authority of Kenya Annual Report, 2012–13*, http://www.ca.go.ke/images//downloads/PUBLICATIONS/ANNUALREPORTS/Annual%20Report%20for%20the%20Financial%20Year%202012-2013.pdf.
40. Blackman and Srivastava 2011.
41. Rijkers, Freund, and Nucifora 2014.
42. *Economist* 2012.
43. See GSMA at https://gsmaintelligence.com/.
44. ITU estimates that some 95 percent of the world's population lived within range of a mobile signal in 2015 (ITU 2015).
45. This aggregate statistic (68 percent) is derived from GSMA (http://www.gsmaintelligence.com), which estimates that, as of Q4 2014, some 98 percent of the citizens of developed economies and 62 percent of developing ones lived within range of a 3G signal. The equivalent figures for 4G/LTE were 88 percent and 15 percent, giving an aggregate of 26 percent.
46. Mayer and others 2008.
47. As an example, the Comoros opened its mobile market to competition in 2007, but the incumbent operator, Comoros Telecoms, was successfully able to resist interconnection due to weak regulation, and the market entrant, Twama Telecom, never started service (World Bank 2014). The Comoros announced a license award for a new second operator, won by Telma, in October 2015.
48. Third-generation (3G) and fourth-generation (LTE) operate in multiple spectrum bands, but mainly at 1,800, 2,300, and 2,600 MHz. In countries where the transition to digital broadcasting is complete, the more valuable spectrum of 700 MHz can be released for mobile communications. This is more attractive to investors as fewer cells are needed to cover the same territory (Dahlman and others 2007).
49. See Partnership for Measuring ICT for Development 2014.
50. Ros and Banerjee 2000.
51. Wellenius 2002.
52. GSMA (Global System for Mobile communications Association) 2013.
53. Minges and others 2014.
54. UN Broadband Commission 2015, 64–69.
55. See http://www.fcc.gov/encyclopedia/connecting-america.
56. See http://ec.europa.eu/digital-agenda/ and https://ec.europa.eu/digital-agenda/en/connecting-europe-facility#the-connecting-europe-facility-to-support-eu-infra.
57. This calculation is based on projects that have received a waiver from the European Commission for the use of state aid in the deployment of broadband networks (see http://ec.europa.eu/competition/sectors/telecommunications/broadband_decisions.pdf).
58. Marino García 2015a.
59. Coleago Consulting 2013.
60. Plum Consulting 2013.
61. Moore 1965.
62. See http://www.mkomo.com/cost-per-gigabyte-update.
63. Biggs and Kelly 2006.
64. *Economist* 2015.
65. This is sometimes referred to as Amara's Law.
66. See http://articles.latimes.com/2006/jul/16/business/fi-overheat16.
67. Samarajiva 2010.
68. Genakos and Valletti 2014.
69. Littlechild 2006.
70. Kemei and Kelly 2015.
71. ITU 2014.
72. http://www.oecd.org/sti/broadband/price-baskets.htm and http://www.oecd-ilibrary.org/docserver/download/5k92wd5kw0nw.pdf?expires=1419284221&id=id&accname=guest&checksum=70B5A3123B6297371A59AC6F4C97AC55.
73. ITU 2014.
74. ITU 2014.
75. Boston Consulting Group 2012.
76. World Bank, forthcoming.
77. See https://www.washingtonpost.com/news/the-switch/wp/2015/09/22/dig-once-the-no-brainer-internet-policy-the-white-house-just-endorsed/.
78. Packet Clearing House 2015.
79. Kende and Hurpy 2012.
80. Kende and Rose 2015.
81. Regulation (EC) No. 2887/2000 of the European Parliament and of the Council of December 18, 2000, on unbundled access to the local loop, at http://europa.eu/legislation_summaries/information_society/internet/l24108j_en.htm.
82. Klein and Wendel 2014.
83. See https://apps.fcc.gov/edocs_public/attachmatch/DOC-327104A1.pdf.
84. See http://www.washingtonpost.com/blogs/the-switch/wp/2014/12/23/fcc-confirms-that-680000-net-neutrality-comments-weremissing-from-the-public-record/.
85. See http://www.nytimes.com/2015/02/27/technology/net-neutrality-fcc-vote-internet-utility.html?_r=0.
86. UNESCO. See, specifically, Article 19 of the International Covenant on Civil and Political Rights (ICCPR); Article 13 of the African Charter of Human Rights (ACHR); Article 9 of the African Charter; and Article 10 of the European Court of Human Rights.
87. See Open Network Initiative at http://map.opennet.net/filtering-pol.html.

88. Dutton and others 2013.
89. Clover 2015.
90. Waldfogel 2011.
91. Internet Society 2014.
92. See http://www.ndtv.com/india-news/supreme-court-reserves-orders-on-validity-of-section-66a-of-it-act-742758.
93. See http://www.google.com/transparencyreport/.
94. See http://www.google.com/transparencyreport/traffic/.
95. See http://blogs.wsj.com/chinarealtime/2015/02/12/china-internet-restrictions-hurting-business-western-companies-say/.
96. This chapter similarly adopts an expansive view of "cybersecurity" and delves more deeply into some aspects of cybersecurity—such as privacy and cybercrime—separately.
97. See Bauer and Dutton (2015), citing other sources.
98. Bauer and Dutton 2015.
99. Article 17 ICCPR; Article 11 ACHR; Article 8 ECHR; and UNGA resolution 68/167 (2013) on the right to privacy in the digital age.
100. YCharts, Facebook Market Cap (June 10, 2015); see http://ycharts.com/companies/FB/market_cap.
101. WEF 2014.
102. Dutton and others 2013.
103. FTC 2013.
104. See http://www.washingtonpost.com/blogs/the-switch/wp/2014/11/13/facebook-rewrites-its-privacy-policy-so-that-humans-can-understand-it/.
105. Polonetsky, Tene, and Jerome 2014.
106. World Bank and Second Muse 2014.
107. See http://georgemdallas.wordpress.com/2014/06/05/making-sense-of-internet-platforms-network-effects-and-two-sided-markets/.
108. Haddad and others 2014.
109. Berlingerio and others 2013.
110. See http://www.economist.com/news/leaders/21627623-mobile-phone-records-are-invaluable-tool-combat-ebola-they-should-be-made-available.
111. See Article 29 Data Protection Working Party 2014.
112. See https://www.ftc.gov/system/files/documents/reports/federal-trade-commission-staff-report-november-2013-workshop-entitled-internet-things-privacy/150127iotrpt.pdf.
113. Recent jurisprudence from both the European Court of Justice (ECJ) and the European Court of Human Rights (ECHR) support striking this balance. In *Digital Rights Ireland Ltd v. Ireland* (Joined Cases C-293/12 and C-594/12 *Seitlinger and Others*, April 8, 2014), the ECJ ruled the Data Retention Directive to be in violation of the EU Charter of Fundamental Rights. In *S and Marper v. UK* 30562/04 [2008] ECHR 1581 (December 4, 2008), the ECHR, using a proportionality analysis, found the United Kingdom to be in breach of Article 8, holding that the long-term retention of both fingerprints and DNA samples interfered with an individual's right to privacy.
114. See http://www.bbc.com/news/technology-29276955.
115. Doupi and others 2010.
116. *Google Spain and Google vs. Agencia Española de Protección de Datos (AEPD) and Mario Costeja González* [Case No. 131/12, 2014] European Court of Justice.
117. Ausloos 2012.
118. See Schwartz and Solove (2014). The EU generally prefers legal instruments that position privacy as a human right, whereas the United States relies more on self-regulation, seeing privacy as a consumer protection issue.
119. UNCTAD 2015
120. UN General Assembly 2013.
121. See the African Union Convention on Cybersecurity and Personal Data Protection (July 27, 2014).
122. OECD 2013. The *OECD Privacy Guidelines* incorporate a "Recommendation Concerning Guidelines Governing the Protection of Privacy and Transborder Flows of Personal Data."
123. See http://www.apec.org/Groups/Committee-on-Trade-and-Investment/Electronic-Commerce-Steering-Group/Cross-border-Privacy-Enforcement-Arrangement.aspx.
124. European Commission (EC 2010).
125. White House 2012.
126. *Maximilian Schrems vs. Data Protection Commissioner* [Case No. C-362/14, 6 October 2015] European Court of Justice.
127. The recent decision by the European Court of Justice about the "right to be forgotten" *(Google Spain and Google vs. Agencia Española de Protección de Datos [AEPD] and Mario Costeja González* [Case No. 131/12, 2014]), which requires search engines to remove links to data upon request if they are inadequate or irrelevant, throws into question not only the balance of data protection and freedom of expression rights, but also extraterritorial application of law and perhaps irreconcilable compliance obligations of multinational companies processing data across borders.
128. See https://www.huntonprivacyblog.com/2015/01/articles/deadline-for-compliance-with-russian-localization-law-set-for-september-1-2015/.
129. See http://www.theguardian.com/us-news/2015/may/07/nsa-phone-records-program-illegal-court.
130. Castro 2013.
131. Dutton 2015.
132. The origins of the debate around net neutrality are the U.S. Communications Act of 1996, as amended. Under the act, "telecommunications services" are regulated under common carrier rules, and other communications services, such as data, are regulated differently. In the United States, the internet

has been classified as a data service and therefore not subject to the same regulatory rules as telecommunications services. In most other jurisdictions, the distinctions found in the act do not apply, although the term *net neutrality* (though derived out of specific statutory language) has come to be applied globally.

133. See http://trak.in/tags/business/2015/04/17/trai-airtel-zero-internet-org-against-net-neutrality-violate-free-internet/.
134. West 2015.
135. See http://www.bbc.com/news/technology-32334181.
136. Council of Europe 2010.
137. See http://www.ohchr.org/en/professionalinterest/pages/ccpr.aspx.
138. See http://www.forbes.com/billionaires/list/#version:static.
139. Citation from entrepreneur Mark Simon, quoted in Madslien 2010.
140. Kushida 2015; Minges 2015.
141. Bresnahan, Gambardella, and Saxenian 2001.
142. Katz and Wagner 2014.
143. See http://fortune.com/2012/05/09/the-random-collision-theory-of-innovation/.
144. FabLabs are similar to Tech Hubs, but focus more on making physical prototypes than software, content and applications development; see, for instance, Tokushima and Tanaka (2015).
145. The United Nations Broadband Commission (UN Broadband Commission 2013) reports that the 134 countries that had a national broadband plan as of mid-2013 had, on average, some 2.5 percent higher fixed broadband penetration and 7.4 percent higher mobile broadband penetration.
146. See http://www.broadbandcommission.org/about/Pages/default.aspx.

References

Ampah, Mavis, Daniel Camos, Cecilia Briceño-Garmendia, Michael Minges, Maria Shkaratan, and Mark Williams. 2009. "Information and Communications Technology in Sub-Saharan Africa: A Sector Review." Africa Infrastructure Country Diagnostic Study, Background Paper 10, African Development Bank Group, Abidjan, Côte d'Ivoire.

Article 29 Data Protection Working Party. 2014. "Opinion 8/2014 on Recent Developments on the Internet of Things." http://ec.europa.eu/justice/data-protection/article-29/documentation/opinion-recommendation/files/2014/wp223_en.pdf.

Ausloos, Jef. 2012. "The Right to Be Forgotten—Worth Remembering?" *Computer Law and Security Review* 28 (1): 143–52.

Bauer, Johannes, and Bill Dutton. 2015. "Addressing the Cybersecurity Paradox: Economic and Cultural Challenges to an Open and Global Internet." Background paper for the *World Development Report 2016*, World Bank, Washington, DC.

Bauer, Johannes, Michel van Eeten, Tithi Chattopadhyay, and Yuehua Wu. 2008. "ITU Study on the Financial Aspects of Network Security: Malware and Spam." http://www.itu.int/ITU-D/cyb/cybersecurity/docs/itu-study-financial-aspects-of-malware-and-spam.pdf.

Berlingerio, M., F. Calabrese, G. Di Lorenzo, R. Nair, F. Pinelli, and M. L. Sbodio, eds. 2013. "All Aboard: Smarter Urban Dynamics." Dublin, Ireland: IBM Research.

Biggs, Phillippa, and Tim Kelly. 2006. "Broadband Pricing Strategies." *Info* 8 (6): 3–14.

Blackman, Colin, and Lara Srivastava. 2011. *Telecommunication Regulation Handbook: Tenth Anniversary Edition*. Washington, DC: World Bank.

Boston Consulting Group. 2012. "Egypt at a Crossroads: How the Internet Is Transforming Egypt's Economy." http://www.bcg.com/documents/file124361.pdf.

Bresnahan, Timothy, Alfonso Gambardella, and Annalee Saxenian. 2001. "'Old Economy' Inputs for 'New Economy' Outcomes: Cluster Formation in the New Silicon Valleys." *Industrial and Corporate Change* 10 (4): 835–60.

Castro, Daniel. 2013. "The False Promise of Data Nationalism." http://www2.itif.org/2013-false-promise-data-nationalism.pdf.

Cho, Sung-Hye. 2002. "Telecommunications and Informatization in South Korea." *Networks and Communication Studies* 16 (1/2): 29–42.

Cisco. 2015. "Cisco Visual Network Index: Global Mobile Data Traffic Forecast Update, 2014–2019." http://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/white_paper_c11-520862.pdf.

Cleland, Scott. 2014. "The Top Ten Reasons to Oppose Broadband Utility Regulation." http://dailycaller.com/2014/05/28/the-top-ten-reasons-against-broadband-utility-regulation/.

Clover, Charles. 2015. "Chinese Internet: Commerce and Control." *Financial Times*, March 13.

Coleago Consulting. 2013. "Revised Spectrum Forecasts Using the New Spectrum Model: Spectrum Required for Various Mobile Communications Markets in 2013." Report for Groupe Speciale Mobile Association. http://www.gsma.com/spectrum/wp-content/uploads/2014/01/Coleago-Report-on-Spectrum-Demand-Model-Results.pdf.

Council of Europe. 2010. "Declaration of the Committee of Ministers on Network Neutrality." Adopted by the Committee of Ministers on 29 September 2010. https://wcd.coe.int/ViewDoc.jsp?id=1678287.

Crandall, Robert. 1991. *After the Breakup: U.S. Telecommunications in a More Competitive Era*. Washington, DC: Brookings Institution.

CSIS (Center for Strategic and International Studies) and McAfee. 2014. "Net Losses: Estimating the Global Cost of Cybercrime." http://www.mcafee.com/us/resources/reports/rp-economic-impact-cybercrime2.pdf.

Dahlman, Erik, Stefan Parkvall, Johan Sköld, and Per Beming. 2007. *3G Evolution: HSPA and LTE for Mobile Broadband*. Oxford, U.K.: Elsevier Academic Press.

Doupi, P., E. Renko, S. Giest, J. Heywood, and J. Dumortier. 2010. "eHealth Strategies: Country Brief, Estonia." European Commission. http://ehealth-strategies.eu/database/documents/Estonia_CountryBrief_eHStrategies.pdf.

Dutton, William. 2015. "Multi-Stakeholder Internet Governance." Background paper for the *World Development Report 2016*, World Bank, Washington, DC.

Dutton, William, Ginette Law, Gillian Bolsover, and Soumitra Dutta. 2013. "The Internet Trust Bubble: Global Values, Beliefs and Practices." World Economic Forum, Geneva.

EC (European Commission). 2010. "A Comprehensive Approach on Personal Data Protection in the European Union." Communication from the Commission to the European Parliament. http://ec.europa.eu/justice/news/consulting_public/0006/com_2010_609_en.pdf.

Economist. 2012. "Indian Telecoms Scandal: Megahurts." February 11.

———. 2015. "The Truly Personal Computer: The Smartphone Is the Defining Technology of the Age." February 28.

Evans, David, Jon Groves, and Will Croft. 2014. "Operator Group Ranking, 2Q 2014." *GSMA Intelligence*. https://gsmaintelligence.com/analysis/2014/09/operator-group-ranking-q2-2014/444/.

Firestone, Rachel, and Tim Kelly. 2015. "Africa's Thriving Tech Hubs." Background paper for the *World Development Report 2016*, World Bank, Washington, DC.

FTC (U.S. Federal Trade Commission). 2013. "Mobile Privacy Disclosures: Building Trust through Transparency." http://www.ftc.gov/sites/default/files/documents/reports/mobile-privacy-disclosures-building-trust-through-transparency-federal-trade-commission-staff-report/130201mobileprivacyreport.pdf.

Genakos, Christos, and Tommasso Valletti. 2014. "Evaluating a Decade of Mobile Termination Rate Regulation." Discussion Paper 1282, Centre for Economic Performance, London.

Getz, Daphne, and Itzhak Goldberg. 2015. "Best Practices and Lessons Learned in ICT Sector Innovation: A Case Study of Israel." Background paper for the *World Development Report 2016*, World Bank, Washington, DC.

GSMA (Groupe Speciale Mobile Association). 2013. "Survey of Universal Service Funds: Key Findings." http://www.gsma.com/publicpolicy/wp-content/uploads/2013/04/GSMA-USF-Key-findings-final.pdf.

Haddad, Ryan, Tim Kelly, Teemu Leinonen, and Vesa Saarinen. 2014. *Using Locational Data from Mobile Phones to Enhance the Science of Delivery*. Washington, DC: World Bank.

Harper, John. 1997. *Monopoly and Competition in British Telecommunications: The Past, the Present and the Future*. London: Pinter.

Heeks, Richard. 2014. "ICT4D 2016: New Priorities for ICT4D Policy, Practice and WSIS in a Post-2015 World." Centre for Development Informatics Working Paper 59, University of Manchester, Manchester, U.K.

Ibarguen, Giancarlo. 2003. "Liberating the Radio Spectrum in Guatemala." *Telecommunications Policy* 27 (7): 543–54.

IDATE. 2014. *DigiWorld Yearbook 2014: The Challenges of the Digital World*. Montpellier: IDATE.

IDRC (International Development Research Centre). 2010. *Radio-Spectrum Allocation and Management in Central American Countries and Their Impact in the Development of the Mobile Telecommunications Services Sector*. https://idl-bnc.idrc.ca/dspace/bitstream/10625/49429/1/IDL-49429.pdf.

Internet Society. 2014. *Global Internet Report 2014: Open and Sustainable Access for All*. https://www.internetsociety.org/sites/default/files/Global_Internet_Report_2014_0.pdf.

Israel, Central Bureau of Statistics. 2014. "Data on the Israeli Economy." http://www.cbs.gov.il/reader.

ITU (International Telecommunication Union). Various years. World Telecommunication/ICT Indicators database. http://www.itu.int/ti.

———. 1997. *World Telecommunication Development Report 1997: Trade in Telecommunications*. Geneva: ITU.

———. 2001. *ITU Internet Reports 2001: IP Telephony*. Geneva: ITU.

———. 2014. *Measuring the Information Society*. Geneva: ITU.

———. 2015. *Facts and Figures*. Geneva: ITU.

Katz, Bruce, and Julie Wagner. 2014. *The Rise of Innovation Districts: A New Geography of Innovation in America*." Washington, DC: Brookings Institution.

Kelly, Tim, and David Souter. 2014. *The Role of Information and Communication Technologies in Postconflict Reconstruction*. Washington, DC: World Bank.

Kemei, Christopher, and Tim Kelly. 2015. "One Network Area in East Africa." Background paper for the *World Development Report 2016*, World Bank, Washington, DC.

Kende, Michael, and Charles Hurpy. 2012. "Assessment of the Impact of Internet Exchange Points: Empirical Study of Kenya and Nigeria." http://www.internetsociety.org/sites/default/files/Assessment%20of%20the%20impact%20of%20Internet%20Exchange%20Points%20%E2%80%93%20empirical%20study%20of%20Kenya%20and%20Nigeria.pdf.

Kende, Michael, and Karen Rose. 2015. "Promoting Local Content Hosting to Develop the Internet Ecosystem." http://www.internetsociety.org/doc/promoting-local-content-hosting-develop-internet-ecosystem.

Kim, Yongsoo, Tim Kelly, and Siddhartha Raja. 2010. *Building Broadband: Strategies and Policies for the Developing World*. Washington, DC: World Bank.

Klein, Gordon, and Julia Wendel. 2014. "The Impact of Local Loop and Retail Unbundling Revisited." Discussion Paper 163, Dusseldorf Institute for Competition Economics, Dusseldorf, Germany.

Kushida, Kenji. 2015. "The Politics of Commoditization in Global ICT Industries: A Political Economic Explanation of the Rise of Apple, Google and Industry Disruptors." *Journal of Industry, Competition and Trade* 15 (1): 49–67.

Lach, Saul, Shlomi Parizat, and Daniel Wasserteil. 2008. "The Impact of Government Support to Industrial R&D on the Israeli Economy." Report prepared for the Israeli Ministry of Finance and the Office of the Chief Scientist, Ministry of Industry, Trade and Labor.

Levinson, Marc. 2007. *The Box: How the Shipping Container Made the World Smaller and the World Economy Bigger*. Princeton, NJ: Princeton University Press.

Littlechild, Stephen. 2006. "Mobile Termination Charges: Calling Party Pays versus Receiving Party Pays." *Telecommunications Policy* 30: 242–77.

Madslien, Jorn. 2010. "Dotcom Bubble Burst: Ten Years On." BBC website, March 9. http://news.bbc.co.uk/2/hi/business/8558257.stm.

Marino García, José. 2015a. "The Economics and Policy Implications of Infrastructure Sharing and Mutualisation and Its Role for the Development of ICT Networks in Africa." Companion paper for the *World Development Report 2016*, World Bank, Washington, DC.

———. 2015b. "Spectrum Management in Guatemala: The Big Bang Reform." Companion paper for the *World Development Report 2016*, World Bank, Washington, DC.

Markovitch, Steven. 2013. "U.S. Broadband Policy and Competitiveness." Background paper, U.S. Council on Foreign Relations, Washington, DC.

Mathison, Stuart, Larry Roberts, and Phil Walker. 2012. "The History of Telenet and the Commercialization of Packet-Switching in the United States." *IEEE Communications Magazine* 50 (5): 28–45.

Mayer, Rebecca, Ken Figueredo, Mike Jensen, Tim Kelly, Richard Green, and Alvaro Federico Barra. 2008. "Costing the Needs for Investment in ICT Infrastructure in Africa." Africa Infrastructure Country Diagnostic Study, Background Paper 3, African Development Bank Group, Abidjan, Côte d'Ivoire.

Meeker, Mary. 2015. "Internet Trends 2015: Code Conference." http://www.kpcb.com/internet-trends.

Minges, Michael. 2015. "Exploring the Relationship between Broadband and Economic Growth." Background paper for the *World Development Report 2016*, World Bank, Washington, DC.

Minges, Michael, Kaoru Kimura, Natasha Beschorner, Robert Davies, and Guanqin Zhang. 2014. *Information and Communications in the Chinese Countryside: A Study of Three Provinces*. A World Bank Study. Washington, DC: World Bank.

Moore, Gordon. 1965. "Cramming More Components onto Integrated Circuits." *Electronics* 38 (8): 114–17.

OECD (Organisation for Economic Co-operation and Development). 1999. *Regulatory Reform in Japan: Regulatory Reform in the Telecommunications Industry*. Paris: OECD.

———. 2013. *The OECD Privacy Framework*. Paris: OECD.

Office of Legislative and Public Affairs. 2003. *A Brief History of NSF and the Internet*. Washington, DC: National Science Foundation. http://www.nsf.gov/od/lpa/news/03/fsnsf_internet.htm.

Packet Clearing House. 2015. "Full Exchange Point Dataset." https://prefix.pch.net/applications/ixpdir/menu_download.php.

Partnership for Measuring ICT for Development. 2014. "Final WSIS Targets Review: Achievements, Challenges and the Way Forward." http://www.itu.int/en/ITU-D/Statistics/Pages/publications/wsistargets2014.aspx.

Plum Consulting. 2013. "Harmonised Spectrum for Mobile Services in ASEAN and South Asia." Report for Axiata Group Berhad. http://www.plumconsulting.co.uk/pdfs/Plum_Jan2014_harmonised_spectrum_for_mobile_asean_south_asia.pdf.

Polonetsky, Jules, Amer Tene, and Joseph Jerome. 2014. "Benefit-Risk Analysis for Big Data Projects." Future of Privacy Forum, Washington, DC.

Ponemon Institute. 2014. "Cost of Data Breach Study: Global Analysis." Study for IBM. http://public.dhe.ibm.com/common/ssi/ecm/se/en/sel03027usen/SEL27USEN.PDF.

PRIF (Pacific Region Infrastructure Facility). 2015. "Economic and Social Impact of ICT in the Pacific." http://www.theprif.org/index.php/resources/document-library/121-prif-ict-study-report-2015.

Qiang, Christine Zhen-Wei. 2010. "Broadband Infrastructure Investment in Stimulus Packages: Relevance for Developing Countries." *Info* 12 (2): 41–56.

Rijkers, Bod, Caroline Freund, and Antonio Nucifora. 2014. "All in the Family: State Capture in Tunisia." Policy Research Working Paper 6810, World Bank, Washington, DC.

Ros, Agustin J., and Aniruddha Banerjee. 2000. "Telecommunications Privatization and Tariff Rebalancing: Evidence from Latin America." *Telecommunications Policy* 24 (3): 233–52.

Samarajiva, Rohan. 2010. "Leveraging the Broadband Telecom Model to Bring Broadband to the People." *Information Technologies and International Development* 6: 93–97.

Sandvine. 2014. "Global Internet Phenomena Report." https://www.sandvine.com/downloads/general/global-internet-phenomena/2014/1h-2014-global-internet-phenomena-report.pdf.

Schwartz, Paul, and Daniel Solove. 2014. "Reconciling Personal Information in the United States and the European Union." *California Law Review* 102: 877–916.

Senior, Dan, and Saul Singer. 2011. *Start-Up Nation: The Story of Israel's Economic Miracle*. New York: Hachette Book Group.

Symantec. 2013. "The Norton Report 2013." https://msisac.cisecurity.org/resources/reports/documents/b-norton-report-2013.pdf.

Tokushima, Yutaka, and Hiroya Tanaka. 2015. *Economic Development Using an Enabling Environment for Contextualized Innovation: The Case of the Poverty Reduction Project by Building-Up the Innovation Environment Using FabLab*. Bohol, Philippines: Fablab Asia Foundation.

UN Broadband Commission. 2013. "Planning for Progress: Why National Broadband Plans Matter." http://www.broadbandcommission.org/documents/report NBP2013.pdf.

———. 2014. "The State of Broadband 2014: Broadband for All." http://www.broadbandcommission.org/Documents/reports/bb-annualreport2015.pdf.

———. 2015. "The State of Broadband 2015: Broadband as a Foundation for Sustainable Development." http://www.broadbandcommission.org/documents/reports/bb-annualreport2015.pdf.

UN General Assembly. 2013. "The Right to Privacy in the Digital Age. Resolution 68/167, Adopted on 18 December 2013." http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/68/167.

UN Population Division. 2014. Population and Development Database, http://www.un.org/en/development/desa/population/publications/development/population-development-database-2014.shtml.

UNCTAD (United Nations Conference on Trade and Development). 2015. *Information Economy Report: Unlocking the Potential of E-Commerce for Developing Countries*. Geneva: UNCTAD.

Ungerer, Herbert. 2000. "Access Issues under EU Regulation and Antitrust Law: The Case of Telecommunications and Internet Markets." Research paper, Weatherhead Center for International Affairs, Harvard University, Cambridge, MA.

Waldfogel, Joel. 2011. "Bye, Bye Miss American Pie? The Supply of New Recorded Music since Napster." NBER Working Paper 116882, National Bureau of Economic Research, Cambridge, MA.

WEF (World Economic Forum). 2014. "Delivering Digital Infrastructure: Advancing the Internet Economy" 7 (April). http://www3.weforum.org/docs/WEF_TC_DeliveringDigitalInfrastructure_InternetEconomy_Report_2014.pdf.

Wellenius, Bjorn. 2002. "Closing the Gap in Access to Telecommunications: Chile, 1995–2002." Discussion Paper 430, World Bank, Washington, DC.

Wellenius, Bjorn, and Peter Stern. 1995. *Implementing Reforms in the Telecommunications Sector: Lessons from Experience*. Washington, DC: World Bank.

West, Darrell M., ed. 2015. *Digital Divide: Improving Internet Access in the Developing World through Affordable Services and Diverse Content*. Washington, DC: Brookings Institution.

Wheeler, Tom. 2015. "This Is How We Will Ensure Net Neutrality." *Wired* online edition, February 4. http://www.wired.com/2015/02/fcc-chairman-wheeler-net-neutrality/.

White House. 2012. "Consumer Data Privacy in a Networked World: A Framework for Protecting Privacy and Promoting Innovation in the Global Digital Economy." http://www.whitehouse.gov/sites/default/files/privacy-final.pdf.

World Bank. 2014. "Comoros Policy Notes: Accelerating Economic Development in the Union of Comoros." http://wbdocs.worldbank.org/wbdocs/viewer/docViewer/index1.jsp?objectId=090224b08249c087&standalone=true&respositoryId=WBDocs.

———. 2015. *World Development Indicators 2015*. http://data.worldbank.org/products/wdi.

———. Forthcoming. "Infrastructure Sharing Toolkit." In *Broadband Strategies Toolkit*. http://broadbandtool kit.org/.

World Bank and Korean Development Institute. 2015. *The Korean Digital Governance and Performance Experience: Lessons and Experience*. Washington, DC: World Bank.

World Bank and Second Muse. 2014. "Big Data in Action for Development." http://live.worldbank.org/sites/default/files/Big%20Data%20for%20Development%20Report_final%20version.pdf.

Wu, Tim. 2010. *The Master Switch*. New York: Alfred A. Knopf.

SECTOR FOCUS 4

Smart cities

Cities are where problems and solutions meet. They are our centers of commerce and innovation—and the gateways to the global economy. With the world rapidly urbanizing, cities will only grow in importance; the urban population of the developing world is expected to double between 2000 and 2030, adding 2 billion city dwellers. This creates urgency to get our cities "right" because the global response to our most pressing challenges—from climate change to rising inequality—will likely succeed or fail in cities.

Innovative urban leaders have begun to tap into new streams of data on the state and performance of their cities, often in real time, to realize a forward-looking vision of a "smart city"—a city that leverages the latest in technology and connectivity to make better decisions and achieve the urban aspirations of its residents.[1] Specifically, smart cities collect lots of data through *instrumentation*, bring these data together through *integration*, and then analyze the integrated data for *intelligence* on how to improve the city's services and quality of life (figure F4.1). Smart cities use this three-step approach to tackle everything from reducing traffic congestion to fighting crime to improving air quality.

Despite widespread enthusiasm, however, discussions held under the World Bank's Urbanization Knowledge Partnership indicate that most city leaders struggle to understand how to best invest in intelligent infrastructure and connectivity to deliver long-term value. In addition, the concept of a smart city has grown somewhat controversial. Proponents argue that smart city innovations offer a genuine revolution in city management. Skeptics see empty hype that risks wastefully distorting the investments of resource-constrained governments as they prioritize "fancy" technology over less exciting but more important foundational investments.

While evidence of sustained impact remains elusive, governments allocate significant sums on smart city projects, including in the developing world. China has launched a reported US$70 billion "smart city" credit line and a US$8 billion investment fund.[2] India is seeking to leverage its homegrown information technology (IT) industry to construct 100 smart cities, with a first-year budget of US$1.2 billion.[3] Rio de Janeiro implemented a first-of-a-kind Intelligent Operations Center, bringing together data from over 30 agencies and services in a command center like that of the U.S. National Aeronautics and Space Administration (NASA). Even resource-constrained cities in Africa are embarking on the smart city journey, such as in Konza Techno City near Nairobi.

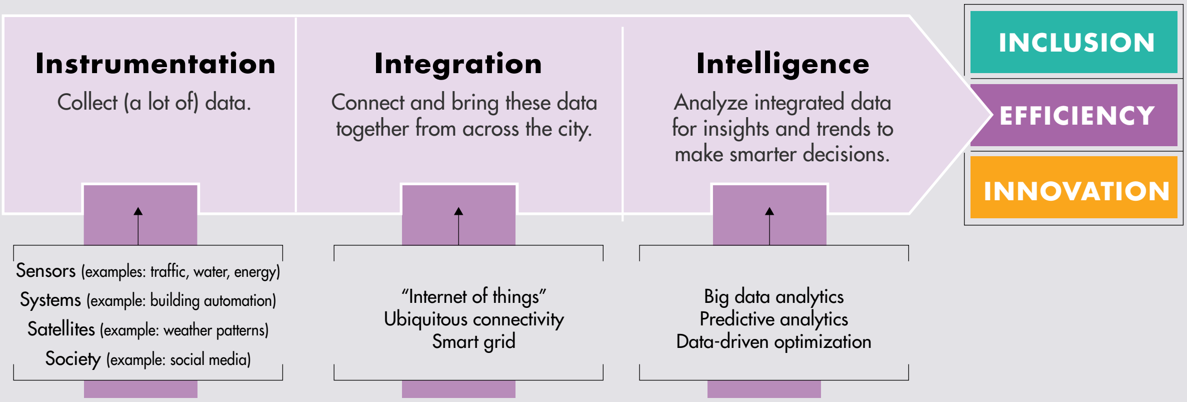
Pragmatically, old and new cities alike have begun to incorporate smart technologies into the everyday fabric and complexities of their existing urban centers to drive greater efficiencies in city operations; provide a platform for innovation at a citywide scale; and promote social inclusion through heightened accountability, citizen empowerment, and smarter decision making.

Efficiency—to do "more with less"

By collecting large amounts of data and then translating these data into insights, cities are able to boost the efficiency and responsiveness of their operations. Data help cities better match the supply of public services with real-time needs and uncover emerging problems before they turn into crises. Smart city technologies make this possible in several ways. *Automated*

This sector focus was contributed by Dennis Linders.

Figure F4.1 Smart cities: From data to intelligence



Source: Adapted from Palmisano 2008.

optimization translates data from cameras, sensors, and anonymized cellphone records into intelligence to, for example, help optimize traffic flows in real time. *Predictive analytics* uses such data to track and predict everything from rainfall to crime hot spots to possible landslide areas. *Evidence-based decision making and planning* can continuously monitor milestones and targets to ensure cities can quickly take corrective actions as needed to achieve their goals.

Innovation—through collaboration at city scale

Most smart city innovations have their origins in the private sector. Engineers argue that a city is essentially a complex system of systems, and each of these systems generates data that can be analyzed to make cities smarter. But for individual "smart systems" to add up to a "smart city," innovations must be on a citywide scale. That requires contributions and ideas not just from commercial firms but also from governments and citizens through public-private-people partnerships.

Open data, social media, and cellphones enable governments, firms, and citizens to exchange vast amounts of information at virtually no cost—making it far easier to share knowledge and ideas that are distributed throughout society. These tools also enable real-time collaboration, enabling governments to view their citizens and firms not just as passive customers of public services, but as key partners in innovative problem solving. Amsterdam and Singapore have begun to use this collaborative approach to bring together citizens, businesses, and government to experiment with innovations to lower their city's environmental footprint, one neighborhood at a time.

Governments can facilitate collaboration through three platforms. Through *local open data*, cities share local data with the public, promoting transparency, accountability, and collaborative problem solving. Through *"living labs,"* governments designate parts of the city as test beds to collaboratively pilot new ideas. Through *urban analytics centers*, cities partner with local universities and industry to seed cross-disciplinary research centers with systematic access to local urban data.

Inclusion—to ensure everyone benefits

City leaders should focus smart city efforts on the needs of *all* residents. Three valuable urban practices in the developing world are worth noting. First, *use data to target the most vulnerable*, as São Paulo did by developing a comprehensive geographic database of socioeconomic and physical indicators to prioritize housing and slum upgrading investments. Second, *open up data to promote accountability*, including grassroots initiatives such as the mapping of facilities, pollution, and community needs in Kibera, Nairobi's largest informal settlement. Third, *tap mobile connectivity to expand civic participation*, as cities in the Philippines have done for participatory budgeting and for crowdsourcing the identification of smoke-belching vehicles.

The road ahead—the city as a laboratory

The explosion of urban data will slowly give rise to a "science of cities." City leaders can speed up this process by turning their cities into laboratories for smart innovations that translate local experiments into global knowledge, and global knowledge into local solutions.

This exchange of ideas will no longer flow only from the West to the rest, since rapid urbanization enables cities in the developing world to leapfrog their global peers by incorporating smart from the start in ways that are cheaper and easier than retrofitting legacy infrastructure. Cities in the "global south," from Rio to Shanghai, often push the boundaries of innovation as aggressively as their peers in the "global north." In fact, smart cities may be the first instance of a large-scale urban transformation that is truly global in origin, with innovations and ideas flowing in all directions simultaneously—and with pockets of innovation appearing in unexpected places.

Accelerating this progress will require actions at all levels. Global institutions like the World Bank can facilitate the sharing of experiences. Cities can work together to establish open standards to avoid vendor "lock-in" and to make it easier to share solutions—a community-developed app in, say, Chicago, can then be rapidly deployed in Chengdu and Caracas. Local governments can address the often fragmented structure of their bureaucracies and outdated procurement systems that are incompatible with the design and implementation of integrated IT systems. And city halls everywhere should bring together governments, firms, and the public to jointly design a vision for the future of their city with long-term goals and short-term priorities to guide the development of smart city projects that deliver value for all the city's residents.

Notes

1. Townsend 2013.
2. *People's Daily*, "China Prepares for Smart City Construction Boom," October 16, 2013, http://en.people.cn/90882/8426660.html.
3. *Times of India*, "Government to Set Up 100 Smart Cities," July 23, 2014, http://timesofindia.indiatimes.com/india/Government-to-set-up-100-smart-cities/articleshow/38919516.cms.

References

Palmisano, Samuel J. 2008. "A Smarter Planet: The Next Leadership Agenda." Speech delivered at the Council on Foreign Relations, New York, November 6. http://www.cfr.org/technology-and-foreign-policy/smarter-planet-next-leadership-agenda/p17696.

Townsend, Anthony M. 2013. *Smart Cities: Big Data, Civic Hackers, and the Quest for a New Utopia*. New York: W. W. Norton.

SPOTLIGHT 5

ENABLING DIGITAL DEVELOPMENT

The data revolution

A report commissioned by the United Nations, *A World That Counts*, proclaims, "Data are the lifeblood of decision-making and the raw material for accountability. Without high-quality data providing the right information on the right things at the right time, designing, monitoring and evaluating effective policies becomes almost impossible."[1]

Recognizing the potential for harnessing the ongoing explosion of data, but mindful of gaps between the developing and developed world, the report calls for a data revolution that would aid in the achievement of the Sustainable Development Goals.

The world is witnessing an unprecedented explosion of data. Digital data overtook analog around 1998, and in 2013 amounted to 46 billion trillion bytes. That's equivalent to about 400 trillion printed copies of this Report, which when stacked would reach from Earth to well beyond Pluto. Figure S5.1 shows the ongoing upsurge of data, as measured by total storage capacity. Figure S5.2 shows the evolution of telecommunications capacity. Although the absolute gap between higher- and lower-income countries is increasing, growth in the latter has been faster since 2008.

In harnessing this data explosion for development, attention focuses on two overlapping innovations: "big data" and open data. Big data are voluminous or fast. They come, for instance, from satellite and ground sensors and as by-products ("data exhaust") from electronic transactions and from mobile phone calls. The promise of big data is to provide information of unprecedented scope, detail, or rapidity. For instance, Global Forest Watch crunches massive amounts of open satellite data in order to generate near real-time, global maps of tropical deforestation.[2]

Open data are those that are freely and easily accessible, machine-readable, and explicitly unrestricted in use. Open data aren't necessarily big, and big data aren't necessarily open. Governments are, or could be, important sources of data on population, public budgets, education and health facility usage and status, weather, and trade. When opened, these data can be combined and recombined in ways that directly benefit the public (for instance, by increasing the transparency and accountability of government) and provide the basis for commercial, value-added services (such as apps for navigating public transit). Box S5.1 presents some examples of both big and open data.

Exuberant estimates of the current and potential economic value of big data and open data range from the hundreds of billions to the trillions of dollars per year. The clearest benefits so far have been for map and weather data. Openly available global positioning system (GPS) data supported markets for geospatial data and services worth US$56 billion in 2013 in the United States alone.[3] At least four companies valued at over US$1 billion—Zillow, Zoopla, Waze, and the Climate Corporation—process and resell open data about real estate, traffic conditions, and weather.

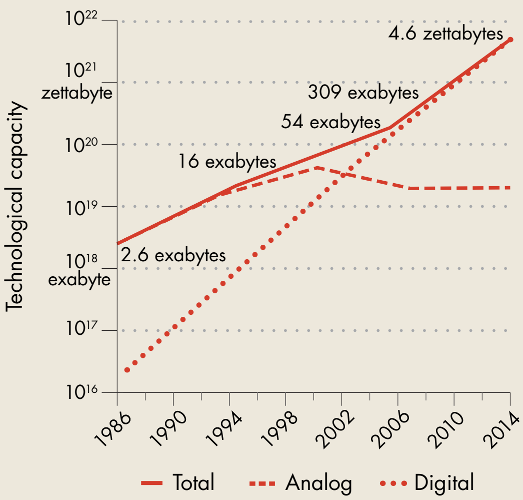
Yet sustained, impactful, scaled-up examples of big and open data in the developing world are still relatively rare. Open data has far to go. Figure S5.3 shows that readiness, implementation, and impact of open data are all highly correlated with GDP per capita, but that there are shortcomings in high-income countries, as well.

Data impact requires willing suppliers and eager demanders. On the supply side, private holders of data may be reluctant to share it for fear of jeopardizing customers' privacy or corporate competitiveness. Yet some of these data, if pooled and shared, could

WDR 2016 team, incorporating contributions by Amparo Ballivian and Thomas Roca (2015).

Figure S5.1 World's capacity to store information

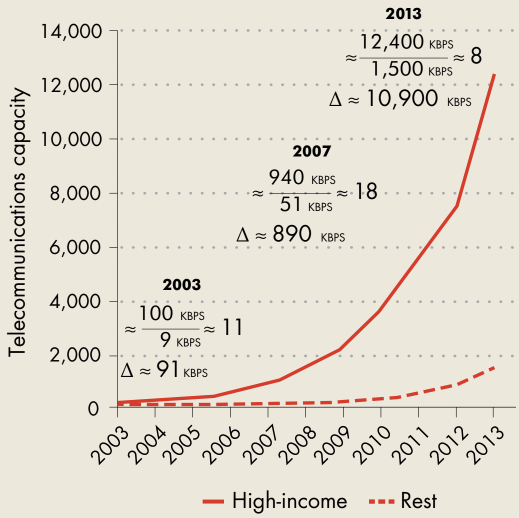
in optimally compressed bytes



Source: Hilbert 2015. Data at http://bit.do/WDR2016-FigS5_1.

Figure S5.2 Growth in telecommunications capacity

in optimally compressed kbps



Source: Hilbert 2015. Data at http://bit.do/WDR2016-FigS5_2.

Note: kbps = kilobits per second.

generate public benefits. There are emerging models that seek to create a symbiotic relationship among public, private, and academic actors that incorporates benefits for all.

For instance, taxi companies may justifiably be unwilling to share detailed data on vehicle movements. Data on average vehicle speed by road segment is valuable for the companies—it helps them

Box S5.1 "Big data" and open data in action

Informing relief efforts in the wake of the Nepal earthquake. A critical need in disaster relief is to track displaced populations for efficient logistics planning. Cellphone location data can provide comprehensive, real-time information on population, but cellphone operators are often reluctant to share this data for technical, confidentiality, or competitive reasons. Flowminder, a Swedish nongovernmental organization (NGO), has worked out procedures for accessing this data and has used it to estimate population movements following the 2015 earthquake to aid in relief efforts. http://www.worldpop.org.uk/nepal/.

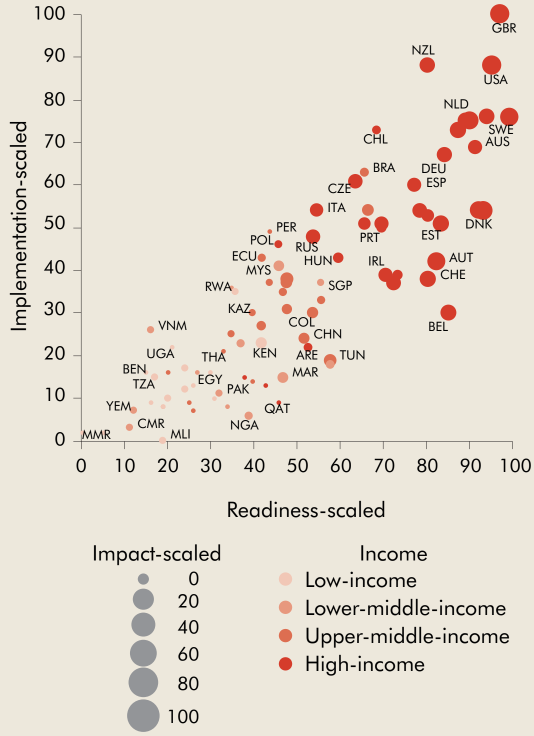
Real-time independent measures of inflation. PriceStats computes daily inflation data for 22 economies by scraping price data from the web. These inflation statistics are more timely than official numbers, and provide an independent cross-check. http://www.pricestats.com.

Accountability for subsidies in Mexico. Fundar Center for Analysis and Research, a Mexican NGO, persuaded the Mexican Ministry of Agriculture to open its data on the large PROCAMPO subsidy program. The data showed that 57 percent of the benefits were going to the wealthiest 10 percent of recipients. A website now tracks these and other financial flows, and allows data to be visualized. http://subsidiosalcampo.org.mx/.

Promoting efficient procurement of pharmaceuticals in Southern Africa. The Southern African Regional Programme on Access to Medicines and Diagnostics (SARPAM) InfoHub assembles information about pharmaceutical procurement volume and prices in the Southern African Development Community. It publishes price data on the web, and estimates the potential savings, for each member country, if medicines were purchased at the lowest available price. http://med-db.medicines.sadc.int/.

Source: WDR 2016 team.

Figure S5.3 Readiness, implementation, and impact of open data



Source: WDR team based on 2014 data from *World Wide Web Foundation 2015*. http://barometer.opendataresearch.org/report/about/data.html. Data at http://bit.do/WDR2016-FigS5_3.

with dispatching—and for city managers it provides a useful gauge of congestion. The World Bank is exploring ways to provide companies with software that distills their data down to average vehicle speed. This summarized data could then be shared between companies and with the public, yielding more accurate and comprehensive estimates of travel speeds.

In Australia, a tech startup called The Yield is working with public sector regulators to test ways to help farmers share data for the common good. The $A 100 million Australian oyster industry loses nearly $A 34 million a year due to harvesting closures by regulators to protect human health when runoff is contaminated. The idea is to equip the oyster farms with real-time sensors on water quality. The data will help individual farmers with farm management, while allowing regulators to optimize decisions, avoiding costly, unnecessary closures and still maintaining safety.

Public agencies are also reluctant to share data, even when it has large public benefits. For example, of the 86 countries surveyed by the Open Data Barometer, one-third of the high-income countries and 85 percent of the remainder had made little or no progress in opening map data. One reason is that cash-strapped agencies support themselves by selling data. This shuts out many potential users, even though the additional cost of providing the data to them would be negligible. A dramatic example of reversing this trade-off is the decision of the U.S. government to reduce the cost of a digital Landsat satellite image from US$600 to zero in 2008. The annual number of downloads increased from fewer than 25,000 to 3 million. The direct benefits are estimated at US$1.8 billion a year for U.S. users and US$400 million for international users;[4] there are substantial indirect benefits as well. The loss of government revenue from selling the 25,000 images was miniscule by comparison. So if the fixed costs of data maintenance can be financed, the benefits from free distribution can be large.

There are other reasons for public agencies to be reluctant to share. Agencies may lack technical skills to share data. They may be unwilling to expose the data to scrutiny because of quality concerns. They may value the political leverage afforded by monopolizing data. Nonetheless, both the G-8 countries and the African Union's High-Level Conference on the Data Revolution have endorsed the concept of making official data open by default.

Effective demand for data may also be weak, even if there is underlying interest. Of course, accessibility to the internet is a prerequisite. Outdated or poor-quality data will discourage demand. Because data literacy is critical, intermediaries can play a key role in interpreting, analyzing, and disseminating open data. But capacity or incentive to do this is often lacking. There has not been as much uptake by journalists as some have hoped. And while a benefit of open data is enhanced sharing among government agencies, relatively few governments are making optimal use of existing statistics for planning purposes, according to PARIS21. However, Bangladesh, Cambodia, and Niger scored high on statistical capacity (according to PARIS21's IDR Metadatabase), showing that it is possible for low-income countries to excel at generating and using statistics.[5]

The pioneering Kenyan Open Data Initiative shows both the promise and challenges of open data. A champion, Permanent Secretary Bitange Ndemo, persuaded ministries to open their data, and the program was inaugurated in 2011. The World Bank, Google, and Ushahidi provided technical and financial support. Drawing on Nairobi's vibrant tech scene, the ancillary Code4Kenya initiative spurred the development of apps that presented health, safety, and other information in engaging and useful ways.

A journalist, Irene Choge, attended a Data Journalism Boot Camp. She then used the Open Data Platform to trace a chain of links: funding for school toilets had gone missing, so the student-to-toilet ratio for many schools was intolerably high, leading to open defecation; consequently students were suffering from illnesses associated with poor sanitation, and female students, especially, were discouraged from attending school; the end result was poor performance on tests. The findings prompted government action.[6]

Despite this promising beginning, the Open Data Initiative lost steam. Data were not updated, the apps struggled to find users, and a legal framework for open data was not in place by mid-2015. Kenya's score on the Open Data Barometer dropped from 43 to 26 between 2013 and 2014.

This example underscores the global need for sustained commitment to openness and for investment in high-quality data if the dream of a data revolution is to be realized. Countries can seek ways to discourage data hoarding, by adequately funding data holders and showing them that they can attain a higher profile by opening their data. Donors and the international community can support these actions through funding, capacity building, and ensuring that their own data are open.

Notes

1. Independent Expert Advisory Group Secretariat 2014.
2. http://www.globalforestwatch.org/.
3. http://gpsworld.com/the-economic-benefits-of-gps/.
4. Miller and others 2013.
5. http://datarevolution.paris21.org/metabase.
6. https://www.youtube.com/watch?v=A58R2yNQtio.

References

Ballivian, A., and Thomas Roca. 2015. "New Data for Development." Background paper for the *World Development Report 2016*. World Bank, Washington, DC.

Hilbert, Martin. 2015. "Quantifying the Data Deluge and the Data Drought." Background note for the *World Development Report 2016*. World Bank, Washington, DC.

Independent Expert Advisory Group Secretariat. 2014. *A World That Counts: Mobilizing the Data Revolution for Sustainable Development*. New York: United Nations.

Miller, Holly M., Leslie Richardson, Stephen R. Koontz, John Loomis, and Lynne Koontz. 2013. "Users, Uses, and Value of Landsat Satellite Imagery—Results from the 2012 Survey of Users." Open-File Report 2013–1269. U.S. Geological Survey. http://pubs.usgs.gov/of/2013/1269/.

CHAPTER 5

National priorities

Analog foundations for a digital economy

Estonia is one of a handful of countries closest to becoming a digital society. After regaining its independence in 1991, it decided to promote the use of digital technologies in all areas of society and the economy. The nation was not rich by European standards, so one objective was to take advantage of efficiency gains. While investing in information and communication technologies (ICTs), Estonia also greatly improved its business climate, human capital, and governance. The greater ease of doing businesses spawned a host of technology-intensive startups, including Skype and TranferWise, a company disrupting the money transfer industry. The country today ranks high in the PISA (Programme for International Student Assessment) educational rankings and invests in digital literacy for its older citizens. The greater accountability in government boosted it from 78th to 40th between 1996 and 2010 on a ranking of 144 countries on their control of corruption. Today, Estonians have access to 3,000 e-government, e-banking, and other services, saving each of them an average of 5.4 work days a year.[1]

Estonia demonstrates that even small and developing or transitioning countries can seize the opportunities the internet offers by implementing a smart and comprehensive digital development strategy. Many other countries have also eagerly invested in digital technologies but have failed to create the environment for it to support development. So, while the internet has spread rapidly, development has advanced much more slowly. Chapter 4 discussed policies that ensure universal, affordable, safe, and open access to the internet. These supply-side policies are critically important, but are not enough.

Why is technology by itself unlikely to solve persistent development problems? The key insight is that a typical task in development has two broad parts: one that can be automated, and one that cannot. The automatable part of the task consists of repeatable, routine activities that produce measurable outputs and outcomes, and therefore are amenable to automation. Tasks performed by, say, bank tellers, bookkeepers, or clerks—and services such as registration and licensing—can to a large extent be done with digital technologies. In contrast, many tasks performed by teachers, researchers, or managers—and services such as policing or those performed in health care—involve activities where the providers must exercise considerable judgment in deciding what to do or how to respond. ICT projects often fail when they focus solely on technology without also addressing shortcomings in the complements that cannot be automated. The line that divides automatable activities from those that are not is, of course, continuously shifting. But solving the most difficult development problems will almost always require more than just technology.

Chapters 1–3 of this Report presented evidence of the problems that can arise from greater use of technology and identified the main risks that countries face as a consequence. To mitigate these risks, investments in digital technologies must be accompanied by improvements of their analog complements (figure 5.1):

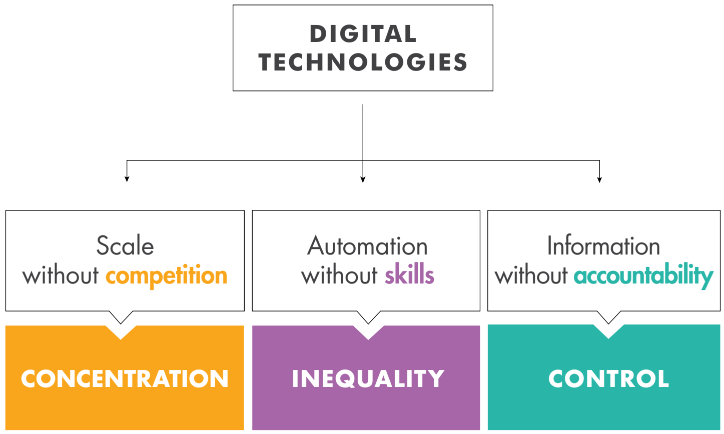
- Lower-than-expected internet adoption means that many firms in low- and middle-income countries forgo considerable productivity benefits. The reasons include a poor business climate and vested interests that hinder market entry and reduce the pressure to innovate. Without improved regulations, especially those governing *competition*, economies of scale brought by the internet could well lead to harmful *concentration* and monopolies—and thus to greater divergence between and within countries, rather than convergence and catching-up.

- Rising shifts of income from labor to capital and the drop in mid-level jobs in many countries suggest that the gains from greater use of technology may not be equitably shared. Without complementary investments in the *skills* that workers need to leverage the internet, automation could exacerbate *inequality* rather than promote greater opportunity and shared prosperity.
- E-government projects have a poor record in many countries; governments have too often been unable, and sometimes unwilling, to use the internet to improve service delivery and increase public participation. Without more capable and more *accountable* public sector institutions, technology investments could lead to more *control* and not to greater empowerment of citizens.

Business regulations that ensure a high degree of competition, skills that prepare workers for the 21st-century workplace, and accountable public institutions that use the internet to improve services—together these constitute the analog foundation that supports an inclusive, efficient, and innovative digital transformation.

The idea that technology alone is not enough to have a widespread impact on development is supported by a growing academic literature. Researchers focus on different angles, but come to similar conclusions (box 5.1). In a growth context, the level of analysis is a country or sector, and what matters is how technology interacts with rules—that is, with regulations and similar endowments. In a labor market context, the level of analysis is occupations or specific tasks, and what matters is the interaction of automation and worker skills. And in a government context, the level of analysis is a public service, and what matters for delivery is the accountability of institutions.

Figure 5.1 Risks from digital technologies in the absence of complements



Source: WDR 2016 team.

The interdependence between technology and complements

Technology and its complements feed on one another. Improvements in the business climate, human capital, and public sector governance are already high on the reform agenda in most countries. With greater use of technology, the complements also become more valuable because they interact. Thanks to technology, firms operating in a well-regulated business environment are more innovative. Skilled workers are more efficient. And accountable institutions are more inclusive. The internet thus tends to amplify existing strengths and weaknesses, and progress in these areas therefore becomes even more urgent. Otherwise, there is a risk of falling further behind for those who do not make the necessary reforms. As the following sections will show, technology does not just increase the value of complements. It can also often raise their quality—for instance, through online business registration programs, online education, or better monitoring.

So how can businesses, people, and governments reap the greatest digital dividends? The Report suggests many detailed steps to strengthen analog complements, but policy makers should also keep in mind a set of overarching principles concerning the interaction of technology and complements.

Guiding premises

The inability to scale up is one of the most commonly cited reasons for failed digital interventions

The popular media is filled with inspiring stories involving technology: digital marketplaces are helping artisans in remote hillsides to access global markets; the on-demand economy is creating new startups and digital entrepreneurs; and social media tools are helping citizens organize and rally around issues of common concern. But after a promising start, many initiatives seem to flounder. For every successful online commerce platform, nearly four fail to achieve scale. Despite the growing popularity of the on-demand economy, the firm startup rate in

Box 5.1 Three ideas about the interaction between technology and its complements

The relationship between technology and complements that is at the core of this Report is also the topic of recent work by a number of prominent researchers.

Technology and rules (competition). Paul Romer develops a simple growth model in which technology interacts with "rules"—including, importantly, regulations shaping the business climate. Technology is tradable and can spread to new places quickly. Rules are established locally. Even if they are negotiated internationally, they will not be simply imported like, say, capital goods. So there will always be a complex, context-specific political process that leads to their adoption and determines how effectively technology is deployed. Together, technology and rules enable the creation or adoption of new "ideas"—new or improved ways of producing, working, or serving citizens. The quality of rules varies across countries. Romer cites the municipal water sector privatization to a French company in Argentina to illustrate his argument. The program was initially successful, but—like in many other countries—eventually ran into popular opposition, which prompted renationalization. The technology required and the rules and preferences about regulating utility monopolies were present in France but not in Argentina. Technologies and rules were thus poorly matched. In contrast, ideas about setting up and operating mobile phone systems spread quickly to many countries—even to fragile states like Somalia. Mobile phone technology, in contrast to landlines or municipal water, easily allows competition among providers even in places with low regulatory capacity. For mobile, local conditions (or rules) have accommodated the new technology.

Technology and skills. David Autor is most concerned with effects of technology on labor markets. Looking at occupations and even individual tasks, he considers how much of a person's job is routine and could be done by a machine—and how much is nonroutine and not easily automated. Those tasks that follow easily codifiable procedures can be done by computers faster, better, and more cheaply. With increasing computing power and better software, the rule of thumb is that if you can fairly easily explain a job to someone, it can probably be automated. Tasks that require problem solving, adaptability, and creativity, in contrast, are very hard to automate. Again, the difficulty in automating a job tends to match the difficulty in describing it. Autor stresses the interaction of technology with nonroutine tasks. Nonroutine jobs cannot easily be automated, but they can benefit from automation because technology tends to complement skills. Workers in nonroutine jobs get more productive as the automation of other tasks increases.

Technology and discretion (accountability). Lant Pritchett, Michael Woolcock, and Salimah Samji focus on public services and develop a typology of organizational capabilities for specific public sector tasks. They do not specifically look at the role of technology, but their framework provides insights about when technology could improve services. Informed by the accountability framework in the 2004 *World Development Report, Making Services Work for Poor People*, their main criterion is whether a task involves local discretion and therefore some judgment by a civil servant. Others are whether a task is transaction-intensive, and thus involves many people; whether it is a service (education) or an obligation (policing); and whether it can draw on existing knowledge or requires innovation. Categorizing public service tasks in this framework helps explain why e-government efforts often fail—when organizational capabilities are poorly matched to technology and the requirements of the task.

These studies make very similar arguments. First, technology alone will not be enough. Second, increasing the use of technology needs to be matched by complementary reforms. And third, knowing the best combination of technology and complements for different tasks, occupations, and services is the key to translating technological progress into development.

Sources: Romer 2010; Autor 2014; Pritchett, Woolcock, and Samji, forthcoming; World Bank 2004.

the United States continues to decline, with the largest decline in the retail and service sectors.[2] And as the Arab Spring showed, citizen mobilizations based on social media are as easily crushed by governments as they were stitched together by citizen activists. All this because it is easy to scale up the technology, but difficult to improve its complements.

The internet is no shortcut to development, but it can be an accelerator

For policy makers, using technology to solve a problem is often more tempting than fixing an ailing institution. A manifestation of this is the popularity of distributing laptops to schoolchildren as an election pledge. There is also growing demand to wire schools, hospitals, and all government buildings. Connectivity is important, but it is not enough. Technology can rarely bypass or substitute for other shortcomings. When technology is deployed in an environment of weak complements, the gains will be limited. But when technology and its complements work together, the impacts can be profound and lasting. While the internet is no shortcut, it can be an accelerator because many digital tools improve the complements.

Understanding the interaction between technology and human complements should guide how much to invest in each

Some sectors, occupations, and services are more amenable to technology than others (figure 5.2). Gains from technology will be larger in public services such as cash transfer programs and utility services—where outcomes can be easily monitored by citizens—than in services that require a lot of discretion, such as policing and management. Similarly, occupations involving routine tasks will be more affected by technology than those requiring a high degree of judgment and intuition. With technological advances, more tasks could become easier to automate, so the relative roles of technology and complements could change over time. Since outcomes are easier to monitor for private businesses, as a rule of thumb, firms are likely to be more successful than governments in using technology to solve problems. Thus in a weak institutional environment, the priority should be to encourage greater adoption of technology by the private sector, while continuing to strengthen the complements in the public sector.

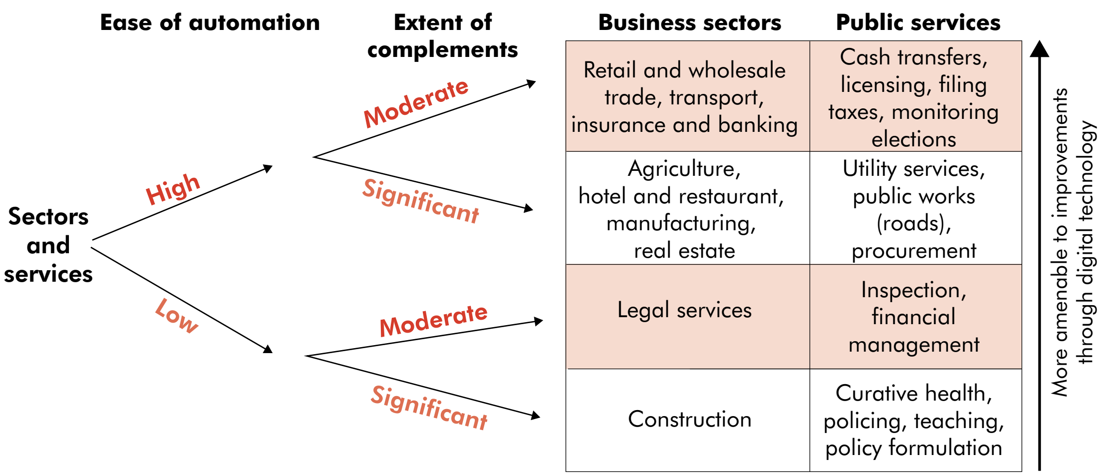
A digital strategy is more about the adoption of ICTs than their production

Many policy makers wish to have a Silicon Valley in their country, dotted with large ICT firms like Apple, Facebook, Google, Huawei, and Samsung. But the widespread adoption of ICTs, not their production, is responsible for most of the growth and job creation.[3] The ICT sector in developing countries is fairly small, accounting for only 3–4 percent of GDP and 1 percent of the total labor force. But when ICT firms enter traditional sectors such as retail, banking, manufacturing, and transport, they spur competition, raise productivity, and expand opportunities. For example, Alibaba has 30,000 employees, but provides a platform for more than 10 million ancillary jobs. Uber has a few hundred coders, but it supports the livelihoods of around 1 million on-demand drivers. The online outsourcing industry creates millions of freelancing opportunities in professional services. And in Mexico, manufacturing firms subject to competition from Chinese imports invest more in digital technologies, thus boosting productivity and creating more employment opportunities.

A digital strategy needs to be broader than an ICT strategy

The digital economy transcends the ICT sector, encompassing most sectors of the economy and society.[4] Yet many governments continue to treat the digital economy as a sector, with exclusive emphasis on developing ICT infrastructure and creating an information technology (IT) workforce. Our analysis shows that a successful digital strategy needs to stand

Figure 5.2 Some services and sectors are more amenable to digital technology than others



Source: WDR 2016 team.

on two pillars—one digital and the other analog. The digital pillar deals with the supply-side issues, focusing on policies to make the internet universally accessible, affordable, open, and safe (chapter 4). The analog pillar aims to strengthen the demand-side policies by creating regulations that encourage competition, basic modern skills for all, and public institutions that are accountable. Countries such as Rwanda, whose vision is to become an information-rich, knowledge-based society, have gradually tried to broaden their digital strategy to include both the digital and the analog foundations.[5,6]

A country typology for digital development

As digital development proceeds from emerging to transitioning and then to transforming, policy reforms become more complex. There are no hard-and-fast rules, but it is useful to consider a sequence of policy priorities in line with technology's increasing penetration (table 5.1):

- *Emerging countries.* In countries where the digital economy is still emerging and internet use is low, the priority is to lay the foundations: Remove barriers to internet adoption such as high duties on ICT capital imports. Improve the business climate, including physical infrastructure critical for online businesses with an offline footprint. Promote digital literacy and basic cognitive and socioemotional skills. Use the internet to provide information and monitor service providers.
- *Transitioning countries.* Countries transitioning toward universal internet use need to address harder problems: Build effective competition regulation and enforcement capacity. Teach advanced cognitive and socioemotional skills that complement technology. Move toward effective e-government systems.
- *Transforming countries.* Countries transforming into digital societies need to tackle complex problems: Regulate platform competition and privacy. Advance ICT and science, technology, engineering, and mathematics (STEM) skills and lifelong learning. Move toward ubiquitous e-government services and participatory policy making.

Classifying countries into various groups is necessarily somewhat ad hoc (figure 5.3). The labels applied in the following sections should therefore be treated with considerable discretion. Technology adoption and the quality of complements vary not only across countries but also across sectors and across firms in the same sector. So a country classified as emerging for its government institutions could be categorized as transitioning for its skills and as transforming for its regulations. Some sectors in a country could be transforming while the rest of the economy is emerging. So the boundary lines across country groups and complementary factors are more indicative than fixed.

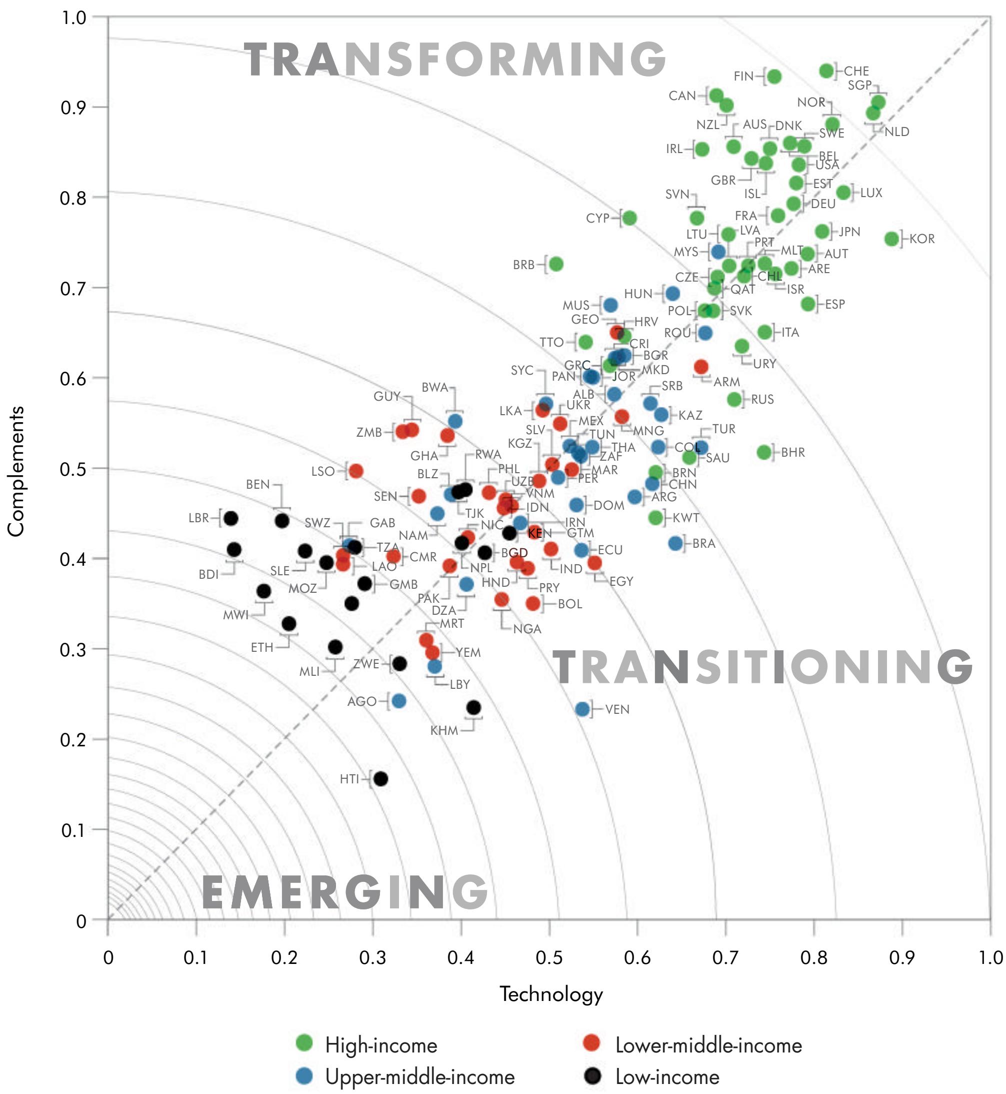
Table 5.1 Policy priorities for emerging, transitioning, or transforming countries

Policy goals	Stage in the digital transformation		
	Emerging	**Transitioning**	**Transforming**
Regulations (competition): A business environment in which firms can leverage the internet to compete and innovate for the benefit of consumers	• Low barriers to internet adoption (including access, affordability, and basic open and safe issues; trade and basic competition issues)	• Effective competition regulation and enforcement (including ease of market entry)	• Critical "new economy" regulation (including platform competition and the legal basis for private sector data collection)
Skills: Workers, entrepreneurs, and public servants who can take advantage of opportunities in the digital world	• Digital literacy and foundational basic cognitive skills, and socioemotional skills	• Higher-order cognitive and socioemotional skills	• Advanced ICT skills and STEM education • Lifelong learning
Institutions (accountability): An accountable government that effectively uses the internet to empower its citizens and deliver services	• Adoption of informational services and monitoring by public sector and nonstate providers • Increased electoral accountability	• Effective e-government delivery systems, provider management, and citizen engagement • Trust and safeguards against privacy and security	• Widespread citizen use of e-government services and participatory policy making • Social protection systems for a changing labor market

Source: WDR 2016 team.

Note: ICT = information and communication technology; STEM = science, technology, engineering, and mathematics.

Figure 5.3 The quality of complements and technology rises with incomes



Sources: World Bank World Development Indicators (various years); World Bank Enterprise Surveys (various years); Gallup World Poll (various years); World Bank Global e-Government Systems database; World Bank ID4D database; United Nations 2014; WDR 2016 team. Data at http://bit.do/WDR2016-Fig5_3.

Note: Technology is measured by the Digital Adoption Index (DAI). DAI is based on three sectoral subindexes covering businesses, people, and governments, with each subindex assigned an equal weight: DAI (Economy) = DAI (Businesses) + DAI (People) + DAI (Governments). Each subindex is the simple average of several normalized indicators measuring the adoption rate for the relevant groups. Similarly, *complements* is the average of three subindicators: starting a business; years of education adjusted for skills; and quality of institutions. See figures 5.4, 5.8, and 5.10 for more details on the construction of sectoral subindexes.

Regulations: Helping businesses connect and compete

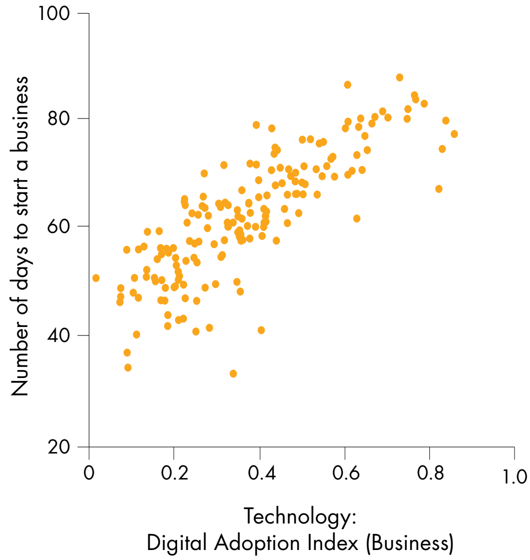
A competitive market encourages firms to use the internet to access new markets, increase productivity, and achieve scale. Firms in more contested industries—facing more domestic or foreign competitors and higher firm entry and exit rates—are more likely to adopt digital technologies (chapter 1). So those countries that are creating a level playing field for their businesses by embracing competition—by making it easier for new firms to enter and for existing firms to reorganize and exit, while preventing incumbent firms from acquiring monopoly power—are expected to perform well in a digital world.

The lack of competitive pressure and absence of basic infrastructure are holding back many firms in developing countries from taking full advantage of the internet. It is not uncommon for incumbent firms to secure profits by seeking protection through regulatory means rather than by competing in the open market. The problem arises when policy makers oblige. There are also instances when regulations are genuinely outdated or reflect risk aversion to technological change and the consequent disruption. For example, regulators around the world seem to be conflicted on whether ride sharing services should be regulated as transport service companies or as software companies. Is mobile money a banking or a telecom product? And in highly connected markets, could the absence of competition across various digital platforms inhibit future innovation? In some low-income countries, the lack of supporting infrastructure—such as electricity, roads, ports, warehouses, distribution, and a well-functioning postal system—could hinder firms from investing in digital technologies.

Appropriate regulation at various levels of digital adoption

Policy reform priorities are likely to vary across countries depending on their level of digital adoption. Matching the country typology with appropriate regulatory reforms leads to the following taxonomy (figure 5.4):

Figure 5.4 Regulations that encourage competition also facilitate higher adoption of digital technologies



Sources: Doing Business database (World Bank, various years); WDR 2016 team. Data at http://bit.do/WDR2016-Fig5_4.

Note: The Digital Adoption Index (Business) is the simple average of four normalized indicators: the percentage of businesses with websites, the number of secure servers, the speed of download, and 3G (third-generation) coverage in the country.

- *Emerging countries* are characterized by low digital adoption and protected markets. They are also likely to suffer from poor infrastructure and weakly accountable institutions. Investing in basic physical and digital infrastructure (chapter 4); lowering tariffs on digital products; encouraging adoption of low-tech, disruptive applications such as mobile money and social media; and reducing product market regulations are some of the policy priorities these countries should consider.
- *Transitioning countries* have mixed regulations, with some sectors open to competition. Many of their business regulations are codified, easily available, and increasingly carried out online. These countries also have fairly good physical infrastructure. Transitioning countries thus need to remove regulatory barriers across major sectors to incentivize firms to invest in more efficient digital solutions and encourage the entry of startups that can put competitive pressure on incumbent firms. When required, they should establish regulatory clarity between online and offline businesses within the same sector. A majority of developing countries and some developed countries fall into this category.
- *Transforming countries* are open to competition in most economic sectors and generally have accountable and capable governments that provide good physical infrastructure and enforce business regulations that promote competition. But they face two distinct sets of problems. First, because they are early adopters of digital technologies, many of their firms have well-functioning but perhaps less productive and nonscalable "legacy systems." These countries would benefit from relaxing their regulatory constraints to level the playing field between incumbent firms and (internet) startups in all sectors, but especially in the legacy sectors. Second, given the universality of digital technologies, these countries have witnessed rapid growth of digital platforms in selected sectors, some of which have achieved a dominant position in their markets. They need to find ways to encourage greater competition across platforms: say, by eliminating exclusivity conditions and introducing portability and seamless transfers of data and information across platforms.

Emerging countries: Invest in infrastructure and enforce product market competition

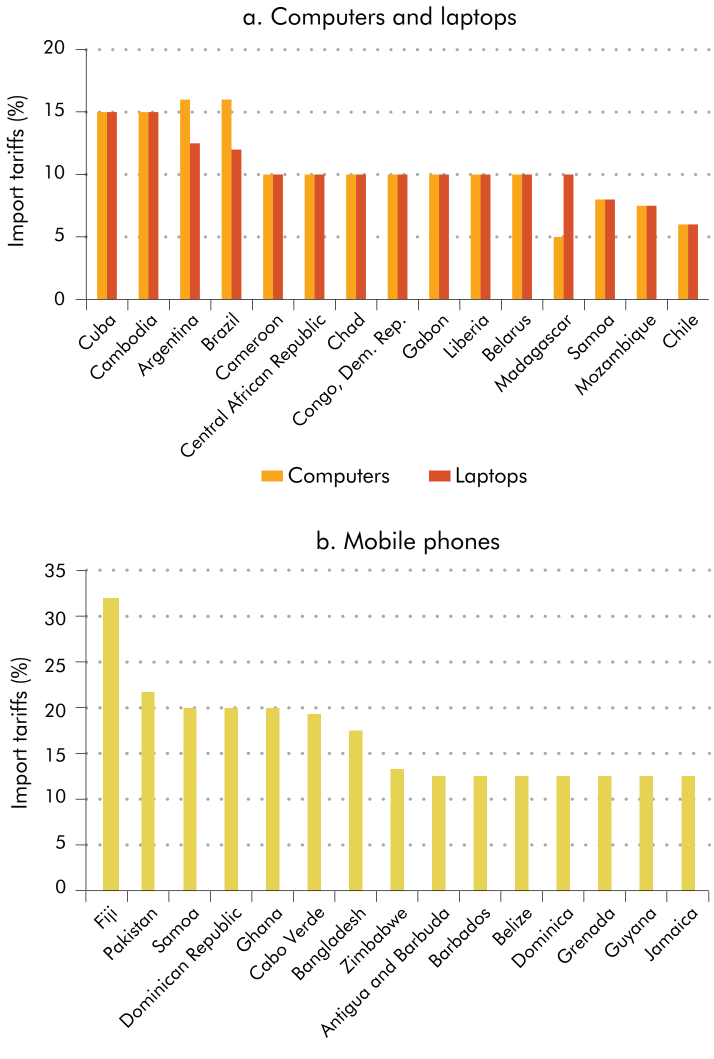
For many lower-income countries, creating basic business-sustaining infrastructure is a priority, requiring finance, local expertise, and innovative solutions. Digital technologies can help overcome some of these problems. Revenues from telecoms—customs duties on hardware, auctioning and managing spectrums, and value added tax (VAT) or sales taxes on services—have been one of the fastest growing sources of revenue in many developing countries. But regulatory capture by powerful telecom firms could undermine this effort, as in Somalia. Many other countries in Africa, however, have the opposite problem—they have used the telecom sector as a "cash cow," taxing it so heavily as to impede its growth prospects. Even so, there are private sector solutions to financing and managing infrastructure services using digital technologies that hold the most promise. For example, Mobisol, a German company, is supplying off-grid energy to villagers in Rwanda by combining solar energy technology with mobile phone–based loan payments.[7]

Countries need to look at the digital economy as a source of growth and jobs and not just as a source of revenue. Some countries impose significant import tariffs on computers, laptops, and mobile phones to meet short-term revenue objectives (figure 5.5). For example, the most favored nation (MFN) tariff rate on computers in Djibouti is as high as 26 percent. Fiji charges MFN tariff rates of more than 30 percent for mobile phones. The tariffs on using digital technologies raise the costs of using digital technologies for firms and households, thus delaying the emergence of the digital economy and its attendant positive effect on growth and jobs. In general, the higher revenue buoyancy in the medium term can more than make up for short-term revenue shortfall from reduced tariffs.

In addition to electricity, countries need to invest in trade infrastructure and customs administration to improve physical connectivity and facilitate the growth of the digital economy. Several countries still have inefficient ports and other trade infrastructure. Among the weak performers on trade logistics in 2007, only a few significantly improved their trade logistics infrastructure between 2007 and 2014, including Afghanistan, Nepal, Nigeria, Rwanda, Serbia, and Tanzania (figure 5.6). Countries can also improve their overall logistics performance by lowering their nontariff barriers and tackling behind-the-border issues. Firms with improved logistics are better positioned to export their products and services using online marketplaces once these platforms gain in importance in their region. But several countries continue to lag behind, including Cameroon, the Comoros, Eritrea, Somalia, and Sri Lanka.

Another infrastructure constraint to a digital economy in emerging countries is the absence of domestic delivery systems. There were 38 countries in 2012 where less than 50 percent of the population had access to home postal delivery (see chapter 1). And several countries had no "last mile" domestic delivery system in place at all: Botswana, Burkina Faso, the Central African Republic, the Democratic Republic of Congo, Gabon, Kenya, Rwanda, Swaziland, Togo, and

Figure 5.5 Digital products are taxed as luxury goods in some countries

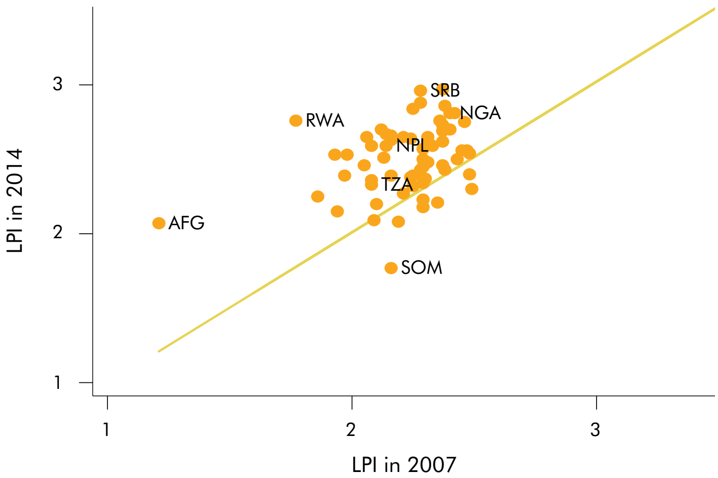


Source: WITS 2014. Data at http://bit.do/WDR2016-Fig5_5.

Note: Panel a shows most favored nation (MFN) tariff rates for computers and laptops. The Harmonized Commodity Description and Coding System (HS) code for computers is HS 8471.49, and the HS code for laptops is HS 8471.30. The MFN tariff for computers in Djibouti (not shown) is 26 percent. Panel b shows MFN tariff rates for mobile phones. For some countries, the MFN tariff rates may exaggerate the level of taxation, especially if they source a large part of their digital imports from Free Trade Agreement partners, as is the case with Chile.

Figure 5.6 Infrastructure complements

Trade logistics in many countries haven't improved in the past seven years



Source: World Bank Logistics Performance Index (various years). Data at http://bit.do/WDR2016-Fig5_6.

Note: The LPI (Logistics Performance Index) covers six areas of logistics: customs, infrastructure, international shipments, logistics quality and competence, tracking and tracing, and timeliness. The index varies from 1 to 7. The figure shows only those countries with relatively weak trade logistics in 2007 (index below 2.5). Observations above the yellow line indicate that countries improved their logistics performance between 2007 and 2014.

Tanzania. Online retailers in these countries thus struggle to deliver parcels to their customers and are forced to invest in their own logistics solution.

Reliable online payment systems are also not available in many African and Central Asian countries, limiting the potential for e-commerce. While most individuals in developing countries do not have access to a credit card, online payment systems for businesses, such as the PayPal business account, provide reliable alternative solutions. In several Latin American countries, small businesses that do not have a bank account can use PagosOnline for payments. Without reliable and legal online payment systems, firms have been resorting to riskier solutions, such as Bitcoin, as in Ghana. Not only are such activities illegal in some countries, but when undertaken on a large scale and in a weak regulatory environment, they could have a destabilizing effect on the financial sector.

Emerging countries should focus on enforcing existing business regulations and competition and antitrust laws. Most countries have laws that define some degree of competition or antitrust regulation but that are seldom enforced.[8] Moreover, business regulations are sometimes implemented in a way that discriminates between firms, increasing regulatory uncertainty. Agreements among competitors on setting prices, sharing markets, and bidding for public procurement, for instance, are one of the most common anticompetitive practices, even though most countries have competition laws in place.[9]

Emerging countries should thus focus first on reducing the implementation gap in enforcing existing laws. Required changes for implementation could be handled through secondary legislation or guidelines. Such changes include transparently defining appropriate fines for anticompetitive behavior, granting sufficient authority and investigating power to implementing agencies to fight anticompetitive regulations in all economic sectors, reducing anticompetitive practices by government agencies that facilitate cartel behavior, and measuring and communicating the harmful effects of cartel agreements to encourage support for competition policy.

Transitioning countries: Enhance competition by removing regulatory barriers and encouraging entry of internet startups in traditional sectors

Competition law and competition authorities

Anticompetitive regulations, while designed with good intentions, can be misused. Vested interests and privileged firms can use them to limit entry into domestic markets; to access government subsidies, contracts, or land; and to insulate them from foreign competition. Such anticompetitive regulations seem to discourage firms in some developing countries—including Brazil, the Democratic Republic of Congo, Ghana, Kenya, Mexico, Morocco, Tanzania, Uganda, Vietnam, and Zambia—from using digital technologies more intensively (chapter 1).

Most countries have a competition authority, though many were set up fairly recently, and enforcement varies, especially when the state or privileged firms benefit from market restrictions. Limited capacity and the difficulty of proving harm to consumers are further barriers. A priority for transitioning countries is to institute strong competition laws and boost the capacity of implementing institutions to enforce the law transparently and effectively. Policy measures include leniency programs allowing participants of cartels to cooperate with government bodies in exchange for lower sanctions—and ex post investigation of potential collusive practices in procurement.

Disruption as a strategy to create competition

Transitioning countries should encourage the entry of internet firms offering traditional services in order to disrupt protected sectors. The internet has created a new wave of entrepreneurship and innovation around the world. Internet firms now compete with offline incumbents in banking, insurance, retail trade, transport, logistics, international currency transfers, accommodation, tourism, media, publishing, advertising, programming, design, and other professional service tasks.

Governments may consider abstaining from imposing regulatory barriers on new internet firms before they achieve a certain scale. Eliminating protection, often against the interests of influential elites benefiting from the status quo, is difficult and takes time. But internet firms can do the work of the regulators and introduce competition in a sector overnight. The mobile money service M-Pesa in Kenya was able to achieve scale because of the regulator's initial decision to regulate it as a telecom and not as a banking sector product. The mobile-money schemes in other countries have often been held up by opposition from traditional banks. At the same time, lack of adequate regulation on the telecom side meant that M-Pesa enjoyed dominant market power in Kenya for a fairly long time, which ultimately had to be curbed by the competition authorities. This highlights the tight-rope walk for regulators in the digital economy (box 5.2).

The internet firms operating in the financial sector are often not subject to the same level of regulations, enabling Yu'E Bao, an online trust fund in China, to enroll 150 million depositors and collect Y 700 billion in deposits in less than two years. It offered higher yields on the deposits by making use of underregulation of the financial sector outside the formal banking system. The ongoing reforms in the financial sector in China have narrowed this regulatory arbitrage.

Transforming countries: Encourage digital innovation but also regulate the digital economy to level the playing field between incumbent and internet firms

Critical "new economy" regulations

While most of the internet's impact will be in traditional sectors that use technology to boost efficiency, "pure" internet firms raise new challenges that regulatory authorities even in advanced economies

Box 5.2 Mobile money: A success story and yet a regulatory minefield

Mobile money started informally, with users making payments of airtime credit to each other (see also spotlight 2). This system is still operating in many countries, such as Somalia, where users exhibit more faith in storable and transferable credit than in the local currency, the Somali shilling. But elsewhere, notably in Kenya, a more formal system of mobile money developed, using a separate store of credit on the user's SIM (subscriber identification module) card. Safaricom introduced its M-Pesa mobile payment service in 2007, and other operators developed rival services. By 2013, transactions of US$21.9 billion—equivalent to just under half of Kenya's GDP—were transacted on mobile devices. M-Pesa was introduced two years later in Tanzania. Although initially slow to take off, it now equates to a higher percentage of GDP (53.2 percent) and will soon overtake Kenya in volume.

Safaricom had a monopoly in the Kenyan market for almost seven years. It had established exclusivity arrangements with M-Pesa agents, meaning the agents could only offer products and services within the M-Pesa network. Agents were thus locked in to a single operator, and so were most users. Since Safaricom controlled more than two-fifths of the mobile money transfer business, the exclusivity contracts with the agents posed an entry barrier for other telecom operators. One reason Safaricom justified keeping its network closed was that it had incurred high costs to develop the existing infrastructure.

Recently, the Competition Authority of Kenya ruled: "(a) that all restrictive clauses in the agreements between Safaricom Limited and its Mobile Money Transfer Agents be expunged immediately, but in any event not later than July 18, 2014; (b) that the Mobile Money Agents be at liberty to transact the Mobile Money Transfer Businesses of any other mobile money transfer service providers; (c) that oversight by Safaricom Limited be thereafter limited to its business with the Agents; and (d) that each Mobile Money Service Provider be responsible for ensuring compliance with Central Bank of Kenya Regulations."[a]

This ruling came weeks after M-Pesa permitted its agents to work with other mobile operators. Eliminating its exclusivity agreements reduced the cost of sending money from M-Pesa users to other unregistered users. For example, the cost of transfers of between K Sh 101 and K Sh 500 fell from K Sh 66 to K Sh 44 within six months after the end of the exclusivity agreement.

Sources: Plaza, Yousefi, and Ratha 2015, for the WDR 2016; Di Castri and Gidvani 2014.

a. http://africanantitrust.com/2014/10/09/antitrust-enforcer-subjects-mobile-payment-operator-to-central-bank-oversight/.

struggle with. Sharing economy firms like Uber and Airbnb scaled up traditional ride sharing and subletting to a global scale. But regulators struggle to determine whether these companies are taxi and hotel companies or simply software providers. Offline competitors complain that they do not follow the same regulations. Where these industries tend to be overregulated—often the case in the traditional taxi business, for example—this new competition can encourage a general regulatory overhaul of the industry.

Once internet firms offering traditional services achieve a certain scale, regulators need to modernize and impose sector-specific regulations to level the playing field between online firms and their offline competitors. New York City regulators started to require Uber drivers to be licensed, to drive vehicles with livery plates, and to have commercial insurance to create fairer competition between the sharing economy and taxi drivers. In other cases, requirements that taxi drivers have full knowledge of local streets have become obsolete with global positioning systems (GPS) and should be scrapped. Airbnb is required to pay local sales tax in several cities where its services compete with those of the hotel industry.

Creating competition across platforms

Concentration in the digital economy paired with network effects or switching costs can lead to anticompetitive behavior. But internet firms confound traditional competition law because they do not act as traditional monopolies. Their services are often free or more convenient for consumers. It is also less than straightforward to establish their real line of business. Google, known as a search engine company, is better described as an advertising firm. It accounts for nearly 90 percent of the online search market in some countries, and around 25 percent of the display-ad market, while Yahoo and Facebook account for about 10 percent each.[10] But given their dominance in the markets for online ads or books, some internet companies have considerable leverage over marketers and booksellers. This is similar to credit card companies' position with respect to retailers. Since many internet firms operate in two-sided markets, where an online platform brings together buyers and sellers, these internet intermediaries could blur price signals in either of the two markets. Research by economists such as Jean Tirole shows that regulations in such industries must be carefully tailored to ensure competition and not harm consumers.[11] These are very challenging problems. Countries could consider orienting their regulations to those under development in the European Union (EU) or North America.

Skills: Making the internet work for everyone

If you compared our world today with the world one hundred years ago, you would encounter amazing advances in science, commerce, health care, transportation, and other areas. But if you were to compare the classroom of a hundred years ago with an average classroom today, you would recognize it immediately: students lined up in rows, paper and pencil in hand; a teacher at the blackboard jotting down facts; students furiously copying all that is written and said, expecting to memorize the facts and spit them out on an exam.

—Robert Hawkins (2002)

Technological changes are disrupting the employment landscape. Occupations are becoming more technology intensive, and "old economy" jobs are giving way to "new economy" careers. In many countries, this transformation is just starting and will take time. But even in these countries, the time for action is now. Changes in education and training take a generation to have an effect, and reforms need to start early so that skills do not become a bottleneck as countries advance in their digital transformation.

A changed world with unchanged classrooms

The skills mix needed to succeed in the labor market is changing, and today's education and training systems are often failing to keep up. The use of digital technologies requires basic cognitive skills, such as literacy and numeracy. But a well-educated worker in the 21st century also needs skills that are easily transferable across jobs and occupations and that help respond to changing labor market demands: higher-order cognitive, socioemotional, and technical skills (figure 5.7). This multiplicity of skills has always been important, but it is now essential. From Lebanon to Peru to Vietnam, employers are looking for workers who work well in teams and can solve problems, think critically, and present their work well to others.[12] Yet in many countries, education systems fail to provide even basic literacy and numeracy. More than half of 15-year-olds are functionally illiterate in middle-income countries such as Albania, Indonesia, Jordan, Kazakhstan, Malaysia, and Peru.[13]

Figure 5.7 The types of skills needed in a modern economy

Cognitive	Social and behavioral	Technical
Literacy, numeracy, and higher-order cognitive skills (for example, reasoning and creative thinking)	Socioemotional skills and personality traits	Manual dexterity and the use of methods, materials, tools, and instruments
Raw problem-solving ability versus knowledge to solve problems	Openness to experience, conscientiousness, extraversion, agreeability, and emotional stability	Technical skills developed through postsecondary schooling or training or acquired on the job
Verbal ability, numeracy, problem solving, memory, and mental speed	Self-regulation, grit, mind-set, decision making, and interpersonal skills	Skills related to specific occupations (for example, engineer, economist, IT specialist)

Source: WDR 2016 team, adapted from Pierre, Sanchez Puerta, and Valerio 2014.

Note: IT = information technology.

Digital technologies accelerate the pace of labor market changes, opening new opportunities but also making skills obsolete more quickly. This calls for more adaptability from individuals and institutions, a stronger link between educational and training institutions and the private sector, and policies that promote lifelong learning. Since skill development starts at birth and is lifelong, a life-cycle approach to learning is necessary.[14]

These two labor market transformations—changing skill mix and rapid skill obsolescence—have profound implications for the skill development agenda. While digital technologies affect the whole skill formation process by changing the role of teachers, how students learn, and the mechanisms to strengthen accountability in education and training (see sector focus 2), priorities for skill development in the 21st century hinge on three questions:

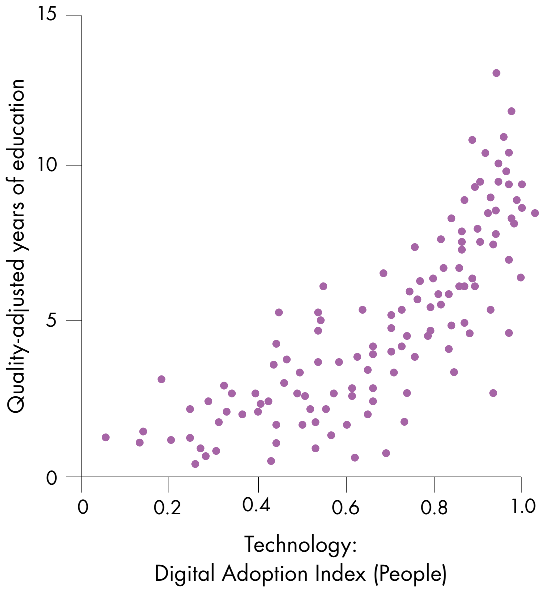
- What are the policies and interventions needed to provide current and future workers with skills for a digital economy?
- How do these priorities vary by each country's labor market challenges and skill base?
- How can digital technologies complement this "analog" policy agenda?

Priorities for a skill development agenda in the 21st century

Countries with strong skill development systems are best prepared to leverage digital technologies, to manage some of the labor market disruptions that technology creates, and to ensure that the benefits of digital technologies are widely shared. In emerging digital countries, such as Nepal or Senegal, the skill base remains weak, with gaps in foundational cognitive and socioemotional skills, as well as in basic digital literacy. Transitioning countries, including Armenia, Sri Lanka, and Ukraine, have done fairly well on foundational skills, but they face the challenge of keeping up with some of the new skill demands arising from digital technologies, especially higher-order skills. Transforming countries, such as the Czech Republic and the Republic of Korea, are best positioned to think about more advanced technical skills (both in ICT and in STEM), and, since many of their citizens are also rapidly aging, also need to prioritize lifelong learning (figure 5.8).

Every country has multiple skill development systems. As international tests make clear, individuals who perform best in less advanced economies are often at par with peers in more advanced countries, and there is a lot of inequality in outcomes within countries.[15] So a simple sequencing of policy reforms oversimplifies what is needed in any country. Even transforming countries need to strengthen foundational skills, and emerging countries need to strengthen their provision of more advanced skills. But skill development is a cumulative process: it is hard to develop technical and high-order cognitive skills without basic literacy or a strong foundation of socioemotional skills. Similarly, foundational and more complex cognitive and socioemotional skills

Figure 5.8 Education that upgrades skills also facilitates higher adoption of digital technologies



Sources: WDR 2016 team, based on World Development Indicators (World Bank, various years) and the World Economic Forum Competitiveness Index (WEF, various dates). Data at http://bit.do/WDR2016-Fig5_8.

Note: The quality-adjusted years of education are constructed by multiplying the average years of education for each country by the normalized WEF's quality of education indicator; for more details, see Monroy-Taborda, Moreno, and Santos, forthcoming. The Digital Adoption Index (People) is the simple average of two normalized indicators from the Gallup World Poll: mobile access at home and internet access at home.

built early in life and throughout general education are the base for the building and updating of technical skills in postsecondary education and training.

Priorities for emerging countries: Build foundational cognitive and socioemotional skills and ensure basic ICT literacy

The analog agenda for building foundational skills starts early, as early as 0–3 years of age, and goes beyond investment in education to that in health.[16] These are the years when children become school-ready, their brains are the most sensitive to learning, and the basis for future learning is laid. Families, individuals, school and training systems, and employers will all play a role in building these skills throughout the life cycle. It is also important to build these skills before specializing too narrowly. Countries like Poland have delayed tracking of students into vocational education, with positive results.[17]

Digital technologies can help build these foundational skills. While there are concerns about the impact of digital technologies on cognitive capacities and socialization, especially among young children, these technologies are here to stay (box 5.3). "Before a child even starts primary school, she will be able to use her parents' smartphone to learn her numbers and letters, giving her a big head start," the Gates Foundation notes.[18] Online educational games for young children, with appropriate adult supervision, are increasingly used to develop foundational skills. ScratchJr, for example, is an application aimed at teaching algorithm thinking and coding principles to kids aged 5–7 years through a simple drag and drop interface.

Access to the internet, laptops, tablets, mobile phones, digital whiteboards, and video-based instruction are increasingly common in primary and secondary education. Programs like One Laptop per Child (OLPC) are operating around the world (box 5.4). In most cases, however, there is no solid evidence base of their effects on learning outcomes, and much more careful evaluation of ICT initiatives in education is needed. But five uses of technology in building foundational skills are promising: connecting teachers to content; making learning more personalized; reinforcing content learned in school; fostering collaboration and increasing students' engagement; and promoting adult literacy (table 5.2).

Digital technologies can complement teachers and connect them to content. The BridgeIT model, started in 2004 and now used in around 10 countries, allows teachers using mobile phones to download video content, which is then connected to televisions in their classrooms. The videos are paired with learner-centered lesson plans, accompanied by teacher training in how to use the technology and incorporate it in the class.[19] A separate initiative, the Bridge International Academies, goes even further. The largest chain of preprimary and primary schools in the world, with more than 110,000 students in Kenya and Uganda, it uses technology and data analysis to standardize and scale education delivery. While the standardization of teaching remains controversial and is being rigorously evaluated, it is an alternative way to make basic education more affordable. The average family of a student in the Bridge Academy lives on US$1.60 a day per person.[20]

Digital technologies can offer access to high-quality material where there are no teachers with the needed skills. In Uruguay, through video, English is taught to first graders by teachers from the Philippines. A pilot study found that videoconferencing and laptops raised the children's scores in English significantly, as well as the English-language proficiency of the Uruguayan teachers.[21]

Box 5.3 The impact of digital technologies on cognitive capacities and socialization

There are concerns about the impact of digital technologies on cognitive capacities and socialization, especially among young children and adolescents, and some evidence backs these concerns. For example, studies show that using search engines decreases our memory. When faced with difficult questions, people are primed to turn to their computers, and, when people expect to have future access to information, they have lower rates of recall of the information and enhanced recall of where to access it.[a] There are also concerns about internet addiction. A survey of nearly 12,000 adolescents in 11 European countries found a 4.4 percent prevalence of pathological internet use. An additional 14 percent had a milder addiction. People who exhibited problematic use were more likely to suffer from psychological problems, such as depression or anxiety.[b]

Yet the fear that new technologies lessen our ability to function is nothing new; in Plato's dialogue, The Phaedrus, Socrates worried that writing would diminish the ability to engage in conversation. Parents and schools can do things to lessen these risks. Strengthening self-regulation in young children can mediate potentially negative effects of internet use.[c] While it is true that using technology to do things for us that we no longer are doing for ourselves means that certain abilities can degenerate, it also means that we are freeing up cognitive energy for other things. More research on the impact of digital technologies on cognitive abilities, and how they can be managed, is an important agenda for the future.

a. Sparrow, Liu, and Wegner 2011.
b. Durkee and others 2012.
c. Spada 2014.

Box 5.4 One Laptop per Child: Strengthening analog foundations and careful evaluation

Of all the educational initiatives that involve digital technologies, the One Laptop per Child (OLPC) program (or more generally, 1 to 1 computing initiatives) is arguably the most ambitious. Its main objective—empowering children by providing them with digital devices at an affordable price—has captured the attention of world leaders, media, and academia.[a] Since the first laptop distribution started in Uruguay in 2007, OLPC programs have distributed more than 2.4 million laptops around the globe.[b] In Uruguay, the program was widely supported by children, parents, and school directors, providing internet access to many low-income children.[c]

Although all OLPC programs increased access to digital technologies, their implementation and impacts on learning outcomes vary greatly. In a meta-analysis of 15 studies of OLPC programs in five countries (China, Colombia, Ecuador, India, and Peru), only the programs that accompanied the distribution of laptops with some level of guidance, from providing training courses to using adaptive software for weekly sessions, improved learning. These guided-use programs had a positive, albeit small, impact of 0.17 standard deviations on average scores, against an insignificant effect for programs where use was not guided.[d]

The success of digital devices in the classroom in improving academic performance hinges on complementing access to digital technologies with investments in teachers, and on embedding the technology with relevant content that can be integrated with traditional classroom activities. More careful evaluations of pilot programs before they go to scale are also important to better understand whether the programs can produce positive results and are cost-effective, as well as the specific changes needed to improve their effectiveness.

a. Trucano 2012.
b. http://one.laptop.org/map.
c. Martinez, Alonso, and Diaz 2009.
d. Arias Ortiz and Cristia 2014.

Table 5.2 Emerging countries: A skill development agenda for a modern labor market

Priority	Pillars of an analog policy agenda	How digital technologies can complement
Foundational cognitive and socioemotional skills	• Early childhood development and school readiness	• Complementing teachers and expanding access to quality material (BridgeIT in the Philippines and Tanzania; Khan Academy) • Making learning more personalized through adaptive curricula and assessments
Digital literacy	• Mainstream of socioemotional skills and basic digital literacy in teaching methods and assessments • Adult literacy	• Reinforcing content learned in school, to consult with teachers or learn new material (Eneza, Kenya) • Facilitating learning and collaboration and increasing students' engagement (Educopedia in Brazil, game-based learning or online games) • Promoting adult literacy (using SMS in Niger and Los Angeles), in combination with e-entrepreneurship

Source: WDR 2016 team.

Note: SMS = short message service.

Digital tools also make it easier to tailor learning to each student and rapidly assess student progress. Impact evaluations suggest that the successful applications of technology help introduce an appropriate curriculum or enable students to move through material at their own pace.[22] Khan Academy is a good example (box 5.5). These types of tools can be particularly helpful in developing countries, where students often need to develop skills that their teachers lack or do not teach.[23]

Digital technologies can reinforce learning. In Mumbai and Vadodara in India, a math reinforcement program, delivered through computer games, had large positive effects on children's academic achievement.[24] Children were offered two hours of shared computer time per week, during which they played games that involved solving math problems. The program increased math scores by 0.35 standard deviations the first year, and 0.47 the second year. Similar uses of technology to reinforce learning are being applied around the world, often using simple mobile phones. Eneza Education, in Kenya, is a virtual tutor that provides practice questions and answers open questions via SMS (short message service) from students on low-cost mobile phones. It has 39,000 active users, and more than 380,000 people have used it at least once.

A fourth promising technology is facilitating collaboration among teachers and students and making learning more fun and effective through games and game-based learning. More often than not, students are not engaged in school. In more than 15,000 classrooms in seven Latin American countries, between one-fifth and one-quarter of total class time, a large group of students (six or more in classrooms with average size of 25) is visibly not engaged in the classroom. This is partly because most classes are boring: for about one-third of all time spent on teaching activities, teachers use the blackboard and nothing else.[25] Using digital technologies for collaboration (box 5.6) or for game-based learning could improve engagement and learning. At its simplest, textbook material could be made more engaging: eLimu, which has embedded the primary education curricula of Kenya in tablets, enriched the content with videos and other animations.

Yet introducing technology alone, without improved teacher training and links to changes in pedagogy, will not improve the learning process. Digital technologies are most likely to have an impact when the focus is not on hardware and software but on how they contribute to learning.[26] In Colombia, Computers for Education had little effect on student test scores and other outcomes. Although students in the program schools were 30 percentage points more likely to report using a computer at school, they used it only for computer science.[27] Similarly, in Ireland, teachers were positive about the usefulness of ICT in secondary schools, yet most uses were outside the classroom for preparing lessons, rather than exploiting the potential of ICT to introduce innovative teaching and learning practices.[28] As with One Laptop per Child (see box 5.4), annual evaluations of Text2teach, the local version of BridgeIT, in the Philippines have

Box 5.5 Khan Academy: A supplemental educational resource in and outside the classroom

Khan Academy is an online learning platform that provides free tutorial videos on disciplines ranging from elementary mathematics to computer programming. It attracts more than 10 million unique users a month (35 percent from outside the United States), who have viewed 365 million videos and solved more than 1.8 billion math problems.[a] It is an example of tools for the "flipped classroom," in which videos substitute for classroom instruction, and class hours are used for practice and discussion.

Khan Academy is built on free lecture videos, adaptive learning practice problems, and personalized data. Lectures are divided by subject, but users can select what to focus on, advance at their own pace, and receive instant feedback. Following the video lectures, students can practice, and the system adjusts the difficulty of practice problems based on a student's performance on the first few problems. Students' online performance is recorded, and students, teachers, and parents can follow progress through the personalized learning dashboards.

While Khan Academy is still used predominantly by individuals for informal study outside schools, its use in schools and other institutional settings is growing. There is not enough evidence to claim that it has been an unqualified success, but the evidence points to its considerable potential. SRI International studied the implementation of Khan Academy in nine schools in the United States from 2011 to 2013.[b] Khan Academy mainly supplemented teachers' own core instruction rather than replacing it. Forms of use varied: additional practice or remediation for students who fell behind, enrichment activities for advanced students, and monitoring student progress. Khan Academy increased engagement of students and the capacity of teachers to support their students, but teachers found it difficult to fully integrate it with the core curriculum.

A pilot in five schools in Chile had similar results.[c] Khan Academy improved student math skills, but was not "flipping the classroom." Moreover, the teachers believe that while Khan Academy improved the procedural skills, it was not best for promoting deeper mathematics learning.

Integrating tools like Khan Academy into education systems shares some of the challenges that other technologies in education face. Translation and adaptation to local contexts is costly. Khan Academy is partnering with other organizations in several countries to do this. And streaming videos requires high-speed connectivity, which is still limited in many developing countries. Since the success of the program is a function of teacher skills and engagement, school and government administrations should support teachers throughout the period of implementation.[d]

a. Murphy and others 2014.
b. Murphy and others 2014.
c. Light and Pierson 2014.
d. Trucano 2015.

identified the need to invest even more in teacher training for further improvement.[29]

Even when used, technology does not substitute for teachers. High-quality education continues to hinge on high-quality and motivated teachers. In India, the computer-assisted learning (CAL) program for math had very different impacts depending on how it was used. When the program supplemented regular classes with one additional hour of CAL instruction every day after school, it raised math scores by 0.28 standard deviation. But when it was a substitute for regular instruction, scores fell by 0.57 standard deviation.[30]

Governments can play an important role in building complementary investments to leverage educational technology. This is primarily about preparing and training teachers in the use of the technology and in how to incorporate it in the classroom. Training programs in developing countries often focus only on basic computer literacy. In Singapore, by contrast, both pre-service and in-service teacher training curricula integrate pedagogy and ICT.[31] With these investments, technologies can amplify teacher productivity and improve the quality of teaching. In systematic reviews of education interventions, technology-assisted learning, together with teacher training programs, have among the largest positive effects on learning outcomes.[32]

Outside formal education, digital technologies can also boost adult literacy. In Afghanistan, Chad, and Mali, more than 60 percent of adults remain illiterate; in Niger, close to 85 percent.[33] Digital technologies,

Box 5.6 Using digital technologies to foster collaboration and learning: Rio de Janeiro's Educopedia

In 2010, the Rio de Janeiro municipality launched Educopedia, a collaborative online platform of lessons open to students and teachers from public schools. By offering stimulating multimedia resources in the classroom, Educopedia's goals are to support teachers in creating and sharing teaching materials online and to increase students' motivation to learn. The lessons online cover math, Portuguese, science, history, geography, English, music, and physical education, organized by grade and week of the curriculum.

The modules generally blend videos and interactive exercises for students with a clear structure and repeated reinforcement questions. Each Educopedia module consists of a lesson plan to help teachers structure the class; supporting content such as PowerPoint presentations on new material and texts, videos, and games; and interactive resources such as a chat system, a digital library, quizzes, summaries, and sets of test questions. The materials are projected on digital whiteboards.

When the program was piloted, teacher take-up was low. The secretariat responded by asking the network of teachers that produces and assesses the adequacy and quality of online materials to reach out to colleague teachers and provide hands-on support in using the new resources. In 2010, Rio municipality teachers used information and communication technology (ICT) only 1 percent of the time in the classroom; a year later, use had quadrupled.

Today, Educopedia operates in all 700 Rio de Janeiro municipal schools and serves 680,000 students; 50 percent of teachers report that they use the tool more than once a week. The impact of Educopedia on student learning has not been evaluated yet, but the secretariat believes its effects on the motivation of both teachers and students are positive. Educopedia was one of the pillars of education reforms in Rio de Janeiro, which between 2009 and 2012 saw a 22 percent increase in its score in the Basic Education Development Index for middle schools. In a recent survey, 80 percent of Rio de Janeiro municipal students agreed that Educopedia contributes to their learning, particularly through the interactive exercises and educational games.

Sources: Bruns and Luque 2014; WDR 2016 team.

especially mobile phones, can promote basic numeracy and literacy for these adults. In Niger, including instruction on using simple mobile phones with voice and SMS capacity in a basic adult education curriculum substantially improved learning outcomes.[34] Similar programs in advanced settings, like Los Angeles, have had similar effects, with technology actually improving literacy without the need for teachers.[35] In only four months, basic reading scores went up about five years, and more advanced reading scores, about two and a half years.

Digital literacy is a new foundational skill

In a world where digital technologies are at the center of people's personal and professional lives, digital literacy—just like reading and writing—is a new foundational skill. Among children and youth, just giving access to these technologies can be enough for them to learn the basic use of devices. The evidence from One Laptop per Child (see box 5.4) and from Hole-in-the-Wall in India indicates as much.[36] The main challenge is to broaden the digital literacy agenda beyond the basic use of devices to focus more on information skills, including the ability of students to search for information and separate high-quality sources from low-quality ones. International experience offers some important lessons (box 5.7).

In many developing countries, the greater challenge is to reach adults, often in low-literacy environments. Lack of awareness of the potential usefulness of digital technologies remains an obstacle to adoption.[37] In some cases, digital technologies, especially mobile phones, are adapted for the illiterate or those with little education through the use of graphics, symbols, and audio or video tutorials. In addition to technical training, which can be costly and which many adults would not use, countries can raise awareness and demonstrate some of the potential benefits of digital technologies—as in Turkey, where a mobile unit goes to lagging regions and shows how to use government services online.

Among youth and adults, digital literacy training can be combined with e-entrepreneurship training and seed funding to conduct business over the internet. Two areas of focus could be e-commerce and online work. For e-commerce, the focus could be on how to

Box 5.7 Emerging lessons from digital literacy programs

Digital literacy programs considered most successful have some principles in common:

- They are mainstreamed into the non-ICT (information and communication technology) curriculum. They emphasize ICT as a tool rather than a subject. Students learn how to use digital technologies not in specialized and isolated labs but as part of their learning other subjects. Finland has gone for mainstreaming, which makes the digital skills learned more useful in real life, but requires training for all teachers. Training also aims at using internet search effectively and safely, and understanding privacy rules.
- They focus on teachers' digital literacy. Evaluations of Khan Academy, the rollout in schools of broadband in Ireland, eLimu and Eneza in Kenya, and the One Laptop per Child programs in Latin America show that a lack of digital literacy or fear of using new methods is a constraint for teachers. As a result, programs are increasingly being combined with intense teacher training. eLimu—which has embedded the Kenya primary education curricula in tablets and enriched the content with animations to make learning more engaging—had to extend teacher training from 15 minutes to a full day.
- They go beyond ICT, into the beginnings of "computational thinking." Such thinking refers to the problem-solving skills and techniques software engineers use to write programs, especially those related to breaking a problem into parts, pattern recognition, abstraction, and algorithm design.[a]
- They are embedded in local content (chapter 4). This can motivate learners by connecting them to information on issues relevant to them but also by reducing language barriers.

a. ISTE and CSTA 2011.

market yourself and be able to sell online. Countries could explore partnerships with e-commerce platforms. Alibaba, for example, offers training on how to sell on its platform, and has signed agreements with governments (such as the Republic of Korea) to do so. For online work, the training could focus on introducing participants to online work, setting up their profiles, and establishing payment accounts. Nigeria is starting to provide this type of training.[38]

Priorities for transitioning countries: Build new economy skills for careers, not just for the first job

Improving advanced cognitive and socioemotional skills requires rethinking curricula and teaching methods

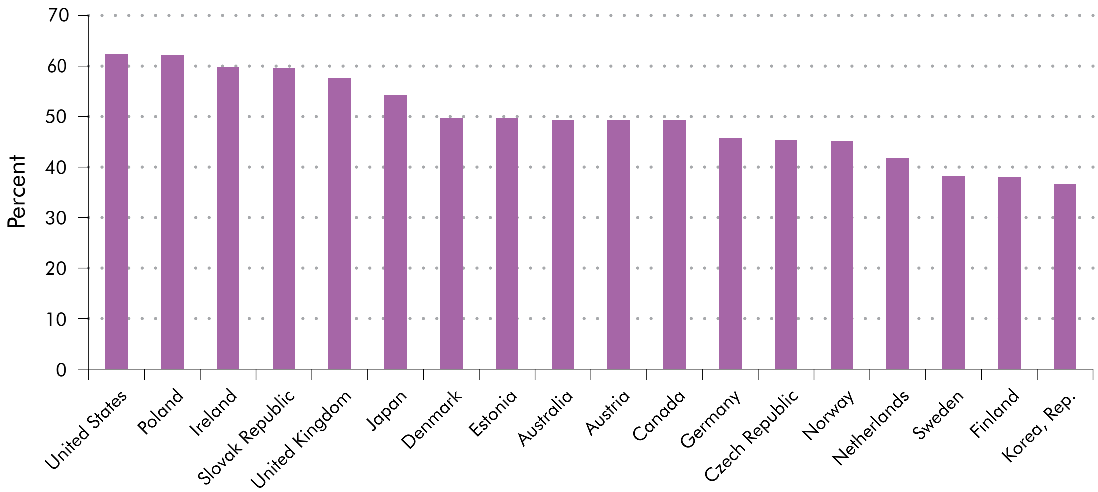
In addition to foundational skills, workers are being required to use more critical thinking and problem solving, communication, teamwork, and creativity. These are general skills, which many traditional education systems fail to impart, and can be applied across occupations and jobs (figure 5.9 and table 5.3). How can teachers, administrators, and policy makers create an environment that goes beyond rote learning and memorization, and where students really learn—where they think critically about information—and apply it to the world around them in meaningful ways?

A first step is to modernize general education curricula and teaching methods, shifting toward student-centered curricula that emphasize new economy skills. Which qualities school systems need in order to develop these skills is debated, but there is agreement that it needs to start early. One model is Montessori schools. Teachers trained in a Montessori perspective emphasize, from early childhood onward, attention to the individual interests of students. Classrooms are less hierarchical. Students have substantial unstructured time to collaborate around shared interests and freedom to research a topic of interest and present it to the class.[39] While rigorous evidence on this is limited, students in five Montessori middle schools in the United States were more intrinsically motivated and interested in their academic activities at school.[40] Similarly, the Perry Preschool Program in the United States teaches kids reading and math, but also to plan tasks, execute their plans, and review their work in groups. Although based on a small sample, the program has been found to boost socioemotional skills and to determine life outcomes of former students well into their 40s.[41]

Modern curricula should balance competency-based and content-based learning, and be combined

Figure 5.9 Even in advanced countries, youth are often unable to think critically and solve problems

Share of youth (aged 16–24) scoring below 2 in the Programme for the International Assessment of Adult Competencies in problem solving in technology-rich environments



Source: Davalos and Santos, forthcoming, based on the OECD Programme for the International Assessment of Adult Competencies (PIAAC) website, http://www.oecd.org/site/piaac. Data at http://bit.do/WDR2016-Fig5_9.

with teaching methods that stimulate and build in critical thinking, problem solving, communication, teamwork, and creativity. The New School model in Colombia (Escuela Nueva, in Spanish) has taken this approach, putting stronger emphasis on group learning and problem solving than on memorization and copying. This model has informed the modernization of the curriculum in many countries: so far, it has been piloted or has been already extended to around 17 countries (box 5.8).[42]

Countries like Brazil, Finland, the Republic of Korea, the former Yugoslav Republic of Macedonia, Mexico, Peru, Singapore, and Vietnam are taking actions to foster new economy skills.[43] Despite being a top performer in international student assessments, Finland recently concluded a large reform of its preprimary and basic education curricula. The aims are to develop schools as learning communities and to emphasize the joy of learning and a collaborative atmosphere, as well as promoting student autonomy in studying and in school life. In particular, there will be much focus on general transversal competencies and work across school subjects. The competencies will also be assessed as a part of subject assessment. The emphasis set on collaborative classroom practices will be brought about in multidisciplinary, phenomenon- and project-based studies where several teachers may work with any given number of students simultaneously.[44]

Table 5.3 Transitioning countries: A skill development agenda for a modern labor market

Priority	Pillars of an analog policy agenda	How digital technologies can complement
Higher-order cognitive and socioemotional skills	• Modern curriculum, teaching methods, and assessments with increased emphasis on critical thinking, problem solving, and socioemotional skills (Escuela Nueva model; Republic of Korea; Singapore) • Modernize teacher training in-service and pre-service accordingly	• Directly promoting critical thinking, teamwork, problem solving, and creativity (through online games, wikis, hackathons) • Delivery of training in socioemotional skills (grit and mind-set interventions) • Promoting collaboration (virtual exchanges)

Source: WDR 2016 team.

Box 5.8 Building new economy skills: Escuela Nueva in Colombia and Vietnam

The Escuela Nueva model started in Colombia in 1976 as an innovation in multigrade teaching, promoting active, participatory, and cooperative learning among primary school students. Today it serves 5 million students in 16 countries, including Brazil, the Dominican Republic, Mexico, the Philippines, Uganda, and Vietnam.

The model is based on several innovations for improving teamwork and developing critical thinking. The curriculum is focused on a self-paced and self-directed learning guide. Group learning is facilitated through the use of learning guides that contain interactive exercises. Teachers are trained in group management. Group learning is also fostered by class arrangements and a modified role of teachers as facilitators. Students are seated in clusters of four or five, with teachers guiding, supervising, and evaluating the children in these groups. The school calendar and evaluations are flexible, so that children can meet learning goals at their own pace.

Evaluations of the model in Colombia and elsewhere indicate that the program is fostering both cognitive and socioemotional skills. The model improves levels of Spanish and math in the third and fifth grades, as well as self-esteem and the abilities to lead others in group tasks and to work peacefully with others in a team. A recent impact evaluation of Escuela Nueva's first two years in Vietnam shows that the model helps children learn to work with each other and develop communication and interpersonal skills. Improved cooperative learning skills also enable a student to obtain better results in math.

Sources: WDR 2016 team based on Bodewig and others 2014; Colombia Aprende 2015; Forero-Pineda, Escobar-Rodriguez, and Molina 2006; Fundación Escuela Nueva 2015.

Singapore has also made large changes to its education system to adapt to the knowledge-based economy. The main change was in 1997, with a move from an efficiency-driven model to an ability-driven model.[45] The efficiency-driven model, an engineer's vision to education, had a top-down approach in designing, disseminating, and enforcing the national curriculum; streaming students by competency levels to ensure that teachers were dealing with students of similar levels; and creating clear but rigid paths to vocational and tertiary education. While this model produced students who scored high on international math and science tests, it produced students who were not critical thinkers and teachers who were not motivated.[46] Under the new ability-driven model, schools have more autonomy over their curriculum and develop programs to suit their students. More emphasis is placed on project work, introduced from primary education onward, with a move from high-stakes examinations to smaller assessments. The government has also emphasized the use of ICT in the curriculum.

Whether to streamline teaching new economy skills into the traditional curricula, as in Finland or Peru, or whether to teach them in targeted classes or interventions, as with grit (that is, perseverance in pursuing long-term goals) in FYR Macedonia, is an open debate. Even if taught separately, it is important to reinforce learning these modern skills across subjects. A teacher could give a lecture on history with little class interaction, or could break the class into small groups that would reflect on the reading material, prepare takeaways, and present to the whole class, thus teaching history as well as teamwork, empathy, communication skills, problem solving, self-regulation, and self-esteem.[47] Changes can also include introducing more open-ended questions in home assignments and in tests, more flexible classroom seating arrangements that allow work in groups, having discussions involving the full classroom, and creating spaces in classrooms and schools for collaborative projects. The increased demands on teachers need to be accompanied by modernizing teacher training, both in- and pre-service. Teacher training needs to focus on how to teach curriculum content and on how to impart socioemotional skills.

Countries are making progress in improving student assessments, critical for identifying strengths and weaknesses in the education system, designing policy, and strengthening accountability. Yet current assessments typically focus on testing information, facts, or the ability to read or perform math operations. While important foundational skills, these skills are often fairly routine and easily programmable, so student assessments can be further strengthened by broadening their scope to better incorporate higher-order skills.

Open-ended questions in tests can put greater emphasis on critical thinking and problem solving. New economy skills can be monitored, as is traditional academic learning, through mechanisms such as the KIPP Report card, where socioemotional skills are identified, measured, and discussed with parents and students at evaluation time.[48] At the international level, the Organisation for Economic Co-operation and Development (OECD) and the World Bank have recently implemented new skill measurement assessments that aim at measuring, among adults, problem solving in technological environments, and socioemotional skills, respectively.[49] L'Oréal, the French cosmetics company, asks job candidates in China to answer three open-ended questions on mobile phones, and then uses "big data" and an algorithm to mine the responses for cues on critical thinking and socioemotional skills.[50]

Digital technologies can also foster higher-order cognitive and socioemotional skills—in at least three ways:

- *Directly promoting critical thinking, teamwork, problem solving, and creativity.* This could be done through digital activities, such as programming. Scratch, a simple programming language for kids, can help develop abstract and critical thinking from an early age. Digital tools, such as wikis—online content-management systems that allow for collaborative modification, extension, or deletion of its content and structure—can promote discussion and communication inside and outside the classroom. Many schools are now using hackathons, events where teams collaboratively work on software projects, and which can provide a creative space that also fosters problem solving. Incorporating learning games into classrooms (game-based learning) and applying the principles of gaming to education (gamification) could also foster higher-order cognitive and socioemotional skills, such as abstraction, reasoning, and teamwork, while bringing the power of play to education and engaging, inspiring, and immersing students in learning (box 5.9).
- *Developing and delivering training in socioemotional skills.* Grit (that is, perseverance in pursuing long-term goals) and growth mind-set lessons,[51] for example, can be delivered via videos and over the internet. Additional online modules that target other socioemotional skills could be part of teachers' toolkits.
- *Supporting teamwork and communication skills by bringing together diverse teams and breaking the distance barrier.* The World Links for Development Program has worked with ministries of education in more than 20 middle- and low-income countries to link classrooms to the internet but also to one another. European Schoolnet has fostered long-term online connections among classrooms across borders.[52] Social media can also be used to connect classrooms.

Priorities for transforming countries: Focus on advanced technical skills and lifelong learning

ICT skills and training in computational thinking

As in other countries, the skills agenda for transforming countries needs to also strengthen foundational skills, and develop new economy skills, such as higher-order cognitive and socioemotional skills. Because the skill base in transforming countries is stronger than in the emerging and transitioning countries, they also have to focus on more advanced technical skills (table 5.4).

To address shortages in advanced ICT skills and improve competitiveness in a growing industry, countries are paying more attention to providing advanced ICT skills training in their education system. Many firms report difficulties in finding workers with advanced ICT skills (chapter 2). Partly in response, coding, as a subject, has been introduced in the general education curriculum in Estonia and the United Kingdom.

Incorporating advanced ICT skills in the general curriculum can teach computational thinking in transforming countries. But not everyone needs to become a professional coder. Incorporating coding in general education can strengthen not only ICT skills but also critical thinking, especially if it is a vehicle to teach logic and learning strategies for solving problems, designing projects, and communicating ideas. Done well, it can be not only about "learning to code" but about "coding to learn."[53]

Training in advanced ICT skills can also be provided less systematically, and outside of the formal education system. This could be the route for countries with less mature education systems. For example, advanced ICT skills could be offered in middle or high schools through accredited massive open online courses (MOOCs). Individuals can also learn coding through specialized online platforms. Codecademy, an online interactive platform that offers free coding classes in seven programming languages, has more than 24 million users who have completed over 100 million exercises.[54]

Box 5.9 Building modern skills: Game-based learning and "gamifying" education

Learning can be fun. Play can be a great conduit for learning and creativity because it taps into people's intrinsic motivation, satisfying needs of autonomy, competence, and relatedness. When playing, many people achieve a state of "flow"—a state of concentration that activates the brain and is considered optimal for new learning.[a] Applying the principles of gaming—rules, goal achievement, progressive difficulty, interaction and student control, uncertain outcomes, and immediate feedback—to classroom activities can teach both cognitive and socioemotional skills. Some games apply these principles to teach basic skills, such as math and vocabulary in games like King of Math and FunEnglish, while others integrate learning into the game. Dragonbox, Freddi Fish, and Guild Wars require creative thinking, problem solving, and building on existing knowledge to succeed.[b] Requiring inference and problem solving, rather than direct questioning for learning, they are more engaging and can lead to sustained learning.[c]

Games can not only increase engagement but also improve learning outcomes. A unique English program in India can be implemented with different technologies (a specially designed machine or games and activities based on special flash cards). New methods yielded gains of about 0.3 standard deviation in test scores.[d] A 2006 study of fifth graders found that playing math games was more effective than basic math drills at building math skills, as measured by performance on a standardized math exam.[e] And two science games, RiverCity, which emphasizes ecology and biology, and Supercharged!, a program on electrostatics, improved learning outcomes over a traditional lecture by 15 to 18 percent and 8 percent, respectively.[f]

But most of today's teachers are not equipped with the skills to make games effective learning tools, such as designing materials and environments for game-based learning, partly because they are not familiar with many tools of the digital age.[g] Teachers need to be trained so that they understand both the potential and the limits of games for learning and fully understand the game, how to play, and how to use it as a teaching tool. Teachers can work with parents in finding appropriate games and defining parameters for usage. Updated curricula, reformed assessments, and resources for learning games can all help to shift classrooms to be focused on learning. Policy makers could also encourage more research and development to create successful learning games that are engaging, thoughtful, and immersing, and facilitate efficient learning.

The future of games and game-based learning extends beyond the classroom. Evoke, developed by the World Bank, uses social media tools and narrative approaches commonly found in video games to empower young people to start solving urgent social, real-world problems. Food Force, created by the United Nations, teaches strategy and networking by simulating aid agencies working in food insecurity. The Facebook game Half the Sky highlights gender equality and raises money for female empowerment. Games can also be tools for job training, especially when real on-the-job training is dangerous; the U.S. military has used video games to teach strategy, skills such as first aid, and military rules and ethics.[h]

a. Jarvilehto 2014.
b. Becker 2007; Prensky 2006; Jarvilehto 2014.
c. McFarlane, Sparrowhawk, and Heald 2002.
d. He and others 2007.
e. Grabowski and Fengfeng 2007.
f. Mayo 2009.
g. Prensky 2006; Becker 2007; Jarvilehto 2014.
h. Prensky 2007.

Countries with a local technology industry or where online work is common, already teach advanced ICT skills outside the education system. In Kenya, NairoBits equips youth with knowledge in web design, IT skills, creative multimedia, and entrepreneurship. This technical training is combined with training in socioemotional skills to build self-confidence. NairoBits-trained youth have secured employment in both formal and informal sectors and report a job placement rate of 90 percent.[55] Similarly, iHub, one of the innovation and hacker spaces in Kenya, holds hacker labs for children and youth aged 10 to 16.

Many developing countries are partnering with the private sector to develop technical training in advanced ICT skills after general education. Mexico First, a partnership with Cisco and Microsoft, targets professionals and university students to facilitate training and certification in ICT.

Table 5.4 Transforming countries: A skill development agenda for a modern labor market

Priority	Pillars of an analog policy agenda	How digital technologies can complement
Advanced ICT skills and STEM in general education and beyond	• Strengthen collaboration between the private sector, governments, and educational institutions (Mexico First) • Promote STEM education	• Coding for kids (Scratch) • Coding among adults and outside the educational systems (NairoBits, Kenya; Codecademy) • Enhancing practical training (virtual labs and online work)
Lifelong learning	• Promote practical training in education • Provide incentives for firms to provide on-the-job training	• Increasing flexibility and reach for adult learning (MOOCs)

Source: WDR 2016 team.

Note: ICT = information and communication technology; MOOCs = massive open online courses; STEM = science, technology, engineering, and mathematics.

Strengthening education in science, technology, engineering, and mathematics (STEM)

Improving STEM education has become a major goal not only in transforming countries but also in most other countries. But good intentions are not always paired with concrete and effective actions. Addressing shortages and deficiencies in the teaching of STEM requires preparing and equipping teachers properly and including STEM across the educational system—not just in tertiary education. It also requires creatively involving the employers, more effectively connecting the teaching and research activities, and establishing financial incentives or compensatory mechanisms to make STEM education viable and affordable to underrepresented groups. And it requires enabling institutions and governments to share experiences and lessons in addressing the STEM education deficits. The World Bank–funded Partnership for Skills in Applied Sciences, Engineering and Technology brings together the expertise in several Sub-Saharan countries with that in Brazil, China, India, and the Republic of Korea.

Women are much less likely than men to choose a STEM field in tertiary education, in both advanced and developing countries, and this is partly reflected in occupational choices. In the United States, although women fill close to half of all jobs nationwide, they hold fewer than 25 percent of STEM jobs, and for every dollar a man earns in STEM, a woman earns 86 cents.[56] Women with a STEM degree are more likely to work in education or health care.

The gender gap in STEM fields starts early, both in the education system and at home. In OECD economies, at age 15, fewer than 5 percent of girls consider careers in engineering and technology, compared with 18 percent of boys.[57] Addressing gender stereotypes in school and at home can encourage girls to believe that they have the required ability for STEM and that significant opportunities will emerge for them. Other actions include providing girls with relevant role models; targeting girls for recruitment into the STEM fields early in their education, as Finland does; clearly establishing targets and incentives for recruitment, retention, and graduation of women in STEM fields; and working with employers to make work settings gender-friendly.

Promoting lifelong learning in rapidly aging societies

In rapidly changing labor markets, the skills learned in formal education risk becoming obsolete. Continued (re)training and upskilling can help workers stay current, and ensure that their skills are complementary to new technological developments.

A first part of a lifelong learning agenda is ensuring that the skills students learn are useful for entering the labor market and provide a strong base for continuing to learn on the job. Given the pace at which digital technologies are changing and how they are changing the labor market, students and adults must learn how to learn.

Governments can:

- *Provide students with practical training and exposure to the world of work prior to their graduation.* In addition to traditional apprenticeships, technology can be useful. Virtual labs and simulation games for science education and machine operations are spreading and moving ever closer to the brick-and-mortar experience.[58] Online work can also expose young students and trainees to the world of work.

- *Explore modular approaches to learning* so that students can move between education and work, as in Denmark or in College to Careers in the United States in postsecondary education. In the latter, students complete modules with clear accreditation and competencies acquired (often equivalent to "expertise" levels), which allow them to monetize the newly acquired skills in the labor market, even before completing the full degree. Students can then return to the community college and continue to the next level of expertise. Nanodegrees or microdegrees, offered by MOOC platforms Udacity and Coursera in partnership with the private sector, take the modular approach to online-based education.
- *Strengthen links between the private sector and higher education and vocational systems.* Ensuring that graduates from the education system acquire job-relevant cognitive, socioemotional, and technical skills requires that firms, universities, and vocational schools, and current and future students, become better connected. The German dual system is a very formal and institutionalized way of fostering these links, but there are other approaches. Chicago's reforms of the city's community colleges targeted curricula more explicitly to sectors with a large presence in the region, including manufacturing and insurance. Specific components of these curricula were discussed with major employers in these sectors to ensure relevance for the job market.[59]
- *Focus publicly financed training on new economy skills and ICT skills.* New economy skills are likely to be underprovided by firms because the benefits do not accrue solely to the firm.[60] Several youth employment programs, such as Jovenes in Latin America, combine technical training with socioemotional skills for disadvantaged groups, and many have had an impact on employment and earnings.[61]

  Vocational training institutes in developing countries are starting to use the internet to deliver at least parts of their courses. The Dominican Republic training institute offers a wide range of online courses, including teacher training and inventory management, and reports particular interest from youth and individuals who are already working or who have family responsibilities.[62] MOOCs can also be a tool for lifelong learning (box 5.10).
- *Promote on-the-job training.* Traditional market failures limit on-the-job training[63] so one common mechanism for promoting on-the-job training is to have institutional arrangements between employers and employees. "Payback clauses" commit the worker to stay at the firm for a specific amount of time if training is provided. In apprenticeships, the worker shares the costs of training through lower wages. The German apprenticeship system is a well-defined program that relies on a dual system of classroom training in vocational institutions and training at the workplace.

  A second common mechanism for on-the-job training relies on financial arrangements that internalize some of the externalities related to employer-provided training. In developing countries, this typically takes the form of training funds, usually through payroll taxes, as in Brazil, Chile, Malaysia, and Mexico. Other schemes compensate firms for the cost of training through levy exemptions, tax rebates, and cost reimbursements. But as with other subsidies, these can be inefficient and crowd out private expenditures on training. It is, therefore, important to target the subsidies carefully, trying to go beyond firm size, as in Malaysia's Human Resources Development Fund.[64] In OECD countries, different cofinancing savings and loan schemes match individual contributions to contributions from employers and governments. Individual learning accounts, learning vouchers, and income-contingent repayment loans are just some of the possible instruments that could be used.[65]

Box 5.10 Massive open online courses (MOOCs): A promising tool for lifelong learning

MOOCs are a recent development in distance learning, characterized by three key aspects: open enrollment, online assessment, and an interactive forum. They separate themselves from traditional distance learning tools by providing postsecondary education in large scale. They are mostly free, with fees for getting certifications. Some popular courses' enrollment reach over 100,000 students. Platforms such as Coursera.org, Udacity.com, and edX.org host these online courses, facilitate online discussions, and assess participants' performances. In the first two years

(Box continues next page)

Box 5.10 Massive open online courses (MOOCs): A promising tool for lifelong learning *(continued)*

following its introduction in summer 2012, open courses offered by HarvardX and MITx, and hosted by edX, attracted an average of 1,300 new participants per course per day.[a]

MOOCs are promising. People from anywhere around the world can access postsecondary education from prestigious institutions with only a gadget and access to the internet. Among adults who work and who have a certain level of skills, online education can be a powerful force for lifelong learning. These are individuals who would appreciate the flexibility (since they can combine it with work, which is one of the usual barriers for retraining). These are also workers who are likely to be best prepared for self-guided learning. In addition, the courses provide access to specialized topics that may not be available in the local economy. At the very least, MOOCs can complement offline learning.

Coursera and edX have started to evaluate their programs. One study finds that a slight majority of MOOC students are seeking certification, and those opting for fee-based, ID-verified certificates have higher rates of completion. The study also finds that literacy and motivation to self-study are necessary characteristics to access and complete MOOCs, but so are more basic elements such as high-speed internet and digital skills.

Yet, while their potential is large, there are questions about financial sustainability, the value of online education, and the evaluation methods. Another study argues that MOOCs are an improvement on noninteractive, online courses, but that the current model is unsustainable. Eventually, content will no longer be free, and star instructors will have to be paid like stars. And although they can be an efficient way for transferring content and reinforcing learning, especially in basic courses, the lack of face-to-face interactions, the absence of individualized feedback from faculty, and the lack of access to complex infrastructure such as labs, make MOOCs an unlikely competitor to existing postsecondary education institutions, especially in the developed world.[b] Finally, in terms of evaluation, MOOCs are complementing multiple-choice and short-answer questions with peer-grading and peer-commenting systems, in which students help each other with assignments and comment on each other's work.

a. Ho and others 2015.
b. Hoxby 2014.

Institutions: Connecting for a capable and accountable government

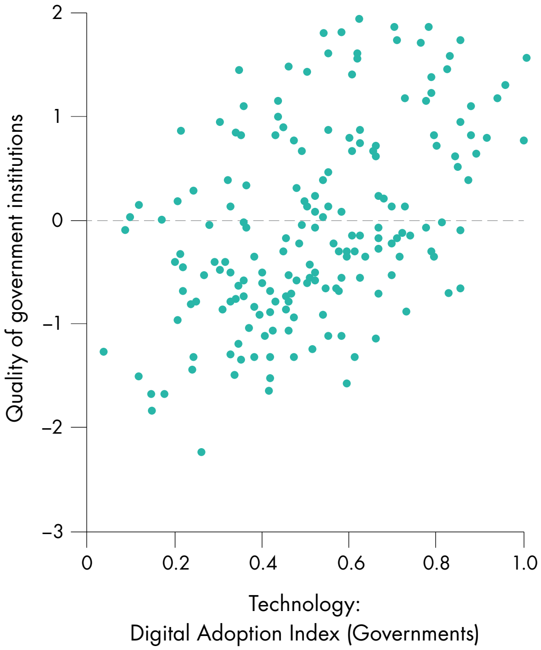
Digital technologies have had limited impact on strengthening government capability and accountability because of the misaligned incentives of policy makers and service providers—a gap between institutions and technology. They have helped willing and able governments serve their citizens better, but they have not yet empowered citizens to make unwilling governments more accountable. The policy agenda is thus to use digital technologies to strengthen institutions by tailoring policies that are compatible with the incentives of politicians and providers. The policy choices for different country contexts are informed by the findings in chapter 3 that for some services, digital technologies can substitute for weak institutions and be transformative—while for other services, digital technologies are only complementary and require strong institutions to have an impact.

Technology mixes appropriate to institutions

The policy agenda needs to be guided by the country context, classified here as emerging, transitioning, or transforming depending on the extent to which government uses digital technology and the quality of political and administrative institutions (figure 5.10).

Emerging countries are characterized by weak institutions and, in fragile contexts, the institutions may be failing. Politicians are often kept in power by a narrow set of elites who are largely unaccountable to the poor. The bureaucracy is largely patronage-based, with little incentive to deliver services. These reform contexts are the most difficult, as the state is failing not only to deliver services but also to perform the most basic functions of maintaining security. The priority in these countries is to lay the institutional foundations so that governments can start performing basic functions. They should ensure that teachers and doctors show up to work and are paid on time. They should curtail the outright theft of public funds

Figure 5.10 Countries with more accountable governments also adopt more digital technologies



Sources: World Governance Indicators (World Bank, various years) and WDR 2016 team. Data at http://bit.do/WDR2016-Fig5_10.

Note: The Digital Adoption Index (Governments) is the simple average of three normalized subindexes: core administrative systems, online public services, and digital identification. Data for online public services are provided by the UN's Online Service Index. Data for core administrative systems and digital identification were compiled by the World Bank for this Report.

through transparency and accountability measures. And they should strengthen alternative channels of service delivery through nonstate providers. The focus, from the perspective of this Report, should be in areas where digital technologies can be effective substitutes for these weak initial institutional conditions. Around 15 to 20 countries fall into this category, among them such fragile and conflict-affected states as Afghanistan, the Democratic Republic of Congo, Haiti, Somalia, the Republic of Yemen, and Zimbabwe.

Transitioning countries have mixed institutions characterized by pockets of pro-poor politicians and performance-oriented agencies. The priority for these countries should be to take advantage of this institutional heterogeneity and to use digital technologies to strengthen government capability in the "islands of excellence" that exist, and through demonstration, scale them up. The emphasis should also be on targeted transparency initiatives, those likely to be relevant to the daily lives of citizens and able to mobilize a broad coalition of supporters among businesses and other elites to align their incentives with those of willing politicians. Most developing countries fall into this category.

In transforming contexts, governments are generally accountable and capable, internet access is close to universal, many services are online, and many back-office systems are automated. One big challenge in taking e-government to the next level is the relatively low use of online services by citizens, especially poor households. Within-government collaboration across ministerial lines is weak, pushing up the transaction costs for citizens to interact with government. Another challenge is that government-citizen collaboration in policy making and service delivery is limited. Policies should focus on deepening collaborative institutions, both within government, through whole-of-government service delivery—and between government and citizens, through participatory approaches, while instituting digital safeguards to protect privacy.

Digital technologies can help in implementing policies more effectively. The key is to align the choice of digital technologies with their availability, skill requirements, and political incentives (table 5.5). While the focus here is on what to do, aligning

Table 5.5 A framework for policies: How to improve services in different contexts

Emerging countries: Laying the foundations for institutions	Transitioning countries: Building capable and accountable institutions	Transforming countries: Deepening collaborative institutions
• Improve informational services to citizens • Strengthen provider monitoring and payment • Establish population registers • Scale up nonstate provision of services • Increase electoral accountability	• Strengthen government delivery systems • Strengthen provider management • Get regular user feedback on service quality • Increase transparency in priority areas	• Improve collaboration across government • Enhance participatory policy making

Source: WDR 2016 team.

policies to institutions should also guide what not to do. For example, the misalignment of policies and political and administrative incentives is one of the most common reasons for failed ICT interventions in government. As chapter 3 showed, many low-income countries have overinvested in low-impact administrative systems, resulting in fiscal waste. So, to use the popular metaphor, investing in "toilets, not the internet" may indeed be advisable. Similarly, political elites will have little interest in collaborative service delivery or citizen engagement in clientelist systems, suggesting that an across-the-board push for open data in emerging contexts is unlikely to be successful.

Emerging countries: Laying the foundations for institutions

Given the persistent failure of many governments to deliver adequate services, the priority in emerging contexts is to use digital technologies to begin building the foundations of government institutions and, where possible, to support alternative institutional channels for delivering services. The digital solutions should be relatively simple and low cost and should not require significant business process reengineering in government bureaucracies or interagency collaboration. Where possible, they should substitute for inefficient government institutions. And to be incentive compatible, they should deliver immediate and visible benefits for politicians without threatening the elites who keep them in power. Examples of appropriate technologies and complements appear in table 5.6.

Although institutions are failing, mobile phones are ubiquitous, and many poor people in even the poorest countries have a cellphone. This almost universal access opens many possibilities for mobile-phone applications to improve services and outcomes, substituting for ineffective institutions in some services and functions. However, what poor people lack is an official identity, which excludes them from accessing many services, both public and private. So, a priority should be to build digital civil-identity systems to establish citizenship and become a platform for nonstate provision of services.

Table 5.6 Emerging countries: An agenda for laying institutional foundations and improving services

Technology	Complements
• Mobile phone–based informational services • Mobile phone–based monitoring and management • Digital population registers • Digital election monitoring	• Civil society and community involvement • Traditional media • Rewards and not sanctions

Source: WDR 2016 team.

The underlying policies can be grouped in five categories: improving informational services; strengthening the monitoring and management of service providers and facilities; developing robust digital population registers for citizen identity; strengthening nonstate provision of services through for-profit and not-for-profit providers; and improving electoral accountability through better monitoring.

Improve informational services to citizens

Mobile phones are delivering information to poor citizens in a variety of low-income countries with positive outcomes, and health applications are among the most promising uses of digital technology (see sector focus 3). In Malawi, governments and nongovernmental organizations send daily reminders to HIV-positive patients on their treatment schedule. In the Democratic Republic of Congo, health call centers enable mothers to get answers to questions about their children's health. And in Benin, Uganda, and Zambia, mobile apps raise health awareness and monitor disease outbreaks.[66] Mobile phones have also improved communication between governments and citizens for natural disasters and relief efforts—and promoted literacy through daily text message stories and teaching tips for teachers, with promising initial results (see sector focus 2).

Strengthen the monitoring and management of service providers and facilities

Ghana, Niger, Pakistan, and Uganda have demonstrated the efficacy of mobile phones as a cost-effective monitoring technology to address absenteeism among teachers and health workers. In principle, similar monitoring approaches can be applied to address missing textbooks, drug stock-outs, and petty corruption. Scaling up from pilots to national programs will, however, face bureaucratic resistance—to be mitigated by focusing on rewards instead of sanctions, such as financial incentives and recognition in the local community. A basic reward—or right—is getting regularly paid for work, a problem in many low-income countries due to inefficient budget execution. In Haiti, three-quarters of school teachers surveyed had gone unpaid for months at a time.[67] Mobile payment platforms provide a low-cost solution, as in the Bridge International Academies in Kenya. If linked to digital population registers, they can also identify ghost workers, as in Nigeria, where a digital identification scheme for civil servants removed about 60,000 fictitious workers from the government payroll, saving US$1 billion annually.[68]

Establish population registers

Digital population registers can establish citizen identity and be leveraged later for a variety of applications through appropriate credential verification (see spotlight 4). The focus should be on developing the identity database and on the systems to ensure completeness and high quality. Only after the country has developed harmonized identity registers can it legitimately begin to tie e-services and issue the right credentials to support them. In many cases, countries, under vendor pressure, have prematurely procured costly smart cards, which then remained unused as the identity registers had not been developed first. India focused on enrollment and unique identity and launched the program without any smart cards or credentials, just an Aadhaar number communicated to individuals. Now, more than five years later, different programs are issuing application-specific credentials linked to the Aadhaar framework and database.

Scale up nonstate provision of services

Citizens in many low-income countries send their children to nonstate schools (for-profit or not-for-profit) and seek care from private health providers. Nonstate provision raises questions of equity and quality. These risks can be mitigated through regulations, disclosures, and public-private partnerships, such as voucher programs and contracting out. These programs, if implemented well, can be highly effective. In an educational scheme for marginal communities in rural Pakistan, the government paid the private provider a per-child subsidy, increasing primary school enrollments and boosting test scores by 30 percentage points.[69] These programs can also be compatible with the interests of even clientelist politicians, as they are likely to be supported by important stakeholders like the business community and private service providers.

Nonstate provision theoretically relies on the power of the market to solve accountability failures in ways that public provision cannot. But in practice, parents may lack the choice of alternative providers or the information on provider quality to "vote with their feet" and hold nonstate providers accountable. The impact of low-cost private schools on student learning is generally positive, but in some cases they can be even worse than their public counterparts.[70] Performance agreements between governments and nonstate providers require some contracting and monitoring capacity in government, and the collection and verification of data to hold nonstate providers accountable.

Digital technologies can improve the impact of these schemes through better data collection, monitoring, and dissemination of information on provider quality. Parents can make more informed decisions, fixing the market failures in private provision. Nondigital school report cards in Pakistan's rural Punjab for example, improved parental information, lowered private school prices, and boosted school quality.[71] Digital technologies can make these choices easier through simpler versions of the school and health care provider rating systems that are now commonplace in the high-income countries. And governments, in the absence of parental choice, can better hold the private providers to account.

Improve electoral accountability

Digital technologies are improving both the sanctity of elections and providing citizens with meaningful and actionable information on government performance. Although the number of electoral democracies in poor countries has increased over the past two decades, the integrity of elections in these new democracies is low. Over half of the elections over the past decade had irregularities either in the run-up to the election or on election day.[72] Elections are well-suited for digitally enabled monitoring. As high-profile events that attract significant international attention and scrutiny, improving electoral integrity may be possible even in politically difficult emerging country contexts.

Digital technologies can reduce election violence, as in Kenya and Mozambique, and uncover fraud in vote-counting, as in Afghanistan. Digital identification is being increasingly used to register voters. In Pakistan for example, ahead of the 2013 parliamentary elections, the digital identity database was used to clean the electoral rolls, leading to the removal of 37 million voters with either no, invalid, or duplicate identities, and the addition of 36 million new voters, mostly young and poor, who had valid identification.[73] Similarly, in the 2015 presidential election in Nigeria, biometric identification was used for the first time to enroll 68 million voters and to eliminate 4 million duplicate identities (see spotlight 4). Despite these successes though, biometric identification is not without its risks in emerging countries. Simpler, lower-cost monitoring technologies like cellphones that require fewer institutional complements may be preferable.[74]

Digital technologies can also improve electoral accountability by exposing corruption and abuse of office, thereby better enabling voters to sanction lawbreaking politicians. Municipal audits in Brazil and Mexico show that targeted digital transparency initiatives can provide salient and credible information on corruption and on the quality of candidates that is easy to understand and attribute to individual politicians. Widely disseminated before an election, such information can influence voters' decisions. But such initiatives are contingent on a supportive legal framework—such as right to information laws or disclosures of conflicts of interest and assets—or on independent supreme audit institutions that may be absent in these country settings. Civil society advocacy, in partnership with traditional media, is necessary to uncover abuse and to make this information available and understandable to voters.

Transitioning countries: Building capable and accountable institutions

By introducing an automated complaint management system we took a noose and put it around our own necks. We are now accountable!

—A manager of the Nairobi water utility

Countries transitioning digitally have invested in the automation of core government administration, such as digital identification, financial and sector-specific management information systems, and on government-to-citizen and government-to-business services. They can increase the impact of these investments through complementary policies and strengthen performance orientation in bureaucracies.

Strengthen government delivery systems

These countries should continue to expand e-government, particularly digital identification systems and the business and citizen-facing services like online registration of businesses, e-filing of taxes, e-procurement, and citizen service centers. But these investments should be conditional on enacting the complementary reforms of regulatory changes, improving interdepartmental and interagency cooperation, and streamlining procedures. Digital technologies can strengthen project management through better monitoring of the different stages of the project cycle. By making procurement and contract monitoring more transparent, they can also give agencies flexibility in negotiating contracts with vendors, relaxing the procurement rigidities that cause many ICT projects to fail (box 5.11). Examples of appropriate technologies and complements appear in table 5.7.

Institutionalize user feedback on service quality

Incorporating citizen feedback into policy maker-to-provider management routines can be a powerful mechanism for tackling petty corruption and improving services, as in the Dominican Republic, Kenya, Nigeria, and Pakistan (chapter 3). It works especially well for private goods and services that are easy to

Box 5.11 Increasing the impact of e-government systems

Better project management: The U.S. Office of Management and Budget in 2009 introduced the IT [Information Technology] Dashboard, a public website that provides detailed performance information on major IT investments by the federal government. That information is then used to review problem projects at monthly TechStat meetings between the federal Chief Information Officer and the respective agencies. The Government Accountability Office found that these reforms improved the transparency and oversight of government IT spending.

Flexible and transparent IT procurement: E-government projects often fail because of rigid procurement rules. But making procurement transparent can ensure that discretion is not abused. The European Union allows agencies to negotiate with multiple bidders and award the contract to the vendor with the best revised bid. The greater discretion would not be possible without the greater monitoring, accountability, and trust afforded through the e-procurement system.

Public-private partnerships: A number of middle-income countries have implemented e-government projects through public-private partnerships, minimizing the risks of failure associated with misaligned incentives and limited government capacity. Such partnerships are feasible for revenue-raising services, for managing citizen service centers, as in Brazil and India, and for government e-procurement systems, as in the Indian state of Karnataka.

Sources: U.S. GAO 2014; Kenny 2014; Krishna 2015, for the WDR 2016.

Table 5.7 Transitioning countries: An agenda for building capable and accountable institutions and improving services

Technology	Complements
• Digital ID, G2G, G2C, and G2B e-government and e-procurement systems • Digital performance management • Targeted digital transparency initiatives • Digital platforms for citizen feedback and participation	• Streamlining of procedures • Improved interdepartmental cooperation • Regulatory reforms • Public-private partnerships for fee-based services

Source: WDR 2016 team.

Note: G2B = government-to-business; G2C = government-to-citizen; G2G = government-to-government.

monitor, like drivers' licenses, property transfer and registration, and water and electricity connections, since users have both the incentive and the ability to provide feedback. Politicians are likely to support it because it yields immediate and visible service improvements without threatening elites and vested interests. Similar approaches can monitor service providers, facilities, assets, and public spending.

Digital platforms can also raise resources from citizens to fund infrastructure, hire contract teachers, and purchase drugs and educational materials, and digital monitoring technologies can assure citizens that their contributions are going to their chosen causes. GiveDirectly, a Silicon Valley–based philanthropy, enables well-off individuals all over the world to contribute funds directly to poor beneficiaries in developing countries. The private sector has also been much more successful in getting citizens to create internet content for public causes. Wikipedia, Yelp, Trip Advisor, and Amazon product reviews provide lessons for solving collective action problems and engaging citizens in public service delivery improvements.

Strengthen provider management through regular small-stakes monitoring

Most services and functions in government—teaching, curative health, policy making, and management—require considerable discretion from workers and produce outputs and outcomes that are difficult to monitor. Improving these services requires strong institutions. Digital technologies can only augment and not substitute for institutions. Even though measuring performance is difficult for these services and functions, the processes of setting goals, of regularly communicating and discussing them with staff, and of associating small rewards, such as public recognition, for teams and individuals in the achievement of even imprecisely measured goals can motivate workers to perform better (box 5.12). A survey of government workers in the Philippines found that a performance incentive scheme triggered improvements in management practices through goal setting and improved teamwork.[75] And a mobile phone–enabled

Box 5.12 Regular, small-stakes monitoring

Regular monitoring with small rewards or sanctions can be more effective than irregular monitoring with large rewards or sanctions. The logic of this proposition is motivated by the economic theory of crime that postulates that the incentives for criminals to commit a crime are a function of the probability (P) of getting caught multiplied by the severity of the punishment (C). While standard economic analysis presumes that what matters is only the product P x C, the evidence suggests that raising the severity of punishment in response to low probabilities of catching criminals is not credible because many law enforcement officials are loathe to impose draconian punishments for smaller offenses. For example, in Hawaii, revoking probation when probationers failed a drug test was for years an ineffective strategy, given the large numbers of violators and the impracticality of sending them to prison for several years. But raising P and lowering C—regular, randomized drug tests and jail sentences of two days—deterred parole violations because the punishment strategy became more credible.

These findings are generally applicable to other services. Digital technologies reduce the cost of monitoring and thus make it more feasible to give regular rewards and sanctions. If the rewards and sanctions are small, they can be feasibly imposed, improving performance.

Source: Romer 2013.

monitoring scheme increased the motivation of rural teachers in part by showing that officials in the faraway ministry of education cared about their work and were looking out for them.[76]

Digital technologies can improve goal setting and within-government communication between policy makers, managers, and providers. Many private organizations are introducing short "pulse" staff surveys to get rapid responses from employees on particular issues, to gauge employee motivation, and to motivate workers through "employee of the month" public recognition schemes, and "gamification" techniques like assigning points, leaderboards, badges, and other small rewards for the achievement of particular activities.[77] The ubiquity of mobile phones makes such within-government feedback channels quite feasible even in low-income countries, and can certainly be applied in the pockets of excellence in transitioning contexts. While the measurement of performance and the feedback is subjective and imprecise, it is the regular communication and monitoring tied to the small-stakes rewards that improve worker motivation.

Reinforce targeted transparency initiatives

Digital technologies can provide a new lease on life for transparency initiatives such as the Open Government Partnership, an international platform for committed domestic reformers. But the initiatives should be targeted and of value to citizens and of interest to the private sector and other important stakeholders. Consider the transparency of government contracting. Governments annually spend over US$9 trillion on procurement, at high risk of corruption, both in bidding and during contract execution.[78] E-procurement is technically easy to implement, yet, as described in chapter 3, developing countries have invested less in such systems than in the more complex budget and treasury systems—or have done so without the complementary reforms to deliver results. E-procurement also has the potential to galvanize substantial support from the business community by reducing barriers to entry—since it expands the market to new entrants, including international firms—and by opening political space for reform.

Digital technologies can also expand the range of actors that generate information, breaking the state's monopoly in information provision. Because such information can be skewed toward the digitally savvy, it should be used where representativeness is not a requirement and the risks of manipulation are small, as with real-time information on emergencies or on the quality of services that are easy to monitor, like electricity and water.

Transforming countries: Deepening collaborative institutions

Many transforming countries have improved service delivery, but only in some areas. Their services are not yet sufficiently integrated, holding them back from more ambitious interventions such as greater government-citizen collaboration in policy making and service delivery.

Increase citizen use of government services through integrated whole-of-government digital solutions

The gap between the provision of e-services and their use is wide—even in digitally advanced countries—and it is not closing. In Australia, Canada, and New Zealand, a majority of survey respondents prefer traditional channels like phones for routine transactions such as paying taxes or registering children for day care.[79] This low use reveals the waste in e-government investments. Part of the explanation lies in less friendly experiences. Federal government websites in the United States provide a poorer user experience than comparable private ones.[80] Of more than 400 applications that the Korean government offers over smartphones, none meet the criteria of a seamless, cross-agency, or cross-functional one-stop service.[81]

Increasing use will require better integration of e-government across government, which requires breaking down agency silos and improving data sharing across government. In the private sector, digitally enabled improvements in customer service, a core differentiator in the service industry, are conditional on high levels of shared knowledge in the firm.[82] Estonia's X-Road data-sharing protocol shows how data integration can work within the constraints of the ministry and agency structure of government (box 5.13). Data integration is also essential for effective open data platforms that the private sector can use to develop applications that citizens want. Examples of appropriate technologies and complements appear in table 5.8.

Expand participatory policy making and service delivery

Increasing use of digital technologies is also conditional on a better understanding of citizens' needs and thus on simplification and customization. Behavioral research has shown that individuals are "cognitive

Box 5.13 Estonia's X-Road

Estonia's X-Road is an internet-based e-government system that enables participating institutions, including private business, to communicate and exchange data.[a] It serves as a platform for application development by providing numerous common services to users, including query design, query tracking, and data visualization. Its open design is protected by digital authentication, multilevel authorization, log monitoring, and encrypted data transfers. This collective process improves the user experience and motivates state institutions to develop digital services and people to tap into digital government services. The common goal is to shift activities from the physical world to the much more efficient digital realm.

X-Road's utility is evident in its exponential growth. The system launched in 2003 with 10 participating institutions. By 2013, almost 900 had joined—70 percent are national or local government agencies, and the remainder private firms. The annual number of queries through X-Road rose from half a million to 340 million. In 2014, two-thirds of queries were automated system-to-system exchanges. The remaining one-third, about 113 million human queries, reflects enormous demand for e-services from a population of only 1.3 million.

The system's main strength is that it is decentralized. Participating institutions retain ownership of their data, but can share it or access other institutions' data as necessary. Estonia's Public Information Act prohibits institutions from requesting user information already stored in a data repository connected to the X-Road.[b] Thus the system's architecture—coupled with complementary policies—has reduced the need for repetitive data entry, increased government efficiency, and reduced costs to users. If e-services are assumed to yield 30 minutes in time saved per interaction (for the service provider and the citizen) relative to predigital physical interaction, the number of applications in 2014 implies a savings of more than 7 million work days a year—5.4 work days for each citizen.

Source: Vassil 2015, for the WDR 2016.

a. See the Information System Authority's website at https://www.ria.ee/x-road/.
b. https://www.riigiteataja.ee/en/eli/522122014002/consolide.

Table 5.8 Transforming countries: An agenda for deepening collaborative institutions and improving services

Technology	Complements
• Integrated whole-of-government digital solutions	• Breaking down of silos
• Participatory policy making and service delivery	• Learning from the private sector

Source: WDR 2016 team.

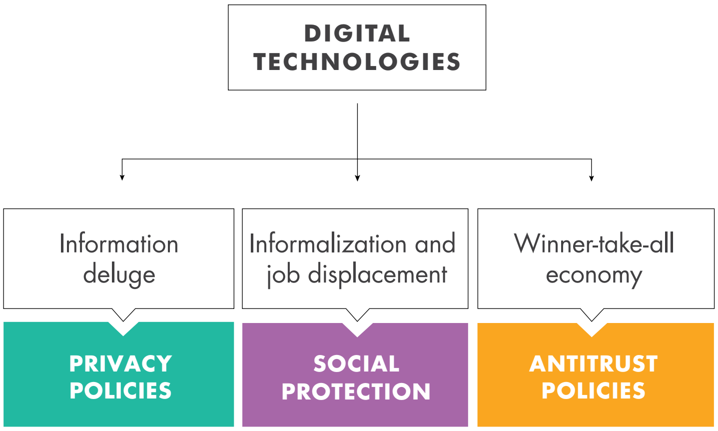
misers" who engage in motivated reasoning. Their decision making is often automatic, and they are more likely to search for and absorb information that confirms their priors rather than process new information that does not.[83] The private sector understands this and simplifies and customizes the user experience to engage customers. Amazon's search tool not only displays results the customer is looking for but also recommends other products based on the customer's browsing history and the purchasing trends of other customers. Transforming countries can learn from the private sector and embed these principles of simplification and customization in their e-services to foster greater collaboration with citizens.

Digital safeguards

Reforms to strengthen the analog complements can ensure a high social and economic return from digital investments. But downside risks remain. Large-scale collection of identifiable information creates privacy and security concerns. Automation changes work in ways that challenge existing social protections and reveal the inadequacy of existing labor laws. And scale economies create antitrust concerns. Digital safeguards that mitigate these risks become more important as the digital transformation proceeds (figure 5.11). Competition and cybersafety are discussed elsewhere in this Report. This section focuses on another important safeguard for the digital economy, namely changes to social protection, taxation policy, and labor market institutions.

Digital technologies are accelerating job creation and job destruction, requiring a more flexible

Figure 5.11 Digital safeguards in the WDR's framework



Source: WDR 2016 team.

workforce that responds to changing labor market demands. They are also facilitating new forms of nonwage employment and work arrangements which, while adding flexibility to firms and workers, can also erode traditional employer-employee relationships (chapter 2). This transformation of the world of work requires a rethink of social protection, tax systems, and labor market institutions. In incipient and transitioning countries, this agenda is less urgent, but it will be important to build systems appropriate for the 21st century and not to blindly adopt models designed by advanced countries for an industrial era.

Support technology adoption and level the playing field between workers and technology

Labor regulations, labor taxation and institutions need to support, rather than impede, technology adoption by firms. They should also avoid making labor unduly expensive, especially for workers who compete more directly with digital technologies. Technology, by accelerating the pace of change in the labor market, can make existing labor regulations obsolete and delay firms' adjustments.[84] And tight labor regulations often apply to low-skilled workers,[85] increasing the incentives for firms to substitute low-skilled workers with labor-saving technology, accentuating the skill-bias of technological change. This appears to be the case globally.[86]

Countries with unduly protective labor markets could be slowing their digital transformation, and distorting firms' decisions to automate work. This is likely to affect countries that have particularly stringent hiring and firing practices.[87] There are also implications for minimum wages, especially their growth path, if workers who earn close to the minimum wage are also in routine occupations susceptible to automation. Tax systems that rely heavily on taxing labor also make labor more expensive in relation to capital and could become unsustainable if wage employment falls. In-work benefits, such as income tax credits in the United States and the United Kingdom, are one mechanism for policy makers to make labor taxes more progressive while improving incentives to work and hire.[88]

Digital technologies themselves can reduce nonwage labor costs related to enforcement. In Brazil, the Annual Social Information report (digital records from social security with information about all workers, their wages, their occupations, and the types of firms they work for) monitors compliance with the Apprentice Law and, increasingly, other labor laws.[89] Oman has a Worker Protection Scheme that allows for monitoring wage payments. Digital technologies can further reduce enforcement costs by shifting from top-down to bottom-up accountability, empowering workers and unions to convey complaints and violations and to resolve conflicts. In the United States, workers can anonymously file online complaints and requests for inspections of their workplace if they believe there is a serious hazard or labor law violation; they can get information about their rights.[90] They can also check online whether their employers have paid their social security contributions. These tools increasing worker agency have the potential to balance the loss of bargaining power for workers in nontraditional work arrangements, such as independent contractors in the gig economy, where many workers are freelancers or work online.

Balance the relaxation of job protections with stronger workers' protections independent of work contracts

Independent contracting, casual work, freelancing, and other new forms of work in online labor markets and the sharing economy challenge the foundations of most social protection and tax systems. In most countries, social insurance schemes—for pensions, unemployment, and health—are tied to a (formal) job, financed through payroll taxes levied in the formal sector.

The evolving nature of work increases the need to delink social insurance from the labor contract. Bolivia, Chile, and Costa Rica have been grappling with providing social insurance to noncontributing, nonwage, informal workers for a long time. Their experiences suggest that all individuals should be registered in the same social insurance system, regardless of where they work, with subsidies for the poor or low-wage earners, and with financing coming from general revenues.[91]

The labor market disruptions that accompany technological change increase the demands on active labor market policies and social assistance systems. The disruptions are likely to be greatest for workers in routine occupations. Some of them are going to need intermediation and retraining services to find new jobs. Others, if they have difficulties transitioning, may need social assistance. Recent technological changes are bringing to the fore discussions of a guaranteed basic income, especially in more advanced countries. And giving workers a stake in digital capital could diversify workers' assets and reduce their costs of displacements—through pension funds, mutual funds, or even more directly in firms active in the digital economy.[92]

A solution is to protect workers rather than jobs, and to level the playing field for regulations and taxation across work contracts. If workers are protected outside their labor contract, regulations and taxes can be more lax across the board. A first step is to do away with regulations that almost prohibit flexible work arrangements. In Montenegro contracts for part-time employment cannot be less than 10 hours per week.[93] Another step is to reform tax systems that tax part-time work at higher per hour rates than full-time work. In Serbia, the reference wage (determining a minimum social contribution) is not adjusted for hours worked, so that social contributions are disproportionately high for part-time workers.[94] Reforms are also necessary in working time arrangements.[95]

Notes

1. See, for example, https://e-estonia.com.
2. Decker and others 2014.
3. See Atkinson and Miller 2015.
4. See OECD 2015.
5. The first stage (2000–05) of Rwanda's National Information and Communication Infrastructure policy prepared the groundwork for the ICT sector. The second phase (2006–10) concentrated on enhancing ICT infrastructure. The third phase (2011–15) focused on improving service delivery. The final phase (2016–20) is expected to concentrate on the enhancement of skills and development of the private sector and community. Instead of first dealing with the supply-side issues and then the demand-side issues, developing countries would be better off by working to simultaneously strengthen the two pillars of their digital strategy. For details, see Rwanda's ICT strategy at http://www.rdb.rw/uploads/tx_sbdownloader/NICI_III.pdf.
6. See Hanna 2015.
7. See http://www.plugintheworld.com/mobisol/.
8. Many developing countries adopt the competition frameworks of more advanced economies, but fail to implement them adequately.
9. Fines imposed by competition authorities remain symbolic in several countries. In Armenia, Kenya, and Central American countries, the current structure of fines and sanctions is not conducive to deterring anticompetitive conduct. In Armenia, maximum fines for price-fixing cartels are 1.5 percent of the average turnover of the 100 largest taxpayers, compared with a best practice of about 10 percent of a firm's turnover in other countries.
10. According to data from the market-research firm IDC.
11. Rochet and Tirole 2006.
12. World Bank 2012a; Bodewig and others 2014; World Bank 2011; Cunningham and Villasenor 2014.
13. Functional illiteracy is defined as the proportion of exam takers who score below a level 2 in the PISA reading test. WDR 2016 team, based on OECD PISA 2012 scores.
14. Guerra, Modecki, and Cunningham 2014; Shonkoff and Phillips 2000; Almlund and others 2011; Cunha, Heckman, and Schennach 2010; Cunha and Heckman 2007.
15. STEP household surveys and OECD's Programme for International Student Assessment (PISA).
16. Guerra, Modecki, and Cunningham 2014; Bodewig and others 2014.
17. Arias and others 2014; Sondergaard and others 2012.
18. Gates Foundation 2015.
19. http://www.text2teach.org.ph/?page_id=2.
20. http://www.bridgeinternationalacademies.com/company/about/.
21. http://www.britishcouncil.co/en/about/english-education-solutions/success-stories/remote-in-service-teacher-training-english.
22. Kremer and Holla 2009; and Kremer, Brannen, and Glennerster 2013.
23. Bruns and Luque 2014.
24. Banerjee and others 2007.
25. Bruns and Luque 2014.
26. Bruns and Luque 2014.
27. Barrera-Osorio and Linden 2009.
28. Devitt, Lyons, and McCoy 2014.
29. http://www.text2teach.org.ph/wp-content/uploads/2012/06/Phase3-by-third-party.pdf.
30. Linden 2008.
31. Bruns and Luque 2014.
32. McEwan 2013; Kremer, Brannen, and Glennerster 2013.
33. World Development Indicators (World Bank, various years).

34. Aker, Ksoll, and Lybbert 2012.
35. Ksoll and others 2014.
36. In a slum in New Dehli, a freely accessible computer was put up for use in a hole in a wall. With no prior experience, the children learned to use the computer on their own (see http://www.hole-in-the-wall.com/Beginnings.html).
37. Research ICT Africa surveys (various years), discussed in chapter 2.
38. Kuek and others, forthcoming.
39. King and Rogers 2014.
40. Rathunde and Csikszentmihalyi 2005.
41. Heckman and others 2010.
42. For more information on the New School model, see http://www.escuelanueva.org/portal/en/escuela-nueva-model.html.
43. In FYR Macedonia, for example, the government is starting a pilot introducing growth mind-set and grit training in primary schools; see Bodewig and others (2014) for a discussion on ongoing reforms in Vietnam.
44. Halinen 2015.
45. The "Thinking Schools, Learning Nation" concept was articulated by the Singaporean prime minister in a speech on June 2, 1997. http://www.moe.gov.sg/media/speeches/1997/020697.htm.
46. Goh and Gopinathan 2008.
47. Guerra, Modecki, and Cunningham 2014.
48. Guerra, Modecki, and Cunningham 2014.
49. See http://www.oecd.org/site/piaac/ and Pierre, Sanchez Puerta, and Valerio 2014.
50. http://www.bbc.com/news/world-asia-china-31617597.
51. See Duckworth and others 2007, for grit; and Dweck 2006, for growth mind-set.
52. Trucano 2015.
53. Resnik 2013.
54. http://www.codecademy.com/.
55. http://www.nairobits.com/.
56. Beede 2011.
57. OECD PISA 2006.
58. Waldrop 2013.
59. For more information on College to Careers, the flagship program of Chicago's reform efforts, see http://www.ccc.edu/menu/Pages/college-to-careers.aspx.
60. Almeida, Behrman, and Robalino 2012.
61. Almeida, Behrman, and Robalino 2012.
62. WDR 2016 team interview with INFOTEP (April 2015).
63. Almeida, Behrman, and Robalino 2012.
64. Almeida, Behrman, and Robalino 2012.
65. OECD 2004.
66. Aker and Mbiti 2010.
67. Adelman and others 2015.
68. Statements of then-minister of finance Dr. Ngozi Okkonjo-Iweala, as reported by the media on October 22, 2014. http://www.news24.com/Africa/News/Tanzania-orders-probe-into-ghost-government-workers-20150329.
69. Barrera-Osorio and others 2013.
70. Tooley and Longfield 2015.
71. Andrabi, Das, and Khwaja 2014.
72. Bishop and Hoeffler 2014.
73. Malik 2014.
74. Gelb and Clark 2013.
75. World Bank 2015.
76. Aker and Ksoll 2015.
77. Banuri 2015.
78. Kenny 2014.
79. Reddick and Turner 2012.
80. Morgeson and Mithas 2009.
81. Eom and Kim 2014.
82. Ray, Muhanna, and Barney 2005.
83. World Bank 2015.
84. Alesina, Battisti, and Zeira 2015.
85. World Bank 2012b; Hamermesh 2014; Kuddo 2015.
86. Alesina, Battisti, and Zeira 2015; O'Mahoney and Van Ark 2003.
87. Kuddo 2015, based on World Economic Forum's executive opinion survey on hiring and firing practices.
88. Chetty and Saez 2009; Blundell and Brewer 2000; Blundell, Duncan, and Meghir 2002; Hotz and Scholz 2001; Trampe 2007.
89. Silva, Almeida, and Strokova 2014.
90. https://www.osha.gov/as/opa/worker/complain.html.
91. Ribe, Robalino, and Walker 2010.
92. Freeman 2015.
93. Arias and others 2014.
94. Arias and others 2014.
95. Kuddo 2015.

References

Adelman, Melissa, Moussa Blimpo, David K. Evans, Atabanam Simbou, and Noah Yarrow. 2015. "Enhanced Teacher Monitoring for Student Results in Haiti." Working paper, World Bank, Washington, DC.

Aker, Jenny C., and Christopher Ksoll. 2015. "Call Me Educated: Evidence from a Mobile Monitoring Experiment in Niger." Working Paper 406, Center for Global Development, Washington, DC.

Aker, Jenny C., Christopher Ksoll, and Travis J. Lybbert. 2012. "Can Mobile Phones Improve Learning? Evidence from a Field Experiment in Niger." *American Economic Journal: Applied Economics* 4 (4): 94–120.

Aker, Jenny C., and Isaac M. Mbiti. 2010. "Mobile Phones and Economic Development in Africa." *Journal of Economic Perspectives* 24 (3): 207–32.

Alesina, Alberto, Michele Battisti, and Joseph Zeira. 2015. "Technology and Labor Regulations: Theory and Evidence." NBER Working Paper 20841, National Bureau of Economic Research, Cambridge, MA.

Almeida, Rita, Jere Behrman, and David Robalino. 2012. *The Right Skills for the Job?* Human Development Perspectives. Washington, DC: World Bank.

Almlund, Mathilde, Angela Duckworth, James Heckman, and Tim D. Kautz. 2011. "Personality Psychology and Economics." In *Handbook of the Economics of Education*, edited by Machin Hanushek and Ludger Woessmann, 1–181. Amsterdam: Elsevier.

Andrabi, Tahir, Jishnu Das, and Asim Khwaja. 2014. "Report Cards: The Impact of Providing School and Child Test Scores in Educational Markets." Faculty research working paper, Harvard Kennedy School, Cambridge, MA.

Arias, Omar, Carolina Sanchez-Paramo, Maria Davalos, Indhira Santos, Erwin Tiongson, Carola Gruen, Natascha de Andrade, Gady Saiovici, and Cesar Cancho. 2014. *Back to Work: Growing with Jobs in Europe and Central Asia.* Washington, DC: World Bank.

Arias Ortiz, Elena, and Julián Cristia. 2014. "The IDB and Technology in Education: How to Promote Effective Programs?" IDB Technical Note IDB-TN-670, Inter-American Development Bank, Washington, DC.

Atkinson, Robert D., and Ben Miller. 2015. "A Policymaker's Guide to Spurring ICT Adoption." Information Technology and Innovation Foundation, Washington, DC.

Autor, David. 2014. "Polanyi's Paradox and the Shape of Employment Growth." NBER Working Paper 20485, National Bureau of Economic Research, Cambridge, MA.

Banerjee, Abhijit, Shawn Cole, Esther Duflo, and Leigh Linden. 2007. "Remedying Education: Evidence from Two Randomized Experiments in India." *Quarterly Journal of Economics* 122 (3): 1235–64.

Banuri, Sheheryar. 2015. "ICT and Public Service." Background paper for the *World Development Report 2016*, World Bank, Washington, DC.

Barrera-Osorio, Felipe, David Blakeslee, Matthew Hoover, Leigh Linden, and Dhushyanth Raju. 2013. "Expanding Educational Opportunities in Remote Parts of the World: Evidence from an RCT of a Public-Private Partnership from Pakistan." enGender Impact (database), World Bank, Washington, DC.

Barrera-Osorio, Felipe, and Leigh Linden. 2009. "The Use and Misuse of Computers in Education: Evidence from a Randomized Experiment in Colombia." Policy Research Working Paper, Impact Evaluation Series 4836, World Bank, Washington, DC.

Becker, Katrin. 2007. "Digital Game-Based Learning, Once Removed: Teaching Teachers." *British Journal of Educational Technology* 38 (3): 478–88.

Beede, David. 2011. "Women in STEM: A Gender Gap to Innovation: Executive Summary." Economics and Statistics Administration Issue Brief No. 04–11, U.S. Department of Commerce, Washington, DC.

Bishop, Sylvia, and Anke Hoeffler. 2014. "Free and Fair Elections: A New Database." Working Paper WPS/2014-14, Centre for the Study of African Economies, Oxford, U.K.

Blundell, Richard, and Mike Brewer. 2000. "Tax and Benefit Reform in the UK: Making Work Pay." Comment paper from host country expert: U.K. Draft peer review for the European Commission, Brussels, November 6.

Blundell, Richard, Alan Duncan, and Costas Meghir. 2002. "Evaluating the Working Families Tax Credit." Social Policy Monitoring Network background paper, Inter-American Development Bank, Washington, DC.

Bodewig, Christian, Reena Badiani-Magnusson, Kevin Macdonald, David Newhouse, and Jan Rutkowski. 2014. *Skilling Up Vietnam: Preparing the Workforce for a Modern Market Economy.* Washington, DC: World Bank.

Bruns, Barbara, and Javier Luque. 2014. *Great Teachers: How to Raise Student Learning in Latin America and the Caribbean.* Washington, DC: World Bank.

Chetty, Raj, and Emmanuel Saez. 2009. "Teaching the Tax Code: Earnings Responses to an Experiment with EITC Recipients." NBER Working Paper 14836, National Bureau of Economic Research, Cambridge, MA.

Colombia Aprende [Colombia Learns]. 2015. "Descripción del modelo [Model description]." Colombia Aprende [Colombia learns]: La red de conocimiento [The knowledge network]. http://www.colombiaaprende.edu.co/html/mediateca/1607/article-89868.html.

Cunha, Flavio, and James Heckman. 2007. "The Technology of Skill Formation." *American Economic Review* 97 (2): 31–47.

Cunha, Flavio, James Heckman, and Susanne Schennach. 2010. "Estimating the Technology of Cognitive and Noncognitive Skill Formation." *Econometrica* 78 (3): 883–931.

Cunningham, Wendy, and Paula Villasenor. 2014. "Employer Voices, Employer Demands, and Implications for Public Skills Development Policy." Policy Research Working Paper 6853, World Bank, Washington, DC.

Davalos, Maria, and Indhira Santos. Forthcoming. *Addressing the Youth Employment Challenge in Europe and Central Asia.* Washington, DC: World Bank.

Decker, Ryan, John Haltiwanger, Ron S. Jarmin, and Javier Miranda. 2014. "The Secular Decline in Business Dynamism in the U.S." Working paper, University of Maryland, College Park.

Devitt, Niamh, Sean Lyons, and Selina McCoy. 2014. "Perceived Benefits and Barriers to the Use of High-Speed Broadband in Ireland's Second-Level Schools." MPRA Paper 60185, University Library of Munich.

Di Castri, Simone, and Lara Gidvani. 2014. "Enabling Mobile Money Policies in Tanzania: A Test and Learn Approach to Enabling Market-Led Digital Financial

Services." Mobile Money for the Unbanked, GSMA (Groupe Speciale Mobile Association), London.

Duckworth, Angela, Christopher Peterson, Michael Matthews, and Dennis Kelly. 2007. "Grit: Perseverance and Passion for Long-Term Goals." *Journal of Personality and Social Psychology* 92 (6): 1087–1101.

Durkee, Tony, and others. 2012. "Prevalence of Pathological Internet Use among Adolescents in Europe: Demographic and Social Factors." *Addiction* 107 (12): 2210–22.

Dweck, Carol. 2006. *Mindset: The New Psychology of Success.* New York: Ballantine Books.

Eom, Seok-Jin, and Jun Houng Kim. 2014. "The Adoption of Public Smartphone Applications in Korea: Empirical Analysis on Maturity Level and Influential Factors." *Government Information Quarterly* 31 (June): S26–S36.

Forero-Pineda, C., D. Escobar-Rodriguez, and D. Molina. 2006. *Escuela Nueva's Impact on the Peaceful Social Interaction of Children in Colombia.* Education for All and Multigrade Teaching: Challenges and Opportunities. Dordrecht, Netherlands: Springer.

Freeman, Richard B. 2015. "Who Owns the Robots Rules the World." IZA World of Labor, Bonn, Germany.

Fundación Escuela Nueva [New School Foundation]. 2015. "Escuela Nueva en el mundo [New School in the world]." http://www.escuelanueva.org/portal/es/modelo-escuela-nueva/escuela-nueva-en-el-mundo.html.

Gates Foundation. 2015. "Annual Letter: Our Big Bet for the Future." Bill and Melinda Gates Foundation, Seattle, WA. http://www.gatesnotes.com/2015-annual-letter?WT.mc_id=01_21_2015_DO_GFO_domain_0_00&page=0&lang=en.

Gelb, Alan, and Julia Clark. 2013. "Identification for Development: The Biometrics Revolution." Working Paper 315, Center for Global Development, Washington, DC.

Goh, Chor Boon, and S. Gopinathan. 2008. "Education in Singapore: Developments since 1965." In *An African Exploration of the East Asian Education,* edited by Birger Fredriksen and Jee Peng Tan, 80–108. Washington, DC: World Bank.

Grabowski, Barbara, and Kel Fengfeng. 2007. "Gameplaying for Maths Learning: Cooperative or Not?" *British Journal of Educational Technology* 38 (2): 249–59.

Guerra, Nancy, Kathryn Modecki, and Wendy Cunningham. 2014. "Developing Socio-Emotional Skills for the Labor Market: The PRACTICE Model." Policy Research Working Paper 7123, World Bank, Washington, DC.

Halinen, Irmeli. 2015. "What Is Going On in Finland? Curriculum Reform 2016." *Current Issues* (blog), March 25. http://www.oph.fi/english/current_issues/101/0/what_is_going_on_in_finland_curriculum_reform_2016.

Hamermesh, Daniel. 2014. "Do Labor Costs Affect Companies' Demand for Labor?" IZA World of Labor, Bonn, Germany. http://wol.iza.org/articles/do-labor-costs-affect-companies-demand-for-labor.pdf.

Hanna, Nagy. 2015. "Transforming to a Networked Society: Guide for Policy Makers." http://www.ericsson.com/us/res/docs/2014/transforming-to-a-networked-society.pdf.

Hawkins, Robert J. 2002. "Ten Lessons for ICT and Education in the Developing World." In *The Global Information Technology Report 2001–02: Readiness for the Networked World,* edited by G. Kirkman, 38–44. Oxford, U.K.: Oxford University Press.

He, Fang, Leigh L. Linden, and Margaret MacLeod. 2007. "Helping Teach What Teachers Don't Know: An Assessment of the Pratham English Language Program." Unpublished report, available at http://www.cid.harvard.edu/neudc07/docs/neudc07_s6_p02_he.pdf.

Heckman, James J., Seong Hyeok Moon, Rodrigo Pinto, Peter A. Savelyev, and Adam Yavitz. 2010. "The Rate of Return to the HighScope Perry Preschool Program." *Journal of Public Economics* 94 (1): 114–28.

Ho, A. D., I. Chuang, J. Reich, C. Coleman, J. Whitehill, C. Northcutt, J. J. Williams, J. Hansen, G. Lopez, and R. Petersen. 2015. "HarvardX and MITx: Two Years of Open Online Courses." HarvardX Working Paper 10, Cambridge, MA.

Hotz, Joseph V., and John Karl Scholz. 2001. "The Earned Income Tax Credit." NBER Working Paper 8078, National Bureau of Economic Research, Cambridge, MA.

Hoxby, Caroline. 2014. "The Economics of Online Postsecondary Education: MOOCs, Nonselective Education, and Highly Selective Education." NBER Working Paper 19816, National Bureau of Economic Research, Cambridge, MA.

ISTE (International Society for Technology in Education) and CSTA (Computer Science Teachers Association). 2011. "Operational Definition of Computational Thinking for K–12 Education." http://csta.acm.org/Curriculum/sub/CurrFiles/CompThinkingFlyer.pdf.

Jarvilehto, L. 2014. *Learning as Fun.* Espoo, Finland: Rovio Entertainment.

Kenny, Charles. 2014. "Publishing Government Contracts: Addressing Concerns and Easing Implementation." Center for Global Development, Washington, DC.

King, Elizabeth, and Halsey Rogers. 2014. "Intelligence, Personality and Creativity: Unleashing the Power of Intelligence and Personality to Build a Creative and Innovative Economy." Paper presented at the symposium "Achieving HOPE: Happiness of People through Education: Innovation in Korean Education for a Creative Economy," Seoul, Korea, November 4.

Kremer, Michael, Conner Brannen, and Rachel Glennerster. 2013. "The Challenge of Education and Learning in the Developing World." *Science* 340 (6130): 297–300.

Kremer, Michael, and Alaka Holla. 2009. "Improving Education in the Developing World: What Have We Learned from Randomized Evaluations?" *Annual Review of Economics One:* 513–42.

Krishna, Gunjan. 2015. "Improving Service Delivery through the Use of Digital Technologies: A Case Study of Karnataka E-Procurement." Background paper for the *World Development Report 2016,* World Bank, Washington, DC.

Ksoll, Christopher, Jenny C. Aker, Danielle Miller, Karla C. Perez-Mendoza, and Susan L. Smalley. 2014. "Learning without Teachers? A Randomized Experiment of a Mobile Phone–Based Adult Education Program in Los Angeles." Working Paper 368, Center for Global Development, Washington, DC.

Kuddo, Arvo. 2015. "Labor Regulations and Institutions for the New Economy." Background paper for the *World Development Report 2016*, World Bank, Washington, DC.

Kuek, Siou Chew, Cecilia Paradi-Guilford, Toks Fayomi, Saori Imaizumi, and Panos Ipeirotis. Forthcoming. *The Global Opportunity in Online Outsourcing.* Washington, DC: World Bank.

Light, Daniel, and Elizabeth Pierson. 2014. "Increasing Student Engagement in Math: The Use of Khan Academy in Chilean Classrooms." *International Journal of Education and Development using Information and Communication Technology* 10 (2): 103–19.

Linden, Leigh. 2008. "Complement or Substitute? The Effect of Technology on Student Achievement in India." Working paper, Columbia University, New York.

Malik, Tariq. 2014. "Technology in the Service of Development: The NADRA Story." Center for Global Development, Washington, DC.

Martinez, Ana, Serrana Alonso, and Diego Diaz. 2009. *Monitoreo y evaluacion de impacto social del plan CEIBAL: Metodologia y primeros resultados a nivel nacional* [Monitoring and social impact evaluation of the CEIBAL plan: Methodology and first national results]. Plan CEIBAL, Montevideo, Uruguay.

Mayo, M. 2009. "Video Games: A Route to Large-Scale STEM Education?" *Science* 323 (5910): 79–82.

McEwan, Patrick. 2013. "Improving Learning in Primary Schools of Developing Countries: A Meta-Analysis of Randomized Experiments." *Review of Educational Research* 20 (10): 1–42.

McFarlane, A., A. Sparrowhawk, and Y. Heald. 2002. "Report on the Educational Use of Games." TEEM: Department for Education and Skills, University of Bristol, Bristol, U.K.

Monroy-Taborda, Sebastian, Martin Moreno, and Indhira Santos. Forthcoming. "Technology Use and Changing Skills Demands: New Evidence from Developing Countries." Background note for the *World Development Report 2016,* World Bank, Washington, DC.

Morgeson, Forest, and Sunil Mithas. 2009. "Does E-Government Measure Up to E-Business? Comparing End User Perceptions of U.S. Federal Government and E-Business Web Sites." *Public Administration Review* 69 (4): 740–52.

Murphy, Robert, Larry Gallagher, Andrew E. Krumm, Jessica Mislevy, and Amy Hafter. 2014. "Research on the Use of Khan Academy in Schools: Implementation Report." SRI International, Princeton, NJ.

OECD (Organisation for Economic Co-operation and Development). 2004. "Co-financing Lifelong Learning: Towards a Systemic Approach." OECD, Paris.

———. 2015. "Digital Economy Outlook." OECD, Paris.

OECD PISA. 2006. "The Programme for International Student Assessment." OECD, Paris.

———. 2012. "PISA 2012 Results in Focus: What 15-Year-Olds Know and What They Can Do with What They Know." OECD, Paris.

O'Mahoney, Mary, and Bart Van Ark. 2003. "EU Productivity and Competitiveness: An Industry Perspective. Can Europe Resume the Catching-Up Process?" European Commission, Brussels.

Pierre, Gael, Maria Laura Sanchez Puerta, and Alexandria Valerio. 2014. "STEP Skills Measurement Surveys: Innovative Tools for Assessing Skills." Working Paper 89729, World Bank, Washington, DC.

Plaza, Sonia, Seyed Reza Yousefi, and Dilip Ratha. 2015. "Technological Innovations and Remittance Costs." Background paper for the *World Development Report 2016,* World Bank, Washington, DC.

Prensky, Marc. 2006. *Don't Bother Me Mom—I'm Learning.* St. Paul, MN: Paragon House.

———. 2007. *Digital Game-Based Learning.* St. Paul, MN: Paragon House.

Pritchett, Lant, Michael Woolcock, and Salimah Samji. Forthcoming. *What Kind of Organization Capability Is Needed?*

Rathunde, Kevin, and Mihaly Csikszentmihalyi. 2005. "Middle School Students' Motivation and Quality of Experience: A Comparison of Montessori and Traditional School Environments." *American Journal of Education* 111 (3): 341–71.

Ray, Gautam, Waleed A. Muhanna, and Jay B. Barney. 2005. "Information Technology and the Performance of the Customer Service Process: A Resource-Based Analysis." *Management Information Systems Quarterly* 29 (4): 625–52.

Reddick, Christopher, and Michael Turner. 2012. "Channel Choice and Public Service Delivery in Canada: Comparing E-Government to Traditional Service Delivery." *Government Information Quarterly* 29 (1): 1–11.

Research ICT Africa. Various years. Household survey. Capetown, South Africa. http://www.researchictafrica.net/home.php.

Resnik, Mitchel. 2013. "Learn to Code, Code to Learn." *edSurge Newsletters*. https://www.edsurge.com/n/2013-05-08-learn-to-code-code-to-learn.

Ribe, Helena, David Robalino, and Ian Walker. 2010. *Achieving Effective Social Protection for All in Latin America and the Caribbean.* Washington, DC: World Bank.

Rochet, J. C., and J. Tirole. 2006. "Two-Sided Markets: A Progress Report." *RAND Journal of Economics* 37 (3): 645–67.

Romer, Paul M. 2010. "What Parts of Globalization Matter for Catch-Up Growth?" *American Economic Review Papers and Proceedings* 100 (2): 94–98.

———. 2013. "Small Stakes, Good Measurement." *Urbanization Project* (blog), July 2. http://urbanizationproject.org/blog/small-stakes-good-measurement/.

Shonkoff, Jack P., and Deborah A. Phillips. 2000. *From Neurons to Neighborhoods: The Science of Early Childhood Development.* Washington, DC: National Academy Press.

Silva, Joana, Rita Almeida, and Victoria Strokova. 2014. *Sustaining Employment and Wage Gains in Brazil: A Skills and Jobs Agenda.* Directions in Development Series. Washington, DC: World Bank.

Sondergaard, Lars, Mamta Murthi, Dina Abu-Ghaida, Christian Bodewig, and Jan Rutkowski. 2012. *Skills, Not Just Diplomas: Managing Education for Results in Eastern Europe and Central Asia*. Directions in Development Series. Washington, DC: World Bank.

Spada, Marcantonio. 2014. "An Overview of Problematic Internet Use." *Addictive Behaviors* 39 (1): 3–6.

Sparrow, Betsy, Jenny Liu, and Daniel Wegner. 2011. "Google Effects on Memory: Cognitive Consequences of Having Information at Our Fingertips." *Science 5* 333 (6043): 776–78.

Tooley, James, and David Longfield. 2015. "Rejoinder to 'Private Schools Rigorous Review Team' on the Role and Impact of Private Schools in Developing Countries: A Response to the DFID-Commissioned Rigorous Literature Review." https://egwestcentre.files.wordpress.com/2015/03/tooley-longfield-rejoinder.pdf.

Trampe, Paul. 2007. "The EITC Disincentive: The Effects on Hours Worked from the Phase-Out of the Earned Income Tax Credit." *Econ Journal Watch* 4 (3): 308–20.

Trucano, Michael. 2012. "Evaluating One Laptop per Child (OLPC) in Peru." *EduTech* (blog), March 23. http://blogs.worldbank.org/edutech/olpc-peru2.

———. 2015. "Establishing and Connecting Leagues of Innovative Schools around the World." *World Bank Blogs,* March 10. http://blogs.worldbank.org/category/tags/european-schoolnet.

United Nations. 2014. "E-Government Survey 2014: E-Government for the Future We Want." United Nations, New York.

U.S. GAO (Government Accountability Office). 2014. "Information Technology: Reform Initiatives Can Help Improve Efficiency and Effectiveness." GAO, Washington, DC.

Vassil, Kristjan. 2015. "Estonian e-Government Ecosystem: Foundation, Applications, Outcomes." Background Paper for the *World Development Report 2016*, World Bank, Washington, DC.

Waldrop, Mitchell. 2013. "Education Online: The Virtual Lab." *Nature* 499: 268–70.

WEF (World Economic Forum). Various years. Competitiveness Index (database). WEF, Geneva, http://knoema.com/WFGCI2014/the-global-competitiveness-index-2014-2015-data-platform-2014.

WITS (Workshop on Information Technologies and Systems). 2014. "Value Creation from Innovative Technologies." Auckland, New Zealand.

World Bank. Various years. Doing Business (database). World Bank, Washington, DC, http://www.doingbusiness.org/.

———. Various years. Enterprise Surveys (database). World Bank, Washington, DC, http://www.enterprisesurveys.org/.

———. Various years. Global E-Government Systems (database). World Bank, Washington, DC, http://data.worldbank.org/data-catalog/pfm-systems-eservices-dataset.

———. Various years. ID4D (Identification for Development database). World Bank, Washington, DC, http://data.worldbank.org/data-catalog/id4d-dataset.

———. Various years. Logistics Performance Index (database). World Bank, Washington, DC, http://lpi.worldbank.org/.

———. Various years. World Development Indicators (database). World Bank, Washington, DC, http://data.worldbank.org/data-catalog/world-development-indicators.

———. Various years. World Governance Indicators (database). World Bank, Washington, DC, http://info.worldbank.org/governance/wgi/index.aspx#home.

———. 2004. *World Development Report 2004: Making Services Work for Poor People.* Washington, DC: World Bank.

———. 2011. *World Development Report 2012: Gender Equality and Development.* Washington, DC: World Bank.

———. 2012a. *Lebanon, Good Jobs Needed: The Role of Macro, Investment, Education, Labor and Social Protection Policies (MILES).* Report of the Middle East and North Africa Human Development Group. Washington, DC: World Bank.

———. 2012b. *World Development Report 2013: Jobs*. Washington, DC: World Bank.

———. 2015. *World Development Report 2015: Mind, Society, and Behavior*. Washington, DC: World Bank.

SECTOR FOCUS 5

Energy

Reliable and affordable access to electricity services is fundamental to achieving the World Bank Group's twin goals: shared prosperity and elimination of extreme poverty by 2030. Efforts to meet the Agenda 2030 Sustainable Development Goal to "ensure access to affordable, reliable, sustainable, and modern energy for all" will also require increased investment, new and refined technologies and systems, and institutional reform. To help the world achieve this energy transformation, the effective use of information and communication technology (ICT), including data and advanced analytics, is already playing an essential role.

Changing energy business models with ICT

Providing electricity to the approximately 1 billion people without access to affordable and sustainable electricity services presents an enormous challenge and opportunity.[1] In Sub-Saharan Africa, only 14 percent of people have access to grid electricity; however, nearly 70 percent now have access to mobile phones.[2] By the end of the decade, it is estimated that nearly 930 million people in Africa will own a mobile phone,[3] creating not only a huge demand for phone charging, but facilitating a variety of energy and other services through the use of mobile phones.

A potential symbiotic relationship therefore exists between the development of information and communication technologies and increasing energy access in Africa and other low-access areas. As an example, cell towers require a local power supply, but in many rural areas the surrounding communities lack access to electricity. Energy service companies in many parts of Africa have been oversizing the energy generation unit of the tower and providing local consumers with access to electricity. The Mobile for Development program of the Groupe Speciale Mobile Association (GSMA) explores such opportunities.[4]

To address some of the financing challenges of rural energy services, companies in Africa and South Asia are leveraging ICT and sensors utilizing cellular networks through various financing models.[5] For example, in the same value chain all the way from electricity distribution to maintenance, ICT is being deployed through short message service (SMS) or voice interaction with clients to collect and analyze mobile data, facilitate mobile payment systems, and utilize applications that are increasingly enabled by the internet. These innovative products and services are facilitating a significant increase in energy access globally. In East Africa alone, they have reached 14 million people in six years. The average annual market growth is 140 percent, according to market research by the World Bank Group's Lighting Africa Initiative.[6]

In East Africa, falling costs of ICT and efficient appliances have enabled off-grid photovoltaic (PV) systems to provide more energy services at a lower price. Instead of relying on traditional means of collecting payments (with high transaction costs and losses), electricity bills can now be paid by cellphone through mobile money services such as M-Pesa. This approach also generates large amounts of data on mobile money transfers, and has helped to establish credit histories for a previously underserved segment of the population. Energy supply companies combine financial information with geographic and census

This sector focus was contributed by Todd Johnson, Anna Lerner, and Karan Capoor.

data to identify new markets and to differentiate customers based on varying levels of service, thus allowing them to tailor the service to the customer's ability to pay.

ICTs have also been deployed to reduce risks for suppliers and to facilitate after-sales service by tagging energy systems (such as solar PV panels and batteries) with sensors so that they can be tracked as they pass through distributors and are sold and installed. The sensors capture remote real-time data about the equipment, enabling the provider to monitor performance and offer maintenance support. Companies like M-Kopa and Off Grid Electric in East Africa have call center agents that resolve most payment or service-related queries, while remaining service issues are addressed by a fleet of technicians on motorcycles who are radio-dispatched.

ICT, the smart grid, and demand management

Improved real-time information and automated controls are increasing the efficiency of the electricity grid all over the world. The "smart grid"—which has come to define a broad range of sensors, meters, and controls enabled by information technology (IT), as well as large-scale and real-time data collection—can enhance the operational efficiency of the electricity system by optimizing energy transactions.[7] The integration of ICT into the grid can improve system security through more rapid analysis of service interruptions and prediction of outages. Connected devices and software offer customers access to real-time data to help them manage their energy usage more effectively, while advanced meters and automatic controls provide opportunities for energy efficiency, such as automatic dimming of street lights, or turning off lights or air conditioning in unoccupied rooms and buildings.

Potentially one of the most revolutionary internet-based innovations in the electricity sector is the ability to adjust consumer demand by providing new signals and transparency. "Demand response" allows electricity consumption to be reduced during peak periods based on agreed-upon reductions in power supply. For example, consumers agree to minor reductions in air-conditioning demand during summer peaks in exchange for a rate cut. This helps increase system reliability, reduce energy supply costs, and lower generation investments due to the reduced need for operational reserves. The International Energy Agency (IEA) estimates the savings potential for demand response programs in competitive markets at 15 to 20 percent of peak demand.[8] So far, such systems have been introduced largely in advanced economies of the Organisation for Economic Co-operation and Development (OECD) and emerging economies. But the development of low-cost sensors that will increasingly be factory-installed in all electrical appliances (televisions, refrigerators, fans, air conditioners) will allow both the monitoring and control of electricity use by consumers and electricity suppliers.[9]

One of the biggest challenges for the power sector of the future is the need to "balance" electricity generation and load on a particular grid. The growth of variable renewable energy is creating new challenges for planners and power system operators, who must rely on other sources of supply when the sun goes down or the wind stops blowing. Predicting such variations in energy production is challenging. In combination with (more predictable) demand variations, it can lead to deviations in power frequency and power system reliability issues, and increase the need for grid balancing assets, such as fast-ramping gas power plants or electric storage.[10] Research by the IEA shows that renewable energy costs can be reduced significantly through new forecasting and digital technologies that can help balance generation and load by monitoring and predicting the supply of variable energy resources.[11] In countries and regions with growing shares of renewable energy such as California, Denmark, and Germany, electricity markets are now designed to match supply and demand on a minute-by-minute basis through sophisticated auctions, regulatory mechanisms, and control systems that rely on the internet.[12]

Energy, open data, and the internet

Having high-quality, easily accessible information on energy resources, demand, and usage is crucial to supporting the formulation of government policies, and can be a catalyst for commercial investment. Just as the existence of high-quality geological data is an imperative for fossil fuel licensing and exploration, publicly available data on renewable energy resources is one of the first steps a country can take to encourage investment. ICT facilitates this resource assessment and mapping through the use of supercomputers to analyze years of historical meteorological and satellite data, by facilitating the transmission of measurement data from field-based instruments, and by supporting the wide dissemination of outputs through open data platforms.

A recent trend in the United States is the provision of anonymous energy use and performance data that can support energy efficiency markets and services.[13] The industry-led Green Button Initiative in the United States is another voluntary industry data standard for utilities and companies; it allows consumers to make their energy consumption data available to service providers, which can help consumers lower their energy bills or "green" their energy supply through home energy efficiency solutions or the design and financing of renewable energy equipment. Since 2012, more than 50 utilities and electricity suppliers have signed on to the initiative, providing over 60 million homes access to their detailed energy use data.[14] In India, a pilot project launched by Prayas Energy Group, a nongovernment organization, has installed around 100 devices in volunteers' homes to measure the availability and quality of electricity on a continuous basis.[15] The results provide a potentially powerful, crowdsourced flow of information that can help consumers understand the causes and impacts of power shortages, and can help policy makers and utility companies prioritize power system investments.

Given the rapid growth of the ICT industry, there has been an increased focus on how much energy the sector uses. Recent estimates of energy use by ICT—split almost equally into energy use by communication networks, computers, and data centers—show that the sector accounts for between 3 and 4 percent of total global electricity consumption, and that energy consumption increased around 7 percent per year between 2007 and 2012.[16] While a breakdown of how much of this increased demand came from developing countries is not readily available, this share is likely significant, as more than 750 million new users have been added in China and India alone since 2000. There are many ways to reduce the energy use from the ICT industry, including moving to faster systems. For example, 2G networks (which are common in developing countries) require over 400 kilowatt-hours (kWh) of electricity per year to deliver 12 gigabytes (GB) of data (1 GB per month), while a 3G network consumes less than one-tenth that amount (35 kWh), and a 4G network uses one-sixtieth (7 kWh).[17] In addition, the industry is exploring new technologies, including microtracing—a new, leaner technology for fiber access that uses less energy. However, many of these gains are offset by ever rising volumes of data.

While it is too early to judge the overall impact of digital technologies on the energy sector, especially in developing countries, it is clear that many of the trends described above will continue to affect energy consumers and suppliers. Ensuring that benefits and synergies are maximized will be critical to meeting the sustainable energy goals of the World Bank's client countries.

Notes

1. World Bank 2015.
2. Ericsson 2014.
3. Ericsson 2014.
4. GSMA 2015.
5. Vogt 2015.
6. http://www.lightingafrica.org.
7. MITei 2014.
8. IEA 2014.
9. Spijker 2014.
10. Martinez-Romero and Hughes 2015. *Power frequency* refers to the frequency of oscillations of alternating current in a power grid.
11. IEA 2014.
12. Martinot 2015.
13. U.S. Department of Energy, "Open Energy Data."
14. U.S. Department of Energy, "Green Button."
15. Prayas Energy Group.
16. TREND Consortium Partners 2014.
17. Koomey 2013.

References

Ericsson. 2014. "Sub-Saharan Africa: Ericsson Mobility Report Appendix." Ericsson, Stockholm, Sweden.

GSMA (Groupe Speciale Mobile Association). 2015. "From Fringe to Mainstream: The Role of Mobile in Energy Access." http://www.gsma.com/mobilefordevelopment/from-fringe-to-mainstream-the-role-of-mobile-in-energy-access.

IEA (International Energy Agency). 2014. "Task 24: Closing the Loop–Behaviour Change in DSM: From Theory to Policies and Practice." IEA, Paris.

Koomey, Jonathan. 2013. "Does Your iPhone Use as Much Electricity as a New Refrigerator? Not Even Close." http://thinkprogress.org/climate/2013/08/25/2518361/iphone-electricity-refrigerator/.

Martinez-Romero, S., and W. Hughes. 2015. "Bringing Variable Energy Up to Scale." World Bank, Washington, DC.

Martinot, Eric. 2015. "How Is California Integrating and Balancing Renewable Energy Today?" http://www.martinot.info/renewables2050/how-is-california-integrating-and-balancing-renewable-energy-today.

MITei (Massachusetts Institute of Technology: Energy Initiative). 2014. "Utility of the Future Study." MITei. https://mitei.mit.edu/research/utility-future-study.

Prayas Energy Group. "Electricity Supply Monitoring Initiative: Watch Your Power Quality." http://www.watchyourpower.org.

Spijker, Arent van't. 2014. *The New Oil: Using Innovative Business Models to Turn Data into Profit.* Technics Publications.

TREND Consortium Partners. 2014. "Assessment of Power Consumption in ICT." http://cordis.europa.eu/docs/projects/cnect/0/257740/080/deliverables/001-trendd16finalwp1report.pdf.

U.S. Department of Energy. "Green Button." http://energy.gov/data/green-button.

———. "Open Energy Data." http://energy.gov/data/open-energy-data.

Vogt, Heidi. 2015. "Making Change: Mobile Pay in Africa." *Wall Street Journal*, January 2. http://www.wsj.com/articles/making-change-mobile-pay-in-africa-1420156199.

World Bank. 2015. "Progress toward Sustainable Energy: Global Tracking Framework 2015." World Bank, Washington, DC.

CHAPTER 6

Global cooperation

Data, spam, disease, poverty, commerce, rivers, and polluted air—all cross borders and touch many people. And all can be better managed if people and nations cooperate. The internet is both a subject of cooperation and a new tool to facilitate cooperation in other realms. This chapter explores its potential for boosting three forms of cooperation.

First is *governing the internet*. The internet requires technical coordination and harmonized standards to ensure its smooth operation worldwide. Wherever you are, when you click or tap on http://www.worldbank.org/wdr2016, a message goes out from your device, initiating processes to discover which of the millions of servers on earth corresponds to that address. Information is handed off from network to network and perhaps from satellite to cable to Wi-Fi, ending up on your screen. That nanomiracle depends on the consensual and universal use of protocols for data transmission and on a legal system that determines who has the right to use the "worldbank.org" address. Less consensus exists about how to deal with cross-border issues such as suppressing viruses and spam, or defining and enforcing rights to privacy, while ensuring cybersecurity and combating cybercrime (see chapter 4). As technology and its uses evolve rapidly together, who decides how the internet is structured and run?

Second is *facilitating cross-border exchanges of goods and services*. During the last two decades or more, countries have worked out trade agreements to collect duties and taxes and to enforce intellectual property rights (IPRs): patents, copyrights, and trademarks. Many of these agreements are poorly adapted for the world of the internet because intellectual property can be duplicated and disseminated with little or no cost, and purely digital goods and services can now cross borders without customs inspections. The increasingly frictionless ease of transacting business can be stymied by 19th-century procedures for shipping physical objects. Can trade and IPR rules and procedures be modernized?

Third is *providing global public goods*—including poverty reduction and environmental sustainability. These are complex and difficult challenges requiring both cooperation and massive amounts of information. Can the advent of the internet make these quests more inclusive, more informed, and more efficient?

Internet governance

We reject: kings, presidents, and voting. We believe in: rough consensus and running code.

—David Clark, computer scientist and internet pioneer[1]

From its beginnings, the internet has always been different from the networks that preceded it—telephone, radio, television, and cable. It was founded as a research network, explicitly noncommercial for the first few decades of its existence, and designed as a radically decentralized network. As a result, it has been governed more like a federation of networks, in some respects like a Republic of Users.[2] But the pragmatic libertarian ideology of the internet's founders is under assault by the commercial and political interests of its other stakeholders, mainly large corporations and nation-states. The growing commercialization of user data by private businesses and mass surveillance by states, including many sovereigns accustomed to greater state control over their citizens, have gradually eroded the trust the internet once enjoyed. This has given rise to widely disparate views on how to govern the internet.

The internet's growing popularity has increased the need to manage its worldwide operation. Whereas less than 2 percent of phone calls cross borders, between 60 and 75 percent of internet traffic is international (depending on the country). Despite its virtual qualities, it has an elaborate physical infrastructure that spans the globe. As a global resource, it requires some degree of international coordination to function. Information flowing through the internet has transboundary repercussions, raising other issues for international debate and discussion. To address these issues, the United Nations–authorized Working Group on Internet Governance defined internet governance as "the development and application by governments, the private sector, and civil society, in their respective roles, of shared principles, norms, rules, decision-making procedures, and programs that shape the evolution and use of the Internet."[3]

How is the internet governed?

The main attributes of the global internet are that it is distributed, decentralized, flexible, multilayered, and end-to-end.[4] Not a monolith, it is instead a mosaic of separate but interrelated infrastructure, applications, actors, and decisions. Consequently, its governance is likewise not unitary but consists of an ecology of decisions and decision makers. Internet governance features are different from those in telecommunications, characterized by a multilateral system.

The governance framework for the internet is considerably more diverse than that of the telecom sector. The policy, legal, and regulatory framework for information and communication technologies (ICTs) has shifted since the start of the millennium. Then it was primarily about the technical and economic regulation of more liberalized and competitive telecommunications infrastructure and services environment—along an arc with the state at the center of the policy and regulatory piece and state-licensed operators orbiting around it. Now it is a much more complex, multifarious, and loose amalgam of policies, laws, and actors having their origins in constitutional rights, criminal justice, and technical and economic regulation. This new framework also involves nonstate actors, national, regional, and even multilateral agents—each with an interest in the wide-ranging and diverse aspects of what has come to be known as the internet governance framework.

The prevailing model of internet governance continues to evolve to include its key stakeholders. The multistakeholder model (MSM) reflects the notion that better policies and outcomes can be achieved if those affected are part of a policy consultation process;[5] it also refers to the range of actors running, administering, and governing the internet.[6] The term came into popular use as a result of the UN's World Summit on the Information Society, held in two phases in 2003 (Geneva) and 2005 (Tunis). The summit confirmed that "management of the internet encompasses both technical and public policy issues and should involve all stakeholders."[7] As described in its agenda, the groups of stakeholders with an interest in internet governance include governments, private firms, civil society, intergovernmental and international organizations, academia, and the technical community (box 6.1).

The MSM label reflects the diverse actors that form the loose de facto framework for internet governance. For example, one of these stakeholders is the Internet Engineering Task Force, a loose affiliation of engineers that is in charge of the protocols that run the internet. Another is ICANN, the Internet Corporation for Assigned Names and Numbers, a California not-for-profit corporation that performs certain technical functions on the internet—such as running root servers (the computers that control traffic on the internet) and administering the system of domain names (.com, .org, .gov). But not all stakeholders feel equally represented within the current governance framework.

The internet unites people; its governance divides nations

Politicians and regulators are increasingly concerned about their inputs into the future governance of the internet.[8] Their concerns may be justified (figure 6.1):

- The rapid and unprecedented growth of the internet has meant that it has evolved from an American technology to a critical global infrastructure in a very short period. This has given rise to an unstated power struggle between its traditional stakeholders and many new ones, especially some developing country governments, which feel left out of the discussion.
- The bulk of internet nonusers are in developing countries—4.2 billion people, more than half the world, have no internet access, and 5.1 billion are not on social media. Their interests, some argue, are best promoted by their national governments.
- Mass collection of user data by private businesses and unwarranted surveillance by governments have eroded trust and fed growing skepticism about the current governance arrangement.
- Increasing use of social media and unhindered access to all content, which is generally thought to be a positive development, can clash with local cultural norms and social practices, prompting some governments to advocate a more activist approach to govern the internet.

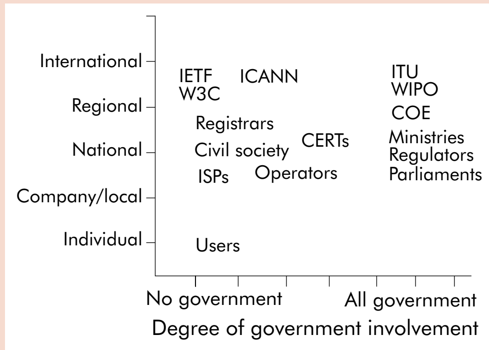
Box 6.1 Categories of stakeholders in internet governance

Individuals, organizations, and institutions with an interest or stake in particular internet governance issues include:

- States, which have policy authority for sovereign nations and are responsible for internet-related public policy issues at the global level
- Private businesses, with expertise in technical and economic fields
- Civil society, especially at the community level
- Intergovernmental organizations, particularly in facilitating the coordination of internet-related policy issues
- International organizations, with important roles in developing internet-related technical standards and relevant policies
- Technical communities, such as the members of technical standard-setting bodies and other experts in computer science and engineering
- Academics, with a focus on and involvement in internet governance.

Figure B6.1.1 maps these stakeholders according to their degree of localization or internationalization.

Figure B6.1.1 Stakeholders in internet governance

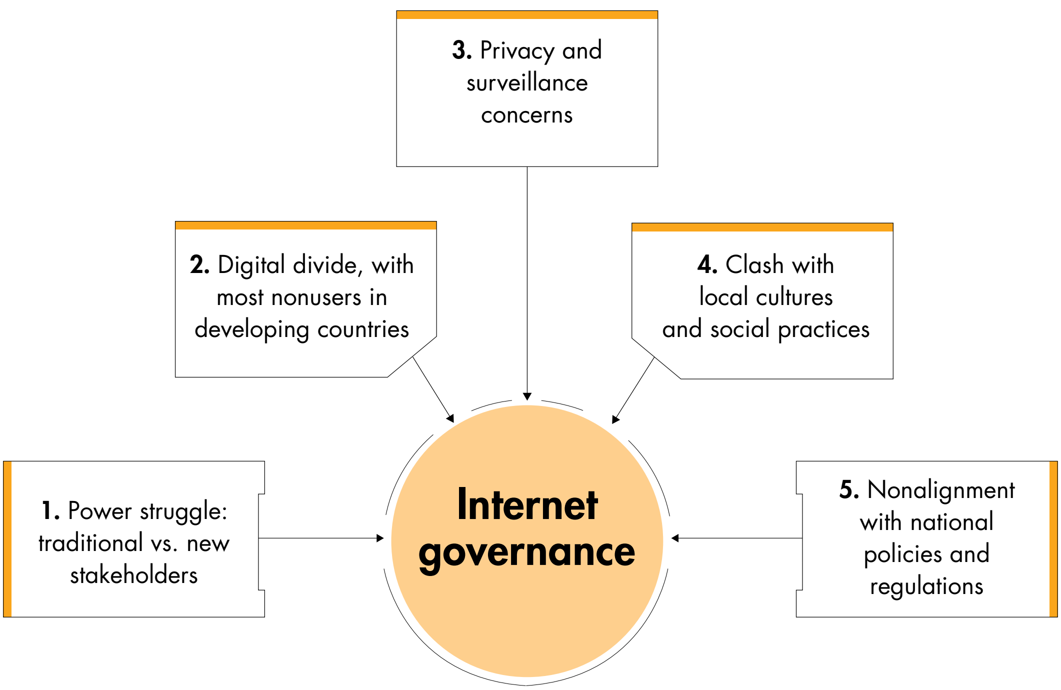


Source: Center for Democracy and Technology, Internet Governance Forum, Athens.

Note: CERTs = computer emergency response teams; COE = Council of Europe; ICANN = Internet Corporation for Assigned Names and Numbers; IETF = Internet Engineering Task Force; ISPs = internet service providers; ITU = International Telecommunication Union; W3C = World Wide Web Consortium; WIPO = World Intellectual Property Organization.

Sources: World Summit on the Information Society 2005, Tunis Agenda for the Information Society, Document WSIS-05/TUNIS/DOC/6(Rev. 1)-E, 18 November: Paragraphs 31, 33, 35; Kummer 2013; Gasser, Budish, and West 2015.

Figure 6.1 Concerns that have fueled the debate on how the internet is governed



Source: Dutton 2015, for the WDR 2016.

Table 6.1 Multistakeholderism or multilateralism

Dimension	Multistakeholder	Multilateral/intergovernmental
Leading principle	Collaborative leadership among stakeholders, with a commitment to resolving particular problems	Sovereign right of governments to determine internet policy and regulation
Representation of stakeholders	Direct engagement of private business and industry, governments, bilateral and multilateral international institutions, civil society and academia, NGOs	National government agency represents interests of all in bilateral and multilateral treaties and agreements, anchored in advice and consultation with all stakeholders
Role of governments	Governments are a key stakeholder, with legitimacy to make decisions	National governments represent other interests in an intergovernmental entity
Process	• Bottom-up participatory • Horizontal across stakeholders • Generally open and transparent	• Top-down consultative • Hierarchical within states and through international agreements and treaties • Intergovernmental negotiations, with open consultation
Examples of relevant bodies and processes	ICANN, Internet Society, World Summit on the Information Society, Internet Governance Forum	ITU, UN, WIPO, WTO

Source: Adapted from Bauer and Dutton 2015, for the WDR 2016.

Note: ICANN = Internet Corporation for Assigned Names and Numbers; ITU = International Telecommunication Union; NGO = nongovernmental organization; UN = United Nations; WIPO = World Intellectual Property Organization; WTO = World Trade Organization.

- More countries are asserting national policy and regulation over areas (mainly around content) that they feel the existing governance structure is not addressing.[9]

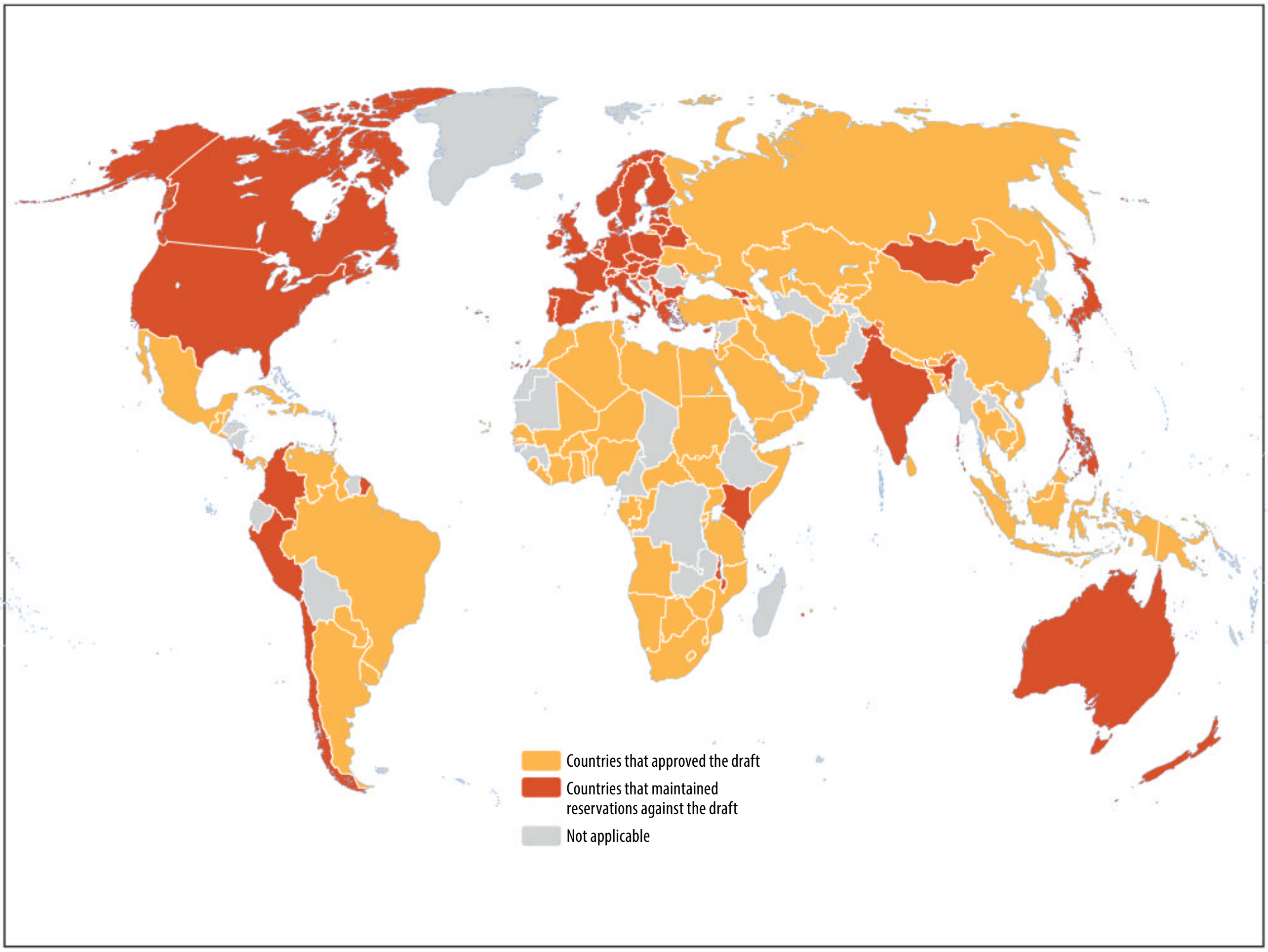
As a result, support for the MSM is not unanimous. Tension between the MSM and a multilateral model (MLM) that puts governance responsibility predominantly in the hands of nation-states has arisen many times since the World Summit embraced MSM. Some governments worry about surrendering sovereignty or asserting national jurisdiction over internet activities within their borders. In September 2011, China, the Russian Federation, Tajikistan, and Uzbekistan jointly submitted a draft resolution to the UN General Assembly on an International Code of Conduct for Information Security outlining their vision of governing the internet.[10]

The promoters of MSM argue that state control of the internet would not leave space for the range of players currently involved in internet governance and could pave the way to suppression of privacy and rights of free expression—say, in the name of national security (table 6.1). Without the checks and balances available through the MSM, abuses might increase. The UN has asserted that rights already protected in the real world—the right to privacy and the right to communicate (to receive and impart information)—are to be protected in the virtual world.[11]

More recently, a new approach to revive the multilateral model arose in an attempt by the membership of the International Telecommunication Union (ITU) to update the International Telecommunication Regulations (ITRs) at the World Conference on International Telecommunications (WCIT) in Dubai in 2012. Measures aimed at regulating privacy and free speech were introduced in a special codicil in the regulations. This resulted in a clear split between 89 countries that approved the new draft and 80 that maintained reservations (map 6.1).[12] Although it was expected that these issues might have been taken up at the ITU Plenipotentiary in Busan, Republic of Korea, in 2014, they were not and remain unresolved.

A key point of contention for countries favoring a multilateral approach is the U.S. government's oversight of IANA (Internet Assigned Numbers Authority).[13] The MLM would like to see an IANA transition to an intergovernmental body, like the ITU. The MSM, especially the United States, insists on further autonomy of ICANN and IANA. In March 2014, the U.S. Department of Commerce announced a process to relinquish its oversight over certain technical functions performed by IANA to the multistakeholder community—in shorthand, the IANA transition, originally scheduled to be completed by September 2015.[14] A key condition of the IANA transition is that oversight of the technical functions would not be ceded to a government or group of governments, but to the multistakeholder community.

Map 6.1 A divided world: Country positions on the International Telecommunication Regulations



IBRD 41790

Source: International Telecommunication Union. Data at http://bit.do/WDR2016-Map6_1.

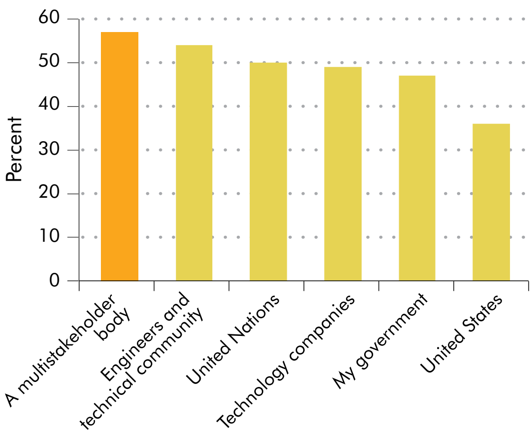
Protecting the interests of users is paramount

This inability of internet stakeholders to reach a consensus on future governance mechanisms could be costly. The lingering uncertainty is likely to affect the private sector's long-term investment planning. Delay in agreeing on new protocols and standards could slow the pace of innovation. Some have even suggested that the internet is at risk of being split, so that the world ends up with several local internets—Google CEO Eric Schmidt calls it the *splitnet*—destroying the essential global character of the internet.

The new governance structure of the internet needs to accurately reflect the plurality and the multifarious nature of internet actors and be flexible enough to accommodate its rapid and continuous evolution.[15] The MSM model is evolving, and that is one of its great strengths. However, care should be taken to ensure respect for principles of good governance (including transparency, accountability, inclusiveness, and representativeness); safeguard meaningful dialogue among stakeholders; empower stakeholders to participate effectively across groups; and prevent capture by special interests.[16] According to one recent survey in 24 countries, the MSM is also the preferred governance model of end users (figure 6.2). It is therefore likely that a multistakeholder format—one that addresses the concerns over the digital divide and trust and use of the internet; provides meaningful forums for "left out" stakeholders; and balances universal community acceptance with appropriate local flexibility—could be the accepted way forward.

Figure 6.2 **The multistakeholder model of internet governance enjoys greater support than other options**

Percentage of respondents who said they would trust the governance options below completely or somewhat



Source: CIGI and Ipsos 2014. Data at http://bit.do/WDR2016-Fig6_2.

Toward a global digital market

One of the advantages of the internet is its ability to deliver digital goods to a global market, unconstrained by national infrastructure—enabling developing country citizens to enjoy the same products as their peers in the rest of the world. Digital transactions will continue to increase as the number of goods and services offered online increases. For example, with the introduction of online music stores in many developed countries in 2004, digital music started to gain a share of global music sales—from 2 percent in 2004 to 46 percent in 2014.[17] Access to a global market can be particularly advantageous to firms in small, island, and landlocked countries, as well as for countries with small populations, where the size of the local market is often constraining growth.

Digital trade is potentially global in scope, but barriers to digital integration prevent firms from reaching appropriate scale (box 6.2). Issues such as trade logistics and infrastructure, online payment systems, and trade barriers can be handled by national governments (chapter 5). But cross-border issues affecting digital trade need international coordination. Indeed, the internet's ability to seamlessly deliver digital goods and services around the world is considerably impeded by various regulations that could be streamlined through greater international cooperation. The two main cross-border issues are barriers to data flows and uncoordinated intellectual property rights regime.

Removing barriers to cross-border data flow

The internet has revolutionized the way data are collected and shared. This in turn has increased economic efficiency and productivity, improving welfare and

Box 6.2 **European Union: A fragmented market for digital products**

Despite being a single market with a free flow of goods, services, and people for many decades, the European Union (EU) still functions like a fragmented market for digital goods and services. Consumers and firms face difficulties in engaging in the digital economy.

Consumers in the EU prefer to shop from online stores that are within their national borders. While 44 percent of consumers made an online purchase from a domestic business in 2014, only 15 percent did so from a business in another EU country.[a] The consumers may have concerns about payment security, product quality, or the reliability of the sellers located in another country (figure B6.2.1). Moreover, consumers in the EU face different prices for the same online goods and services because of the practice of geoblocking, in which services and prices are limited to a geographic location. Consumers are directed to their local websites, where they face different prices from online retailers based on their location. Content like video is also restricted within a single geographic location.

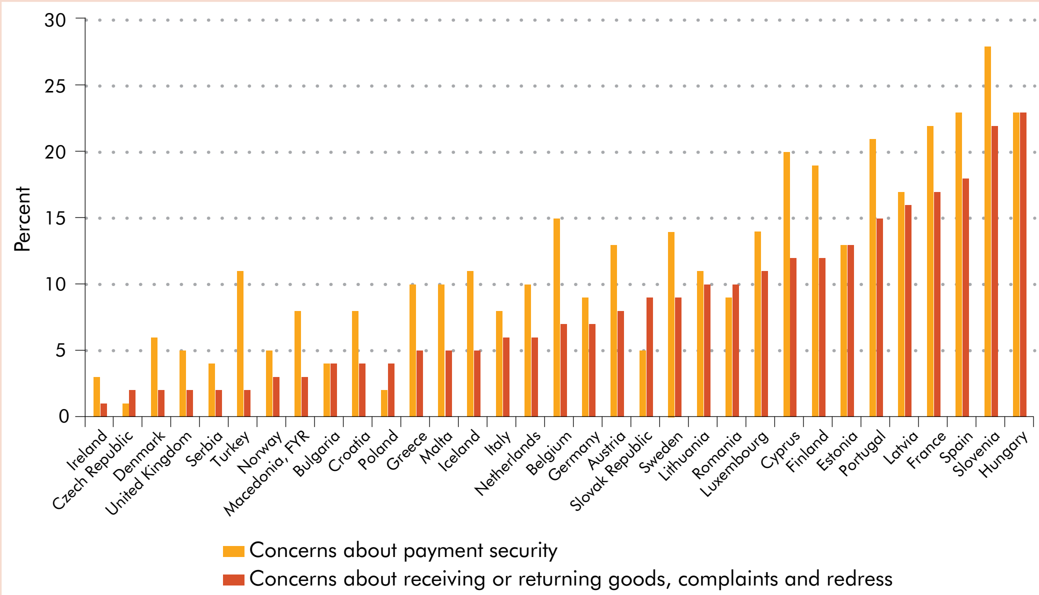
Firms within the EU also face many difficulties in selling their goods and services online in other EU markets. Firms engaging in e-commerce face high and uneven cross-border delivery charges, which are passed on to consumers. For example, Copenhagen, Denmark, and Malmo, Sweden, are separated only by an 8-kilometer bridge, but a package sent from Copenhagen to Malmo costs €27 whereas a package sent from Malmo to Copenhagen costs €42.[b] Moreover, firms face large costs to adapt to various national laws, and believe that the costs outweigh the benefits of setting up a website (figure B6.2.2).

(Box continues next page)

Box 6.2 European Union: A fragmented market for digital products *(continued)*

Figure B6.2.1 Perceived barriers to buying over the internet in 2009

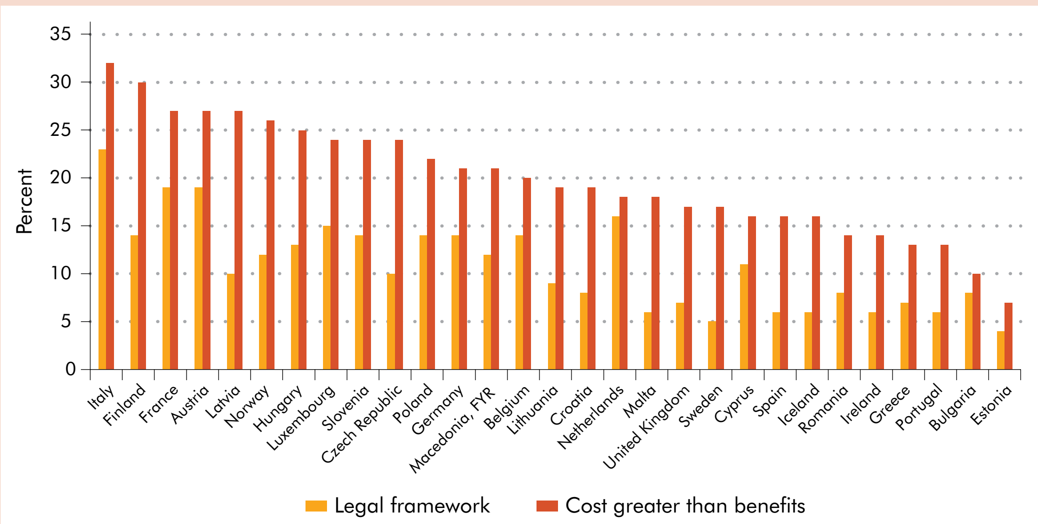
percent of individuals responding



Source: Eurostat. Data at http://bit.do/WDR2016-FigB6_2_1.

Figure B6.2.2 Obstacles for enterprises not selling online in 2013

percent of enterprises responding



Source: Eurostat. Data at http://bit.do/WDR2016-FigB6_2_2.

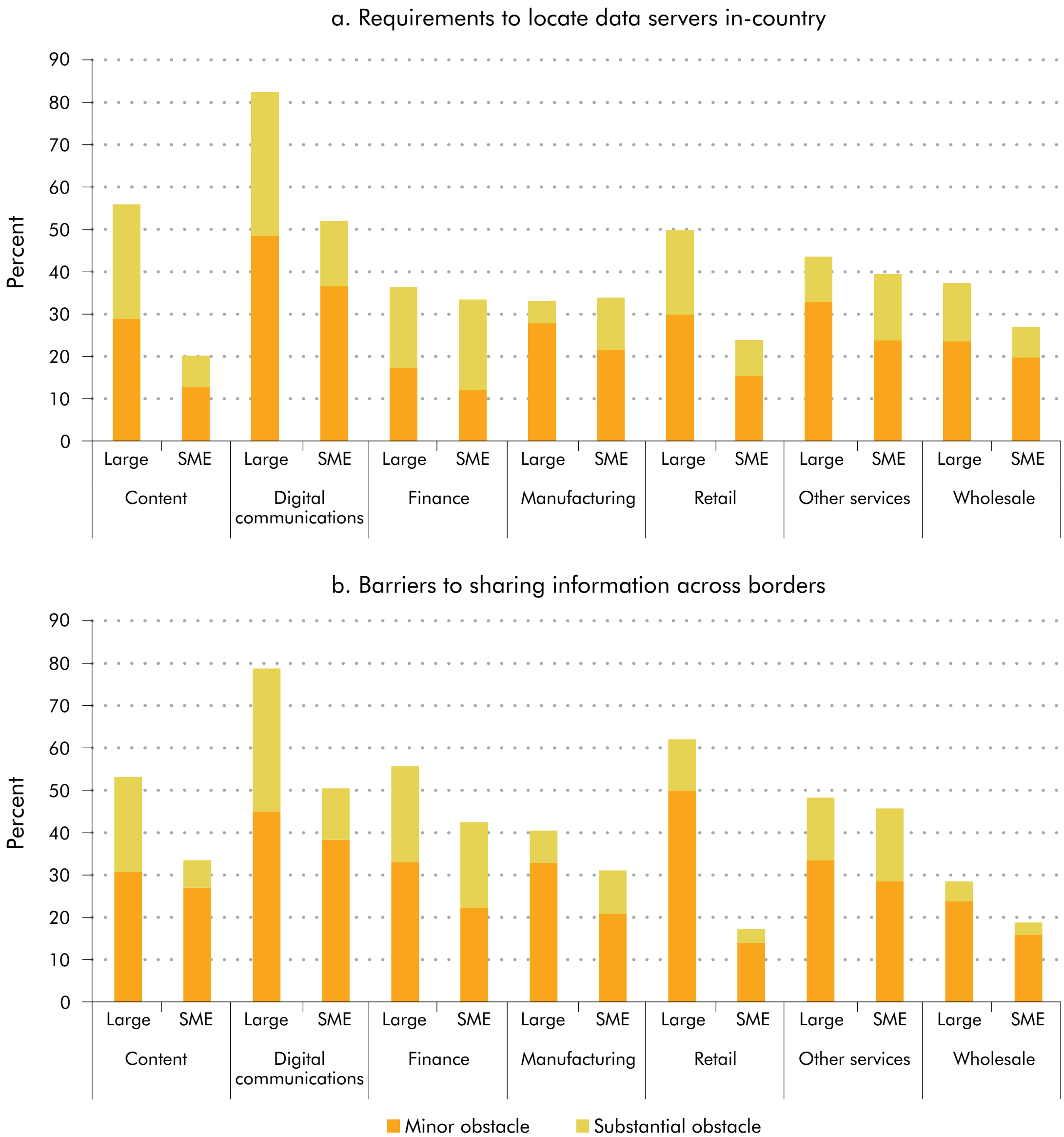
a. European Commission (EC) (2015).

b. Figures given by Andrus Ansip, the European Commission vice president for the digital single market. See http://www.politico.eu /article /cross-border-delivery-costs-pose-problems-for-small-businesses/.

raising standards of living. Barriers to data flows prevent countries from benefiting fully from the internet, increasing costs and inefficiencies for firms and individuals. Firms require free flows of data across national borders to operate internationally. This is increasingly important with production being fragmented into global value chains and the digitization of goods and services. Firms move data internationally to control and coordinate their international operations, maintain an efficient supply chain, and manage human resources, production, and sales. The data can range from personal information about employees and customers to production and technical data. The emerging use of cloud computing and the "internet of things" (see spotlight 6, "Six digital technologies to watch") will increase the need for freer data flows. In a survey of U.S. firms in 2012, a large share of firms felt that data localization requirements and privacy

Figure 6.3 Perception of U.S. firms on barriers to data flows as obstacles to trade, 2012

percent of firms responding



Source: USITC 2014. Data at http://bit.do/WDR2016-Fig6_3.

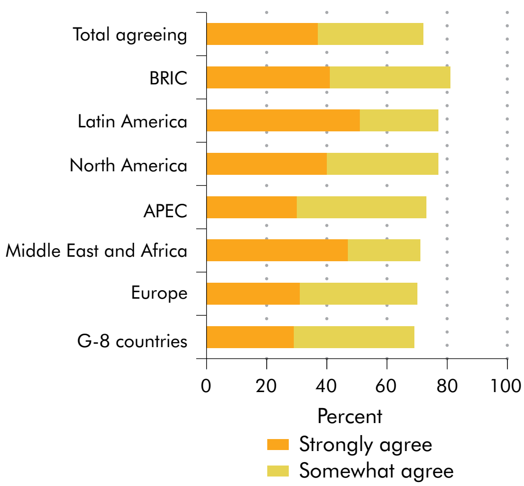
Note: Large firms are classified as firms with more than 500 employees. SMEs (small and medium enterprises) are firms with more than 20 employees and less than 500 employees.

requirements have emerged as substantial obstacles to trade (figure 6.3). Many of these firms operate globally and have business models that depend on free access to data about their users.

In contrast to industry preferences for open data flows, many countries are beginning to insist that data should reside within their national borders—often referred to as "data nationalism"—and are imposing barriers on cross-border flows of data. So-called data localization requirements require firms to locate data servers and data centers within the country to store and process the information. Other countries have strict regulations about data leaving their borders to protect privacy, reflecting the preference of their citizens, as users become more cautious and risk averse to how their data are being used for commercial gains (figure 6.4). Barriers to data flows can affect trade more than an increase in tariffs: they can prevent firms from entering or operating in a sector, while tariff rates merely impose an additional cost to operations that can be absorbed by the firm or passed on to customers.

Cross-border data flows, which are essential to international trade, are a substantial portion of data traffic, comprising about 16–25 percent of U.S. data traffic and 13–16 percent of European data traffic.[18] Cross-border data flows are likely to increase with the increasing use of cloud computing, which relies on data flowing back and forth as users retrieve and update information directly on the servers. Barriers to data flows will force firms to relocate tasks and operations, change their information technology (IT) architecture, engage a different supplier, or discontinue services to customers. These barriers disrupt two of the most important business trends facilitated by the internet: the fragmentation of production into global value chains, and the creation of offshore service hubs like the business-processing operations in India or the Philippines.

Figure 6.4 A majority of respondents agree that their online data and personal information should be physically stored on a secure server in their own country



Source: CIGI and Ipsos 2014. Data at http://bit.do/WDR2016-Fig6_4.

Note: APEC = Asia-Pacific Economic Cooperation; BRIC = Brazil, Russia, India, China; G-8 = Canada, France, Germany, Italy, Japan, the Russian Federation, the United Kingdom, and the United States.

The estimated effects of barriers to cross-border data flows are significant. An economic simulation conducted by the European Centre for International Political Economy (ECIPE) considers the proposed or enacted legislation on data flows in six developing countries and the EU and calculates the costs of regulations on businesses.[19] The countries examined are proposing a mix of regulations in their legislative packages that will impose stricter privacy regulations, such as the right to be forgotten and the consent to transfer data to a third party (table 6.2). The study finds that these laws can reduce gross domestic product (GDP) by up to 1.7 percent, investments up to 4.2 percent, and exports by 1.7 percent (figure 6.5).[20]

The argument to remove all barriers to data flows, however, is not as clear-cut as the arguments to remove barriers to cross-border trade and investment. Government regulations to place data servers in the country or to prevent information from being shared across borders can stem from legitimate concerns about privacy and security for their citizens' information. Countries may believe that imposing data localization and privacy requirements will allow them to better protect the data in their country. But it is not always clear whether the data are more secure in a local data server or in a dedicated secure server overseas. Moreover, data localization requirements might threaten the progress of new technologies that depend on unhindered cross-border data flows such as the internet of things, "big data," and cloud computing.

While countries may have legitimate reasons to impose barriers to data flows, these barriers should not be a disguised method to impede trade and economic activities. By imposing barriers on data flows, countries may mistakenly believe that they can encourage domestic data-driven sectors, like cloud service providers. Such policies are akin to import substitution strategies, which have had a mixed record. Moreover, the barriers should not treat firms differently according to their ownership, as that would reduce competition and slow down digital adoption in the rest of the economy (chapter 1).

Table 6.2 Many countries have proposed comprehensive legislation on data flows

Proposed requirement	Brazil	China	EU-28	India	Indonesia	Korea, Rep.	Vietnam
Data localization requirement	No	Yes	No	Partial	Yes	Partial	Yes
Consent required for data collection	Yes	Yes	Yes	Yes	Yes	Yes	No
Consent required for transfer to third parties	Yes	Yes	No	Yes	No	Yes	No
Right to review	No	No	Yes	Yes	Yes	Yes	No
Right to be forgotten	Yes	Yes	Yes	No	No	Yes	Yes
Breach notification	No	Yes	Yes	No	Yes	Yes	No
Impact assessment	No	Yes	Yes	No	No	No	No
Data privacy officers	No	No	Yes	No	No	Yes	No
Sanctions for noncompliance	Yes	Yes	Yes	Yes	Yes	Yes	No
Government access required	Yes	No	No	Yes	No	No	Yes
Data retention requirement	Yes	No	No	Yes	No	No	Yes

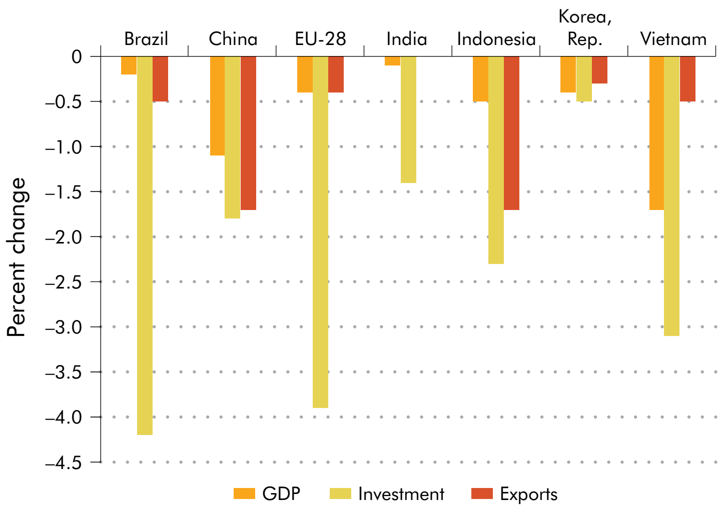
Source: Bauer and others 2014.

Note: EU-28 = current member countries in the European Union.

While these barriers remain, developing countries participating in global markets should ensure that they are not excluded because of weak or absent regulations. At a minimum, countries should enact data protection regulations following internationally recognized principles so that multinational companies do not avoid the country because of uncertainty about compliance and trust in the handling of data.[21] For example, the EU allows personal data to leave its borders if countries have "adequate" protection for personal data. Australia allows data to leave its borders only to those jurisdictions with substantially similar levels of privacy protection. However, these regulations continue to evolve, and countries must constantly adapt to such changes to reduce the uncertainty and compliance costs on companies.[22]

Recognizing the importance of cross-border data flows, many countries have agreed on basic principles to coordinate their data regulations, as with the recently revised Privacy Guidelines and Declaration on Cross-Border Data Flows by the Organisation of Economic Co-operation and Development (OECD), or the Privacy Framework of the Asia-Pacific Economic Cooperation (APEC). Other efforts focus on ensuring that companies that move data across borders have rigorous internal policies to maintain the privacy and protection of the data. In the absence of international coordination on privacy rules, other solutions are being sought that rely on companies' internal policies to protect privacy, such as the EU's Binding Corporate Rules and APEC's Cross-Border Privacy Rules. While these programs help facilitate cross-border data flows, the rules may be too cumbersome for most firms and implicitly benefit larger firms.[23]

Figure 6.5 Changes in GDP, investment, and exports due to regulatory restrictions on data flows



Source: Bauer and others 2014. Data at http://bit.do/WDR2016-Fig6_5.

Note: The figure shows percentage changes according to simulations using a GTAP model. EU-28 = current member countries in the European Union; GTAP = Global Trade Analysis Project.

Setting global standards on data exchange

Standard setting can be another tool to reap digital dividends. Data exchange standards, for instance, can greatly facilitate cross-border services and enable a seamless flow of information (see spotlight 5, "The data revolution"). Various ongoing initiatives look at setting data exchange standards in certain sectors at the international level. The standard should also be open, and use publicly available platforms and software, so that it does not exclude firms. One example is the GS1 system of standards used in transport and logistics. The GS1 assigns a global unique number so that any firm can identify and share product data with its trading partners. The number allows anyone to trace the origins of the product up the supply chain and track its movement downstream.

Data exchange standards are being promoted in the context of Open Data by international organizations. Examples include the Comprehensive Knowledge Archive Network's (CKAN) standards—already adopted by more than 40 governments and organizations, such as the governments of the United Kingdom and Uruguay and the EU—and the Open Data portals for Africa and Bermuda. Progress has also been made in developing data exchange standards for geospatial information (such as the EU INSPIRE directive) in the electricity sector, particularly for smart grids, and in the health sector.

Countries should consider joining ongoing international efforts for standard setting for data exchange, and expanding them to other areas, at least for critical sectors. Data exchange standards, however, are not a silver bullet; they need to be accompanied by appropriate policies and actions to have some effect on the digital market. For e-freight, the International Air Transport Association (IATA) has been working on setting data exchange standards and has identified actions that need to be in place for these initiatives to succeed.[24] One is the requirement that public institutions (such as customs for e-freight) accept electronic documentation as an alternative to paper-based documentation. Another is that all relevant actors need to be involved and act in a coordinated fashion (such as customs, security, and transportation). And third is an end-to-end supply chain vision and e-document, as well as common business processes that are aligned with international standard-setting bodies such as the World Customs Organization, the United Nations Centre for Trade Facilitation and Electronic Business, and the International Civil Aviation Organization.

Better coordination of intellectual property rights regime

The internet allows people to purchase products and access vast amounts of content and information, whether protected by intellectual property rights (IPRs) or not, leading to allegations of IPR infringements. IPR infringement presents a risk to consumers who might purchase counterfeit goods, and a disincentive for firms and artists to create new products and content.[25] National IPR regimes allow firms to protect and use their intellectual property. But having different IPR regimes and multiple IPR registrations, in different countries creates problems for firms selling in global markets. Firms must seek recognition and enforcement in each jurisdiction. Similarly, if a firm wants to use an IPR it does not own to produce a digital good or service, it must apply for licenses in each country in which it wants to sell. While there are international treaties governing recognition and protection across member countries, each jurisdiction has different rules and requirements, depending on the type of IPR. Navigating these IPR regimes is confusing and creates large administrative costs for firms. These costs can even prevent firms from entering new markets.

Firms operating in the global market face huge costs to apply and use IPRs across borders. For example, in order to protect an IPR, a separate patent application is needed in each country where protection is sought. A patent application that is valid in the EU costs at least five times more than an application in the United States.[26] The scattered nature of the IPR regime can add complications for firms when they need to identify the rights holders and construct a new business model. In particular, the firm offering a digital good or service over the internet needs to apply for a copyright license, patent, or trademark in each market it serves, and then must be ready to enforce it under each national regime. The complexity and costs of doing so can discourage new market entrants. Only larger firms will be able to bear those costs and reap the benefits from the internet.

Countries should make it easier for firms to protect their intellectual property rights, thus stimulating more innovation and creative sectors. The regulation process to apply for intellectual property licenses should also be harmonized and streamlined. The Patent Cooperation Treaty allows firms to file an international patent application, but this just creates a standardized application for the firm that must still be submitted to national authorities. Going one step further would be preferable. For instance, under the World Intellectual Property Organization's Madrid Protocol, firms need only register their trademark in any signatory country and it will be protected across member countries. Similarly, it should be easier for firms to obtain licenses to certain IPRs that will allow them to operate globally. The availability of an online licensing system for intellectual property rights can reduce the administrative burden to firms.

National IPR regimes should extend beyond the laws defining and protecting the intellectual property (IP). Countries need a broader public sector IP strategy, which considers how policies and regulations in tax, education, science, technology, and industrial policies can not only make it easier for firms to protect their IPRs but also help to stimulate innovation and creative sectors and benefit the public interest. The availability of an online licensing system for IPRs can reduce the administrative burden to firms. Such an online licensing system requires international coordination and an agreement among many countries. Countries can also allow the concept of "fair use" in intellectual property regulations that permits an individual or business to use the IPR for purposes such as research and education, journalism, and library activities.

Leveraging information for sustainable development

Eliminating global poverty and heading off planetary environmental threats are two of the world's greatest challenges. The costs of action are in the trillions of dollars, making global cooperation essential. But development assistance represents only 0.6 percent of developing country income. How can donors, development agencies, nongovernmental organizations (NGOs), and international organizations hope to make a difference? They can use digital technologies to deploy funds and knowledge more efficiently and to include more people in the process. They can do so in three ways:

- *Getting wired for feedback*. Development projects are often very sensitive to context and have no standard blueprints. They could be more relevant if their design and implementation drew on local knowledge. Projects could be more successful if wired for rapid feedback, allowing continuous improvement by implementers and more effective supervision by funders. National-level policies could be fine-tuned with early information on whether poor people were benefiting. Digital technologies can make these feedback processes much cheaper and easier. But can stodgy organizations and their partners become nimble users of feedback?
- *Taking information to scale: information as an input.* Decision makers from villages to capitals lack the information they need to optimize their actions. Farmers could better manage their fields with timely information about weather, pests, and markets. Ministries could better fight poverty with up-to-date information about where poor people live and their constraints. Land markets and environmental protection could be more efficient with accessible information about the condition and ownership of land. New technologies make it possible to widely and cheaply distribute all this information, supporting better outcomes. But can this succeed over the resistance of those who benefit when information is tightly held?
- *Mustering global information for global goods.* Global weather and water data are costly to gather but now almost costless to distribute. They take on the character of a global public good. Information on weather affecting mountain headwaters helps people prepare for floods or harvests half a continent away. New technologies make it easier to assemble and analyze this information. But who will pay for it? And can countries agree to share it with their downstream and downwind neighbors?

Table 6.3 and figure 6.6 map these information needs onto the landscape of development spending. Some projects are characterized by geographic dispersion, sensitivity to local environmental and social context, and an inherent need for adaptive implementation. These activities could benefit greatly from rich and rapid feedback. Another class of funding involves investments in big infrastructure systems or support for government policies. Here, fine-grained and timely information—on everything from poverty to water consumption to service delivery—could support better decisions on system design and operation. This section explores the potential scope of these benefits and the largely institutional challenges in attaining them. The discussion is unavoidably speculative.

Getting wired for feedback—more inclusive, better, faster data to guide development projects

Feedback on what is working and what is not enables more nimble and effective implementation. In the past, feedback has been thin, slow, and unreliable. Now the technical barriers to better feedback have been overcome. But often organizational inertia prevents the benefits of innovative technologies from being achieved. Revamped structures and incentives point to possible ways forward.

Lack of feedback hampers development efforts

Development agencies committed US$6.8 trillion in project assistance from 1947 to 2012. One would not expect these projects to be universally successful. Development is inherently complex, and development agencies venture into areas that others would not; a high success rate would indicate unambitious objectives. But there is room for improvement in the performance of international foundations, donors, and lenders, whether bilateral or multilateral. About one-third of the recent projects of international financial

Table 6.3 Information as feedback and as input, by expenditure type

Expenditure type	Example	Information as feedback	Information as input
Dispersed and intensive services	Rural primary health, community-driven development	Rapid feedback on service provision, uptake, and impacts	n.a.
Dispersed land and water management	Watershed management	n.a.	Rapid feedback on crop, water, soil, infrastructure, and environmental conditions; information on weather, hydrological and market conditions
Small-scale and dispersed infrastructure	Rural roads and sanitation	Feedback on infrastructure construction, use, condition, and maintenance	n.a.
Large-scale infrastructure	Hydropower	n.a.	Optimizing design and operation of power and water systems
Policy design	Educational policy design	n.a.	Fine-grained, timely information on economic and social conditions for policy design
Institutional development	Legal and judicial development	Feedback on institutional capacity and performance	n.a.
Budget support	Development policy loans	Timely and fine-grained feedback on impacts of policy implementation on income distribution, service delivery, environmental conditions	Strategic planning for the Sustainable Development Goals

Source: WDR 2016 team.

Note: n.a. = not applicable.

institutions are deemed unsuccessful by the institutions themselves (figure 6.7). What goes wrong?

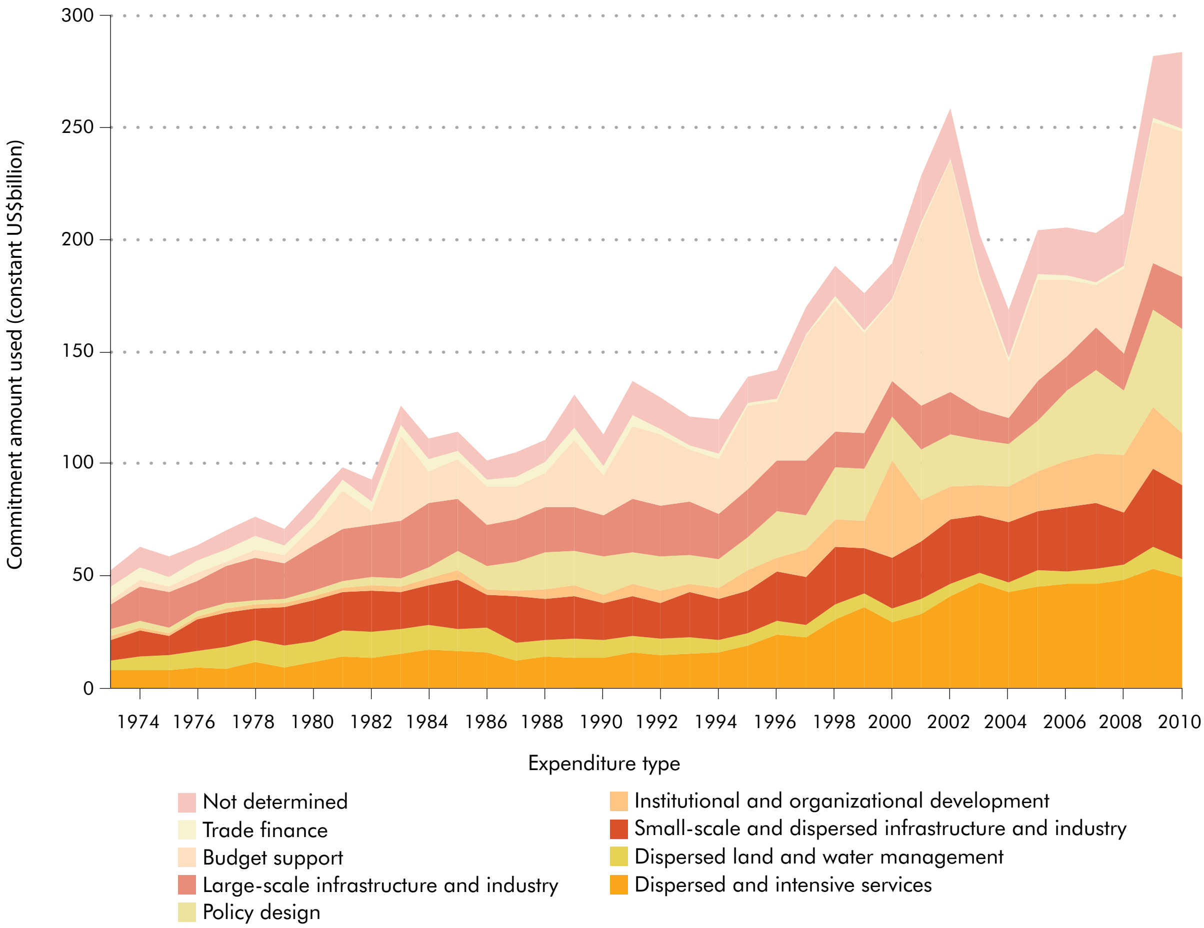
Critics paint development practice as inflexible, ineffective, and out of touch.[27] Too much emphasis on spending rather than on results, they say. Project designs are cooked up by development experts and government officials, in this view, and often do not reflect local preferences, insights, or political realities. They can be further hampered by lack of rigorous, systematic learning about the success or failure of prior projects. Without reliable information on project effectiveness, flashy bad ideas go viral while subtle good ones languish. With such poor design, projects can go off the rails. And if they do, there is often no fast channel for feedback and course correction.

A combination of rigid design and poor feedback might be particularly lethal for "complex" and context-sensitive projects, where workable solutions require experimentation.[28] Consider health services, where success depends on changing the culturally rooted behavior of clients and staff—or watershed management, where social and environmental conditions vary from one valley to the next.

Yet there is a paradox: monitoring and evaluation (M&E) improves performance, but agencies underinvest in it. The correlation between a project's outcome and the quality of its M&E is stunning. Figure 6.8 (based on data from the World Bank, the only official donor agency that publishes this information in this detail) shows that the few projects with high-quality M&E are almost all rated "satisfactory" or "highly satisfactory" in outcome; the larger number with "negligible" M&E are mostly rated "moderately unsatisfactory" or worse. Evaluations suggest a strong causal link: a good M&E system supports clear formulation of objectives, and M&E detects and solves problems in implementation.[29] Despite this, an OECD survey[30] of 28 donors finds pervasive shortcomings in their M&E systems. A majority of the donors report incomplete results frameworks, difficulty in tracking outcomes, and a view by partners that a results framework is a formal requirement rather than a useful tool. Feedback loops are reportedly lacking. NGOs echo these views. Many donor staff and recipients see M&E as a burdensome "extractive industry," generating information that satisfies some distant funder's accountability requirements but does not serve the needs of project managers or beneficiaries.

Worse: learning is slow. The multilateral development banks have independent evaluation units for both accountability and for learning—an important source of objective feedback. But these units do not

Figure 6.6 **The evolution of development aid by information needs, 1973–2010**



Source: WDR tabulation from AidData (http://AidData.org). Data at http://bit.do/WDR2016-Fig6_6.

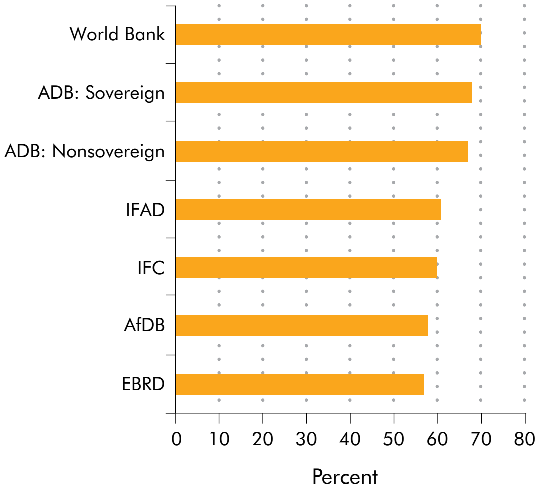
have resources to review every project in depth. They also focus on after-the-fact evaluations to avoid conflicts of interest. This slows feedback: at the World Bank, the average lag between project approval and evaluation is 7.5 years.

Technology enables feedback for agile implementation and learning

New technology should make M&E even faster, cheaper, and more effective. A poster-child example is the World Bank–backed Sujala project in Karnataka, India, which employed a technology-intensive M&E system operated by the Indian Space Research Organisation.[31] This combined remote-sensing imagery with household surveys and sophisticated data systems for management and geographic information. Detecting that benefits were not being focused on the poorest groups, the project fixed the problem. It rigorously demonstrated a 24-percent increase in average incomes, together with environmental improvements, and helped shape the revised national watershed guidelines.

Computer-assisted surveying—by mobile phone or by tablet-wielding field agents—now enables much faster and more reliable assembly and use of information on the progress of projects. A nascent example is the Social Observatory, a pilot that embeds a variety of feedback systems into a multibillion dollar program on rural livelihoods—precisely the kind of complex program noted earlier. The Observatory fields rigorous but slow randomized controlled trials to determine whether particular phases or elements of the program had the desired impact. It supports internet-connected management information systems, wired from the village up, that allow program managers at the district or state level to detect and correct anomalies in performance. Perhaps most interesting, it supports a beneficiary-designed survey, administered

Figure 6.7 Proportion of international financial institution projects with successful outcomes



Sources: Based on most recent available reviews of independent evaluations or independent validations of self-assessments. Data at http://bit.do/WDR2016-Fig6_7.

Note: ADB = Asian Development Bank; AfDB = African Development Bank; EBRD = European Bank for Reconstruction and Development; IFAD = International Fund for Agricultural Development; IFC = International Finance Corporation. "Outcome" is an index combining efficacy, relevance, and efficiency. "Success" is a rating of 4 or better on a 6-point scale (IFAD, IFC, World Bank); 3 or better on a 4-point scale (ADB, EBRD); or 2.5 or better on a 4-point scale (AfDB).

by locally recruited women using a tablet computer. The annual survey, planned for 1 million respondents, aims to provide actionable feedback at all levels from village to state (box 6.3).

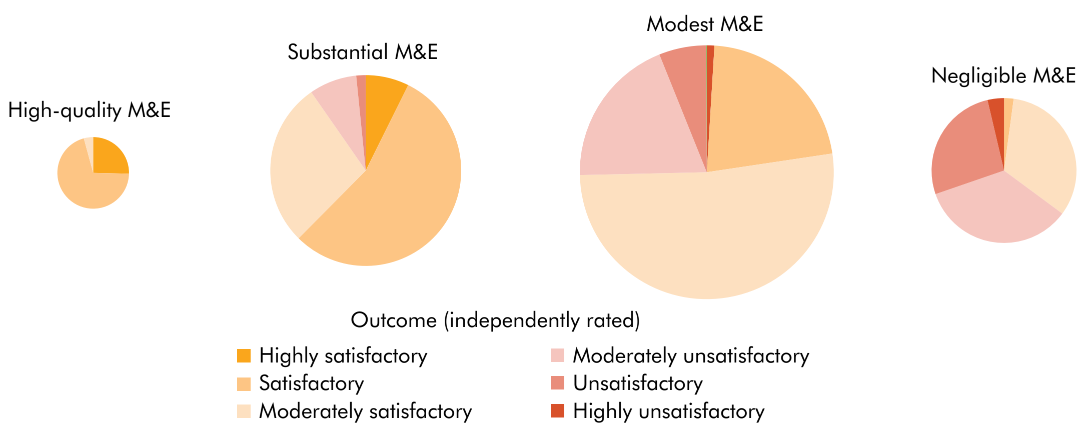
Feedback is facilitated for programs that are built around data platforms. For instance, the Bridge International Academy in Kenya monitors teacher and student performance, allowing management to intervene when teachers, students, or schools are underperforming (see chapter 3). Bus rapid transport systems can automatically monitor vehicle speed and ridership, tracking maintenance, capacity use, and responses to weather. Health systems can track use and outcomes if patients and providers use digital ID cards to log services. Remote sensing can track program impacts on agriculture, water use, deforestation reduction, or air pollution. Ground sensors can track the sustainability of infrastructure in remote and conflict-affected areas, as in Afghanistan and Pakistan. These systems offer rich, representative, actionable real-time information.

Organizational inertia impedes agile, feedback-intensive approaches

These techniques are technically feasible, but are they organizationally feasible? One obstacle is a skills gap, but this can be remedied through training. Obstacles posed by incentives are more formidable. First, donor agencies, their staff, and their recipients are often focused more on maximizing disbursements than on optimizing results. Disbursements are more immediately linked to organizational power and survival, and have traditionally been much easier to track and manage.

Second, organizations cling to procedures that assume that projects can be thoroughly planned in advance and in detail. According to an OECD survey, "Development practitioners report being constrained by rigid results frameworks that are not flexible enough to include new sets of information to adapt to

Figure 6.8 High-quality M&E improves project outcomes



Source: WDR 2016 team based on World Bank data. Data at http://bit.do/WDR2016-Fig6_8.

Note: Colors code the proportion of projects by outcome. The size of the circle is proportional to the number of projects in the M&E category. M&E = monitoring and evaluation.

Box 6.3 The Social Observatory and P-tracking

"Do you decide on what types of clothes to wear based on your own preferences?" That's a question on a survey instrument to assess whether Tamil Nadu's Empowerment and Poverty Reduction Project (part of the Pudhu Vaazhvu Project, or PVP) is actually having an impact on women's empowerment. For project beneficiaries, it was a touchstone indicator of empowerment.

That may be because it was crafted by a group of the women the project is designed for.

The Social Observatory seeks to build diagnostics and feedback loops into the implementation of PVP and similar livelihood projects in India. These are complex projects, operating in hundreds or thousands of locations. They have multiple objectives and lots of moving parts: job training, loans for small-scale income-generating activities ranging from dairy production to sanitary napkin manufacture, even self-defense classes. So it is hard to get a fix on what is going on without a lot of information. To provide useful feedback, the Observatory deploys a variety of tools, including randomized controlled trials, internet-connected management information systems, and "P-tracking," the participatory approach to monitoring.

P-tracking builds on a few innovations. First, as the name suggests, the survey instrument was designed in a participatory fashion with a group of beneficiaries to ensure that the information is seen as relevant. Indeed, the women report that the acts of administering and responding to the survey helped change perceptions. (The survey is not village-specific; after testing, it was standardized for statewide use.) Second, it is administered by local staff, not by some external contractor. Third, it informs higher-level project management but also provides actionable information at the village level.

Digital technologies help. The surveys are administered using tablet-based software, and the data are pooled through village-based internet connections. (These, by the way, also allow villagers to buy train tickets, pay electric bills, and check school exam scores without hours-long queueing or travel.) Automating the survey makes it easier to train the local interviewers. It is difficult to imagine how the Social Observatory could realize its goal of scaling up to 1 million respondents, and providing timely annual information, using traditional paper-based surveys.

Most interesting, the Observatory tackled ways to make this massive information set digestible, a problem facing all producers of data, big or small—and a particularly challenging problem when many users are illiterate. The Observatory commissioned an interactive graphical display that allows a village to compare its performance with neighbors, catalyzing healthy competition.

Like so many promising ideas covered in this report, P-tracking is still in a demonstration phase. About 40,000 interviews have been completed in a pilot district, and it will be a big leap to cover the projected million. Another challenge will be to mainstream annual P-tracking data into project implementation at all levels. Information supply is just half the battle.

Source: WDR 2016 team; http://www.worldbank.org/en/programs/social-observatory.

changing contexts and emerging challenges."[32] Third, when funders—such as taxpayers—cannot directly observe results, there can be a conflict between accountability and learning. The OECD survey notes that "results data for accountability purposes tend to emphasize the positive," getting in the way of learning. Ninety percent of the agencies surveyed reported difficulties in using results for accountability. In sum, as seen also in chapter 3, rapid feedback may be technically feasible, but it will have limited impact unless there is willingness to accept it and flexibility to act on it.

A focus on results and learning can shift incentives toward demand for information

Thus the key to technology effectiveness is, once again, in the analog world—in institutional structures and incentives that elevate feedback and learning. Many private companies, and some development agencies such as the Bangladeshi-based development organization BRAC, already have cultures that do this. For others, culture change will be a challenge. Traditional and nontraditional agencies are experimenting with ways to make their business more agile—ways that are untried and carry risks as well as promise.

One approach concentrates on inclusion—bringing in feedback and ideas at the design stage so as to combine global technical expertise with profound local insights and knowledge. Amplify, an innovation of the U.K. Department for International Development (DFID), tries to build collaborative networks of development practitioners to develop more inclusive proposals for grant funding. It uses online crowdsourcing to suggest and refine ideas, and facilitates collaborations among distant groups—such as a New York design study and a Nepalese NGO.

Another approach to changing institutional incentives is by pursuing outcome-based aid. This shifts funder and client attention from disbursements to results. Disbursements are made only after achieving pre-agreed outcomes. This should motivate both funders and recipients to rapidly track processes, outputs, and results, introducing the possibility of flexibility in getting those results; a downside is shifting implementation risk to the recipients. The World Bank's new Program for Results (P4R) uses independent verification of outputs and outcomes to motivate countries to beef up their own monitoring systems. In Vietnam, for instance, a P4R sanitation project links disbursements to installations of household toilets. The state audit agency sends out surveyors equipped with smartphones to independently verify, with GPS-stamped photos, a sample of health ministry–reported installations. Beyond simply incentivizing particular outcomes, this approach may catalyze a wholesale shift in P4R clients toward a culture of results, motivating them to invest in real-time monitoring.

More disruptively, development impact bonds have been proposed as a way to use an outcome-based approach to solve agencies' constraints of inflexibility, risk aversion, and short time horizons. In this relatively untried approach, agencies contract with a private party or NGO for the achievement of specified and verified results, potentially over a period longer than most projects. The contractor has the flexibility to decide how to achieve those results—and could profit or lose depending on performance. But the approach's effectiveness will depend on how well specified and reliably measured the indicators are for making disbursements. Poorly specified proxies could produce perverse impacts, as could measurement systems subject to tampering. Digital technologies could make a difference by allowing better measurement and independent verification of the desired outcomes. They could also monitor unexpected social or environmental impacts. And they can be used to collect rich qualitative data as a check against the potential bias of narrowly specified quantitative targets.

Another way to motivate attention to results is by an evidence-based approach to financing, as illustrated by the Development Innovation Ventures initiative of the U.S. Agency for International Development (USAID). Small grants support proof-of-concept pilots. Ideas that have passed the first stage are rigorously evaluated in a second-stage testing phase. Those with demonstrated impact can get large grants for scaling up. Although Development Innovation Ventures is not restricted to digital technologies, many of the supported concepts are based on ICTs or use ICTs for monitoring in the demonstration phase. ICTs could thus speed the more reliable demonstration and dissemination of investment ideas.

To sum up, an alternative vision of development practice starts with incentives. Project or program staff get incentives and flexibility to pursue results. So do beneficiaries. Digital technologies facilitate rapid, real-time monitoring of outputs and outcome results that matter, and provide this information in a comprehensible form to those who can act on it—complemented by systems that assess impacts. Consistent with privacy considerations, these data streams would be made public, as open data. Anyone—program managers, civil society, academics, or auditors—can have access to this information. With many eyes on the information and a profusion of analyses, accountability and learning are enhanced. In this system of *open-source evaluation*, it is important to have an independent group assure integrity of the data system.

Taking information to scale

How can emerging opportunities to build internet-based services make development and environmental management more efficient and inclusive? These services reduce the cost of information as an input, thereby reducing risks or improving decisions—for individuals, for managers of infrastructure networks, and for public authorities. The rationale for involvement by development or international agencies is fourfold. First is a characteristic feature of information services: many of these interventions are expensive to set up and run, but can distribute information at very low marginal cost. So financing becomes problematic. If the service is nearly costless to distribute, then it is efficient to provide it to everyone who might benefit. But the fixed costs must be financed somehow. High fees might exclude poor people; low fees imperil sustainability; price discrimination might be difficult. And if the information can be copied, it may be difficult to get anyone to pay for it. So there is often an argument for public or donor finance. Second, the information often underpins a public good, such as environmental protection or poverty reduction, reinforcing the rationale for public finance. Third, development agencies—including NGOs and foundations—can play a distinctive role not only through finance, but also via capacity building, and support for complementary investments and policy reforms. Finally, there is a need for international coordination to face planetary issues such as climate change.

What follows are some concrete examples of how information and analytics might be able to boost efficiency at the individual and system level, with implications for the role of development agencies (box 6.4).

Information as an input to individuals

Poor people are often poor in critical information: about the benefits of hand-washing, or tomorrow's weather forecast, or the price their produce will fetch. When information becomes dramatically cheaper, there is a prospect for welfare gains. Some of the clearest and most relevant examples to poverty reduction are in agriculture, which will here serve as an illustration of the wider potential across many aspects of life and the economy.

For tropical maize in Africa, yields are typically only one- fifth of the potential, and for other crops and places in the developing world, yields rarely exceed 80 percent of the potential.[33] Many factors account for this poor performance, but a lack of information—about techniques, weather forecasts, and markets—is a part of the gap. Traditional agricultural extension agencies have tried to fill the information gap, but have depended on in-person farm visits and printed material. Extension agents are typically assigned to serve an impossibly large number of farmers spread over a logistically daunting stretch of countryside, so information flows are low, and do not include customized information based on seasonal and daily weather forecasts.

Pilot programs are beginning to tap the potential of ICTs to reduce costs and increase the reach of extension efforts. Some initiatives in India show

Box 6.4 ICTs and the Sustainable Development Goals

In the year 2000, when the international development community came together at the United Nations (UN) to approve the Millennium Development Goals (MDGs),[a] the digital revolution was just beginning. At that time, there were fewer than 1 billion mobile phones in use worldwide and just 400 million internet users. In the intervening years to 2015, when the MDGs were reviewed, both indicators have grown by more than sevenfold. Thus target 18—*to make available the benefits of new technologies, including ICTs (information and communication technologies)*—was one where progress was easy to show.

But with the new generation of Sustainable Development Goals (SDGs), adopted by the UN in 2015, the bar has been raised. As part of a broader goal 9, on infrastructure, industrialization, and innovation, the SDGs commit to "significantly increase access to ICTs and strive to provide universal and affordable access to the internet in LDCs [least developed countries] by 2020." Given that many developed countries are already close to saturation in terms of mobile penetration, it is logical to focus on internet access, and specifically on the needs of the LDCs. The two key words in the new target are "universal" and "affordable."

Given the current low level of internet penetration in the LDCs—just over 10 per 100 inhabitants by the end of 2015[b]—achieving "universal" coverage would imply a required growth rate of 51 percent a year, much faster than the LDCs have achieved since 2000. Affordability is also likely to be a challenge as only 1 of the 48 LDCs, Bhutan, actually met the UN target in 2013.[c] Nevertheless, LDC mobile coverage currently stands at close to 70 subscriptions per 100 inhabitants. As those mobile phones are upgraded to smartphones, and as coverage of 3G (third-generation) and 4G (fourth-generation) signal expands, this target will become more attainable—although perhaps not by 2020.

The real significance of the internet for the SDGs is likely to lie in helping to achieve other targets, such as target 3.9 on achieving universal health coverage, target 5b on promoting women's empowerment, or target 10c on reducing the transmission costs of migrant remittances to below 3 percent.[d] As noted, timely, fine-grained information on households, the economy, and the environment can accelerate achievement of the SDGs. This information can provide actionable feedback on where and why progress is or is not being made. This is the essence of the "data revolution," called for by the High-Level Panel of Eminent Persons in their 2013 report, which kick-started discussion of the post-2015 development agenda.[e]

a. See http://www.un.org/millenniumgoals/.
b. See ITU 2015.
c. The target for affordability, as defined by the UN Broadband Commission, is a monthly price for entry-level broadband below 5 percent of gross national income (GNI) per capita: see http://www.internetsociety.org/map/global-internet-report/?gclid=CLv0tI35yMYCFQ2QHwodcWYGaw#affordability-mobile-broadband.
d. See UN 2014.
e. See UN 2013.

Box 6.5 Digital Green: "How-to" videos for agriculture and health

Digital Green uses video cameras, battery-operated projectors, and the internet to get information into the hands of villagers in India and Africa. It works like this: Local people film local farmers demonstrating a useful agricultural technique or health practice. These include preparation of seeds, enhancements of milk yield in cattle, and oral rehydration therapy for children suffering from diarrhea. The videos are pooled on the internet. Then local resource people download, show, and explain seasonally appropriate videos to community assemblies. The premise is that the home-grown videos convey the technical details of the technique, and do it with the credibility of a neighbor speaking in a familiar dialect.

The system automatically keeps track of which videos are most likely to prompt adoption, so monitoring is an integral element of operations, not a burdensome add-on. An early self-evaluation reported a 90-percent reduction in the cost per adoption. A randomized controlled trial found that 16 percent of farmers exposed to Digital Green adopted a yield-increasing, water-conserving rice cultivation system, versus 10 percent in a control group. The program, in operation since 2008, reached 660,000 people in 7,645 villages by April 2015.

Sources: http://www.digitalgreen.org; Gandhi and others 2009; Vasilaky and others 2015.

mixed results.[34] A program that sent voice advice to farmers was little used and had no impact. Another, targeted at cotton farmers, shifted them to less harmful pesticides and more valuable crops. A program that put smartphone-equipped extension agents in contact with experts improved farmer awareness of extension services, but the impact on incomes was not measured. In Peru, however, a careful experiment showed that provision of market information via cellphones boosted farmers' selling prices by 13 percent and increased the participation of subsistence farmers in the markets.[35] The effects were particularly marked for perishable goods and for risk-averse farmers. A particularly interesting program—because its "how-to" video approach could be applied in domains outside agriculture—is Digital Green (box 6.5).

More ambitiously, a movement toward "precision agriculture" crunches big data to provide farming advice. At its most capital-intensive, an instrumented tractor gathers georeferenced data on field conditions and plant health. These data are combined with weather data and fed into a computer model of plant growth. The model then works through the tractor, fine-tuning the application of fertilizer and pesticide as it traverses the field. By curbing overuse of fertilizer, water, and pesticides, precision agriculture can improve the environment while boosting farm profits.

More affordable approaches are needed for the developing world. An emergent example is a system of decision support for rice agriculture in Colombia developed by the national rice association with support from the International Center for Tropical Research. Colombian rice yields have been falling as increased climate variability invalidates traditional calendar-based rules of thumb on when to plant. The decision-support system merged historical data on climate and harvests with current weather forecasts to advise farmers on optimal planting decisions. In an early application, the model correctly foresaw that crops would fail due to drought and advised farmers not to waste time and money on planting.

Donor funds (including NGO funds) and technical inputs have been important in most of these initiatives. Many fail to scale up. All face the challenge of finding a sustainable business model. This may entail a combination of subscription sales and recurrent public financing. Assessment of the benefits of this information could help in pricing decisions and in determining the role of public finance.

Information as an input to managing complex systems

Much of development involves managing complex systems, such as power networks and urban transportation. With better information and analysis, these systems can be designed and managed for greater efficiency.

Power utilities can be helped by information in a variety of ways (see sector focus 5, "Energy"). Developing countries, though short on power, nonetheless see much of their electricity production lost to poor maintenance and to theft. Data analytics can optimize schedules for transformer maintenance and replacement, and can pinpoint locations for attention to reduce theft. Big data can also be used to enable grids to assimilate the ebb and flow of power from wind turbines and solar panels, and to adjust prices in real time to shave off peaks in demand. Put together, these tweaks in system operation can reduce power outages, reduce the need to invest in expensive peak supply, improve the bankability of power, and reduce environmental damages. Many of the same principles can be applied to water utilities.

Urban transport is another complex system where newly cheap information unlocks possibilities for greater efficiency. A good starting point is with the most basic foundation of planning: of the 25 largest low- and lower-middle-income cities, 92 percent do not have complete maps of their transit networks.[36] Compiling these maps used to be time-consuming and expensive. Recently, though, Manila developed and applied a mobile phone–based application to survey and map routes, using an open-source data standard. The map powers a consumer trip-planning app and is being used by city planners to reduce redundant routes and plan a new mass transit corridor. In Seoul, the transit agency used locational data from 3 billion nighttime phone messages to map travel patterns and design an optimal route for the immense city's first late-night bus service. Traditional household surveys would have been slower, more expensive, and less informative. Moving on from static mapping, an initiative in Cebu, the Philippines, was able to ingest real-time taxi data to generate speed and congestion maps for the entire city. This reduced the time to analyze travel time for a bus corridor from two weeks to two seconds. Ultimately cities may be able to use real-time data to design and implement policies that increase transit accessibility, decrease travel time, substitute for expensive road construction, and abate congestion and pollution.

Rural land management, to be efficient, depends on accurate and accessible information about land plots. Land sales and rural credit markets function better when there is a comprehensive system of land registration. Secure, registered land tenure also gives farmers incentives to invest in their land and protects them from illegal expropriation. ICTs have revolutionized the logistic burden of mapping, recording, and verifying landholdings—key elements of documenting land tenure. They do so in two ways. First, mapping boundaries with GPS is much faster, less expensive, and less demanding of scarce skills than traditional surveying. Second, open and transparent digital registration of land titles reduces the cost of verifying ownership and inhibits fraud and corruption. Thus land registration is a platform for building a variety of valuable services.

As an example of the potential, a pilot land regularization project in Rwanda used aerial photography and digital registration, and was found to double the rate of investment and maintenance of soil conservation structures.[37] The effect was particularly marked for female-headed households. But the gender impacts were complicated because of the way tenure regularization interacted with laws and traditions. Married women improved their land access, but those in informal unions were worse off. Girls' and boys' planned land inheritance was equally boosted—except in female-headed households, where sons gained an edge. Contrary to expectations, there was no effect on access to credit. Overall, the pilot was sufficiently successful that it is being expanded nationwide, to 10 million land parcels, at a cost of US$5 a parcel.

Environmental management also depends on land data. Since the 1970s, Brazil has used satellites to monitor deforestation in the Amazon. In 2003 the government made a landmark decision to release the raw data. This enabled NGOs such as IMAZON to develop their own analyses, improving the information base and raising public awareness and pressure for environmental action. Starting in 2004, the Brazilian government began using monthly data to guide enforcement of forest and agricultural policy, with demonstrable impacts on reducing deforestation.[38] More recently, Brazil embarked on an ambitious program to precisely map every rural property and use satellite observations to monitor compliance with forest conservation regulations. By September 2015, it had registered 2.1 million properties covering 2.6 million square kilometers.[39] Registry in this environmental cadastre is a condition for credit and other services, motivating compliance. It also sets up a framework for trading forest conservation obligations, which reduces the cost and increases the benefits of conservation.

Disaster risk management inherently demands a great deal of timely and location-specific information. Over just the past few years, internet-enabled information has begun to change the way in which donors respond to emergencies, and is helping to increase disaster preparedness and resilience (box 6.6).

For all these systems' management challenges, big data offers plausible efficiency gains. In many cases, realizing those gains involves overcoming not just technical obstacles, but also political ones.

Box 6.6 Disaster risk management

As climate becomes more volatile and populations swell in coastal, floodplain, and earthquake-prone areas, disaster risk management (DRM) becomes ever more important. Annual disaster losses now average US$200 billion globally, and large disasters can derail a country's growth. Information and communication technology (ICT) applications—especially those involving crowdsourced, open data and open-source software—are rapidly being incorporated in each aspect of DRM:

Risk identification and mitigation. The best way to deal with disasters is to build resilience in advance, so that when the storm or flood or earthquake hits, lives are not lost and damage to property is minimized. This requires extensive, geographically precise information and planning. What locations are subject to natural disasters, with what probability? How sturdy are the buildings in those locations, and who occupies them? Which ones need to be shored up and how much will that cost? Detailed answers have typically not been available. Map data have been inadequate, often inaccessible, and difficult to handle. But with revolutions in geographic information systems, remote sensing, and crowdsourcing, that is changing.

In flood-prone Jakarta, Indonesia, for instance, the Disaster Management Agency asked the heads of the city's 267 wards to map the location of critical infrastructure using OpenStreetMaps, a tool that allows volunteers to create detailed digital maps that can be used without restriction. More than 1 million buildings have been mapped. InaSAFE, an open-source software program, was then used to analyze potential impacts of floods, and helped in the response to the 2013 and 2014 floods. More recently, petajakarta.org exploited the city's high rate of Twitter usage to crowd-map flood locations in real time during the 2014–15 monsoon season, helping citizens navigate the flooded city and augmenting the DRM agency's information base.

Early warning. Many lives have been lost for lack of adequate warning of impending disaster. Now, widespread access to mobile phones, combined with weather monitoring systems, allows for timely and near-universal warnings. For instance, the Philippines's Project NOAH (Nationwide Operational Assessment of Hazards) uses real-time data from rain gauges, water sensors, and radar to provide evacuation alarms.

Damage assessment and response. In the chaos following a disaster, it has been difficult to match relief supplies with need, and then to inventory damage and prioritize recovery operations. Here again, crowdsourcing has revolutionized response. After the devastating 2010 Haiti earthquake, a spontaneous volunteer effort used the Ushahidi platform to aggregate and map status reports and requests for help from social media and text messages. Over 1,000 Haitian volunteers living abroad translated and geolocated the messages. And more than 700 volunteers used OpenStreetMaps to create new maps. These were subsequently updated, by more volunteers, with satellite and aerial imagery, to form the basis for the postdisaster needs assessment. Technological progress continues: after Vanuatu's 2015 cyclone, drones were used to survey damage, providing much more detailed damage information than is possible with aerial photography.

The move of these methods to open-source software and open data is noteworthy, and has implications beyond DRM. For capacity- and cash-constrained agencies in developing countries, open-source software is much cheaper to acquire than proprietary software, and avoids dependency on a single supplier. It allows high levels of customization and, because it often adheres to open standards, easier integration with other software. It encourages cross-fertilization, community building, and code sharing with others around the world; for an example, see geonode.org. These advantages need to be weighed against the potentially (but not necessarily) higher level of support offered by proprietary software.

Similar considerations apply to open data. By opening data, it is easier to find and assemble the multiple layers of information—land cover, topography, population, infrastructure, hydrology—necessary for DRM. And, of course, open data can be distributed to users free of charge.

Crowdsourced data are not without difficulties. Accuracy and completeness are issues. Both Haiti and Jakarta developed systems for confirming the accuracy of reports. Sustainability of volunteer engagement is a challenge, since DRM data need constant updating. Feeding back the information to communities is one way to encourage this.

Of course, crowds are just one data source. A key to DRM is the integration of many different kinds of information. Rio de Janeiro's Center of Operations prepares the city to deal with its many risks, including floods and landslides, by combining real-time information on rain, tides, transport, and city services with 560 video cameras. It also serves to coordinate the diverse government departments, and to feed information to the public and the media.

Sources: WDR 2016 team based on inputs from the Global Facility for Disaster Reduction and Recovery; Haklay and others 2014; Heinzelman and Waters 2010; Holderness and Turpin 2014; Matheus and Ribeiro 2014.

Powerful interest groups may stand to lose from systems efficiency. These include consumers and utility employees who benefit from electricity theft, operators of unregulated minibuses, land-grabbers, and flouters of environmental regulations. Disaster risk management and climate adaptation require extensive coordination among ministries used to working independently. Donors may be able to play a role in supporting the complementary reforms necessary to overcome these obstacles.

Information as an input to poverty reduction efforts

In fighting poverty, as in any strategic endeavor, it is useful to diagnose challenges and track progress. Timely, disaggregated poverty indicators could promote accountability, boost motivation, and provide the kind of relevant feedback described earlier in this chapter, at the policy level. For instance, many proposed policy reforms have potentially large and poorly understood distributional impacts, sometimes leading to contentious gridlock. The ability to predict those impacts and then to verify them in practice could help to accelerate reforms. Up-to-date information on the location, health status, and consumption patterns of poor people could help design and target programs more efficiently. For these reasons, a panel commissioned by the United Nations[40] sees better data as an indispensable tool for achieving the Sustainable Development Goals (SDGs) (see spotlight 5, "The data revolution").

To date, however, development decisions and priorities have often been made while flying blind. For instance, energy subsidy reform—a trillion-dollar-a-year issue with huge poverty and environmental implications—is contentious in many countries. Yet an authoritative global analysis of the poverty impacts of reform was forced to use household data that were, on average, more than eight years old.[41] Consider this sobering picture of the state of knowledge about African growth and poverty.[42] Just half of African countries compute GDP using current standards; when Ghana adopted those standards, national income was found to be nearly two-thirds higher than previously thought. Only one-third of countries have two comparable measures of poverty over time, and even then the latest estimate is often years out of date. To make things worse, basic civil registration systems cover only 45 percent of births in Sub-Saharan Africa, making it difficult to track child mortality (one of the starkest measures of poverty) or to get an accurate measure of population. Thus it is difficult to track progress even at the national level, let alone at the fine-grained level relevant to provinces or communities.

However, many countries lack the money to fund basic information systems, the organizational incentives to share information, and the human skills to supply and use data. International actors can help on all counts. Donors have supported keystone household surveys, including the Living Standards Measurement Surveys and the Demographic and Health Surveys. These have provided crucial information for decision making, with the added benefit of facilitating international comparisons, thanks to standardized definitions. Donors have also supported capacity building at national statistical organizations. But as noted, coverage is far from complete and timely. A comprehensive program of statistical gap-filling for the 77 low-income countries that belong to the World Bank's International Development Association (IDA) is estimated to cost about US$1 billion a year.[43] Current official development assistance runs around US$350 million, according to the report, while domestic spending is not known.

Costs may be reduced, or effectiveness improved, through new technologies. For instance, computer-aided surveying can reduce the cost of traditional household surveys by 60 percent.[44] New opportunities are arising to complement traditional censuses and surveys with big data that can provide up-to-date information at a fine geographical level. For instance, cellphone call detail records are being used to impute real-time measures of poverty—and internet data, to construct real-time inflation or even GDP measures. These techniques are not likely to replace traditional statistical sources. Quite the contrary: high-quality censuses and surveys become even more valuable because they can adjust for biases in big data (see box 6.7).

Mustering information for global public goods

Many problems—climate change, ozone depletion, air pollution, epidemics, financial crises—are features of globally interconnected environmental, economic, and social systems. Addressing them requires coordinated global actions. Setting priorities and targeting actions require global information. That information is itself a global public good. As such, it is subject to the scale effects described earlier in this Report.

Perhaps the quintessential example is the immensely valuable data on weather, water flows, and climate. One estimate of the benefits of upgrading developing country weather systems to developed country standards is between US$4 billion

Box 6.7 Can "big data" provide real-time, geographically detailed information on poverty?

Traditional surveys and newfangled big data sources have complementary strengths and weaknesses. Surveys work very hard at being accurate—for instance, precisely tallying the value of everything a household buys or produces—and making sure that everyone in the target population, especially poor people, are covered. This makes it possible to accurately measure changes over time. But even with tablet-assisted surveying, traditional household survey data will be months old before they are published. And sample sizes of a few thousand do not allow much insight into what is happening with subgroups or at particular locations.

So researchers are trying to estimate income with cellphone use data, which cover a large proportion of the population, are literally up to the minute, and can provide a snapshot of activity at the level of a village or urban ward. The estimates use information such as how often the user buys airtime, in what denominations, and the frequency of international calls. Hurdles include finding ways to ensure data anonymity and convincing phone companies to share data. But the big disadvantage, from a monitoring perspective, is that the data do not accurately represent the population. Many poor people do not have phones. And the relationship between income and airtime purchases will change over time as prices of service and phones change.

One possible solution is to use repeated small "gold standard" surveys to calibrate the cellphone data. A hint of the possibilities is given by a study that successfully replicated the results of a populationwide opinion poll based on a survey of Xbox gamers—a predominantly young, male group. The key was a sophisticated method of correcting for the skewed nature of the sample using information on the age and sex distribution of the general population.[a]

a. Wang and others, forthcoming.

and US$36 billion a year.[45] Data on river flows are essential for disaster risk planning and for planning and operating hydropower and irrigation systems. And detailed long-term data are essential for tracking and understanding climate change patterns. These data are sorely underprovided. Because weather is a global system, every observation of temperature and precipitation improves weather forecasts (and climate models) at the transnational and even global levels. But poor countries do not have a dense enough network of observation stations even for their own purposes, let alone to contribute to the global good (see map 6.2). Another 4,000 to 5,000 stations are needed in Africa alone.[46] Part of the problem is a lack of funds and capacity to build and maintain stations. Another is that many state-run hydrometeorological agencies refrain from the free distribution of globally valuable data to garner modest revenues from selling data points, not just in poor African countries but also in the majority of European countries.[47]

Once again, technology is making it easier to gather and analyze data of global significance. For instance, tropical deforestation is a global concern, a major source of carbon emissions and biodiversity loss and an issue related in complex ways to rural poverty. Yet until recently, data on tropical deforestation were spotty, inconsistent among countries, and woefully outdated. Now, Global Forest Watch publishes monthly deforestation maps that can spot clearings of as little as 25 hectares.[48] On the horizon are satellite data that might enable daily monitoring at a level well below a hectare. Similar advances are being made in transboundary air pollution (see sector focus 6, "Environmental management") and surveillance of emergent zoonotic diseases.

So there is a role for global finance in the supply of this kind of information, but that is only the beginning. There is a need also to build the willingness to share information, and the capacity to use it.

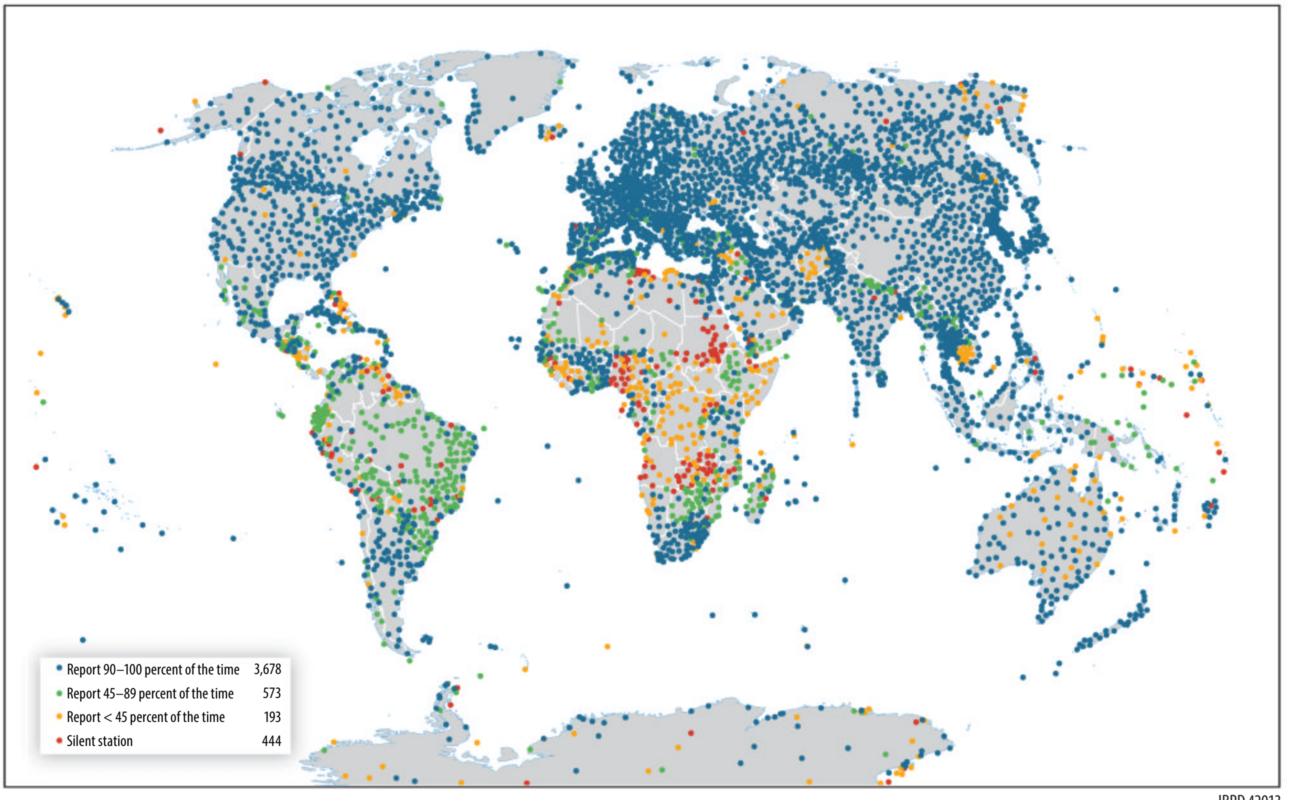
The future of global development cooperation

What's the role of development agents and international organizations in a world where their financial heft is miniscule? The answer set forth here is threefold: in concentrated efforts in the poorest countries; in catalytic injections of ideas, backed with cash, everywhere; and in spearheading global collective action. The data and technology revolutions are arriving in time to bridge the gap between resources and ambition by amplifying the impacts of action and including more people in the formulation and execution of plans. But for this to work, development agents must tackle policy constraints, internal and external.

Start with the *how* of development operations. With new technologies, development agencies can

Map 6.2 Availability of reports from weather stations

Proportion of time that weather stations report SYNOP (surface synoptic observations) data to the World Meteorological Organization



Source: World Meteorological Organization SYNOP data for October 2013, https://www.wmo.int/pages/prog/www/ois/monitor/index_en.html.

IBRD 42013

be more inclusive by tapping the wisdom of beneficiaries in designing interventions. They can crank up their efficiency by using rapid feedback to refine and improve their actions through trial and error, and use open-source evaluation to align performance management with learning. But these approaches will not come easily in organizations that emphasize spending and outputs over results, have burdensome structures for accountability, and see any failures as damning rather than informative. If traditional agencies cannot adapt, some of their business may be taken up by disruptive newcomers, such as GlobalGiving, GiveDirectly, or development impact bonds (box 6.8).

Next, the *what*. Previous chapters have pointed to many areas where external agencies could catalyze development—for instance, in supporting policy reforms that would open up internet access or new approaches to service delivery in health. In this chapter, the emphasis is on creating information services that help individuals and systems managers make better decisions in ways that promote poverty reduction. These services have fixed setup costs in software and data assembly, but can have near zero costs for distributing information. So the private sector will tend either to shy away from providing these services, or to price them at a level that shuts out poor people who could benefit.

Donors can provide the funds and expertise to help get these services going. They can, for instance, support the assembly of critical data and the creation of broadly applicable open-source software. There is a real need, however, for coordination. A DFID study found 70 unrelated mobile-for-health pilots in Uganda, and over 1,800 mobile apps worldwide.[49]

There's another reason for development agents to get involved: to help address the policy issues that impede innovation, or to support complementary investments or capacity building. Thus, for instance, making progress on urban transit could require a combination of information systems, investments in infrastructure, and investments that address opposition to regulation of minibuses or reduction in on-street parking.

Box 6.8 Disruptive approaches to development

Some radical reimaginings of development assistance involve digital technologies to eliminate some of the overhead costs and procedures of traditional approaches. GiveDirectly uses satellite imagery, crowdsourced assistance, and machine learning to identify poor villages in Kenya.[a] The trick: using thatched roofs as an indicator of poverty. Staff are dispatched to the villages to enroll the residents of the thatched houses. GiveDirectly then sends US$300, by mobile phone, to the enrollees. Overhead costs are just 8 percent (for staff and the cost of foreign exchange and money transfers). A randomized controlled trial found a 42-percent reduction in the number of days children go without food, a 58-percent increase in assets, and a 38-percent increase in revenue from self-employment.[b]

GlobalGiving's internet platform allows nongovernmental organizations (NGOs) to post development project proposals for funding by donors, large and small. Thus it taps a more grassroots field of ideas and implementers than traditional agencies. Its website keeps track of project performance and NGO credibility (such as whether NGOs regularly report audits), feeding this information back to donors. GlobalGiving uses its platform to provide online capacity building to the grantees, and allows them to build a reputation based on performance and investments in learning. It plans to assist the grantees in tracking their results, ultimately fostering benchmarking and mutual learning.

GiveDirectly and GlobalGiving thus sidestep much of the traditional costly apparatus for project selection, appraisal, and supervision. GiveDirectly achieves these efficiencies by focusing on a logistically simple intervention. This cannot substitute for interventions that involve externalities or require collective action or large investments. But it implicitly challenges interventions that have more "moving parts"—can they achieve equal impact at equal cost? Global-Giving achieves efficiencies by pushing project appraisal, quality assurance, financial controls, and safeguards to the funders and to the wisdom of crowds, informed by a growing stream of data. Time will tell whether these are inherently niche operations, or the pioneers of a new way of doing development business.

a. Abelson, Varshney, and Sun 2014.
b. Haushofer and Shapiro 2013.

Finally, external agents and international organizations can encourage the unlocking of existing data. Open data can be a powerful tool (see the discussion of open data in the context of disaster risk management in box 6.6). But too often, socially beneficial data are kept under wraps. Both the public and private sector are culprits. As noted, this is true of government-collected data on weather and river flows. In some transboundary river basins, upstream countries do not share river flow data with downstream neighbors, crimping flood preparedness and irrigation management. Basic data on poverty also suffer. Among the Sub-Saharan household surveys that underpin poverty estimates and give insight into causes and correlates of income, education, and health outcomes, fewer than half are available online and free of charge.[50] For East Asia and the Pacific, the proportion is less than 20 percent. Private telecom companies closely hold, and use for commercial purposes, data on cellphone calling patterns useful for transport planning and poverty analysis.

Donors and development agencies can catalyze the potential for open data in several ways. They could work with partners to expand the availability of open data. The principle would be that all supported activities should generate open data by default, with exceptions on the grounds of privacy and other defined concerns. So, support for health and education systems should ensure that these systems track and disclose performance data to the extent possible, while preserving confidentiality of individual records. This also holds for public-private partnerships (PPP), many of which currently do not furnish any data about their performance, and which may use client-generated data for commercial gain. Agencies that advise on or finance concessions in power, water, transit, telecom, and other services could demonstrate to public authorities the advantages of making performance data open. Data could include public scrutiny of the concessionaire, informative new data "mash-ups," and the capacity for open-source evaluation of options for improved equity and efficiency. Agencies could then help governments craft PPP contracts that recognize the rights of clients to their own information and of the public to anonymized performance data. Donors, both traditional and nontraditional, can set a good example by ensuring that their own data are open—particularly, meteorological and hydrological data with transboundary benefits. They can support policy reforms in developing countries that fund data-producing agencies, allowing them to reduce fees.

Agencies or international organizations could also explore the potential to create sectoral data standards. Open data are more useful when they can be consistently compared and aggregated across units. Data standards also make it easier to develop apps and programs for use and analysis. The Group on Earth Observations, an international consortium, is doing this for remote sensing data. Development agencies could work together to create standards for data on development impact or results. A beginning would be to more thoroughly report results under the International Aid Transparency Initiative standards. Some agencies report financial transactions, but only 5 out of 68 agencies publish machine-readable information on project targets and results—which would allow benchmarking and comparison across providers.[51]

Finally, as noted, there are significant financing needs for building the data that could guide the pursuit of the SDGs, and the capacity to use those data. There could be opportunities to build reusable, customizable open-source software and systems for monitoring the SDGs, reducing duplication of efforts, saving costs—and improving lives.

Notes

1. David Clark's often-quoted statement refers to the work of the Internet Engineering Task Force (IETF). See https://www.ietf.org/tao.html.
2. Wu 2010.
3. World Summit on the Information Society 2005.
4. Much of the discussion in this section is derived from Dutton (2015) for this Report.
5. Sadowsky 2014, 82; UNESCO 2015.
6. Portions of this section are adapted from Satola and Kelly (2014).
7. See http://www.itu.int/wsis/index.html.
8. Dutton 2015 for this Report.
9. Dutton 2015 for this Report.
10. See, for example, Judy and Satola (2014).
11. In May 2011, UN Human Rights Council Special Rapporteur Frank La Rue issued his report on the right to freedom of expression on the internet, saying that states are increasingly censoring information online through arbitrary blocking or filtering of content, criminalizing legitimate expression, imposing intermediary liability, disconnecting users from the internet, and not providing adequate protections to privacy and data. See http://www2.ohchr.org/english/bodies/hrcouncil/docs/17session/A.HRC.17.27_en.pdf.

    The UN Human Rights Council issued a second report in April 2013 suggesting that nations' laws on surveillance were overbearing and recommending that states revise and align their surveillance laws to comply with international human rights. See http://www.ohchr.org/Documents/HRBodies/HRCouncil/RegularSession/Session23/A.HRC.23.40_EN.pdf.

    In June 2012, the UN Human Rights Council adopted a resolution preserving human rights on the internet, affirming that people have the same rights online that they have offline—in particular, freedom of expression (A/HRC/20/L.13) (June 29, 2012).
12. The WCIT Final Acts are available at http://www.itu.int/en/wcit-12/Pages/default.aspx. For an analysis of the outcome, see http://www.cullen-international.com/asset/?location=/content/assets/regulatory-intelligence/regulatory-news/wcit-12_post-mortem_culleninternational.pdf/wcit-12_post-mortem_culleninternational.pdf.
13. IANA, a subsidiary of ICANN, has traditionally performed certain technical functions essential for the smooth and secure running of the internet, including control of the internet protocol (IP) addressing system (numbering resources, including IPv4 and IPv6), managing IP protocols, and managing the root zone database for domain names (domain name management). The U.S. government, through the National Telecommunications and Information Administration (NTIA), a branch of the U.S. Department of Commerce, has had oversight over these functions through a series of agreements with ICANN, first formalized in 1998 under what was called a memorandum of understanding. The memorandum went through several iterations and morphed into what was then called the Joint Project Agreement, which itself underwent one amendment. In 2009, it was replaced by a document called the Affirmation of Commitments. In each iteration of the agreement between NTIA and ICANN, and over time, NTIA has "loosened" its oversight of the performance of these IANA functions by ICANN. This latest move by NTIA can be seen as part of a continuing evolution away from NTIA's control and oversight of IANA functions.
14. In August 2015, NTIA announced it would defer the deadline for considering a transition proposal for at least a year.
15. In addition to endorsement of the MSM by the UN's World Summit on the Information Society, both the Organisation for Economic Co-operation and Development and the European Commission have reconfirmed their support. See European Commission (EC 2014) and OECD (2014b).
16. See European Commission (EC 2014).
17. It is important to note that the sale of music files does not necessarily take place across borders. In

many cases, the sale of digital goods across borders is blocked by geographically limited IP regimes. This applies to other digital goods like e-books and videos. Instead, one should think about these cross-border transactions as transactions between firms in different countries for the license to sell the content. See Nicholson and Noonan (2014) for a discussion.
18. Mandel 2013.
19. Bauer and others 2014.
20. Bauer and others (2014) calculate the percentage changes to GDP, investment, and total exports as a result of the proposed legislation in a Global Trade Analysis Project (GTAP) model. The effects of the data regulations are included in the model as an increase in business costs, an increase in costs for data-driven services trade, a decrease in investments, and a decrease in the effectiveness of data-related research and development.
21. National Board of Trade 2015.
22. For example, in October 2015, the European Court of Justice declared invalid the EU-U.S. "safe harbor" rules regulating internet firms' retention of Europeans' data in the United States. An ongoing case between Microsoft and the U.S. Department of Justice seeks to clarify whether U.S. government agencies can access e-mail messages stored in Microsoft servers in Europe.
23. For example, the EU's Binding Corporate Rules (BCRs) require firms to set up internal company policies and appoint personnel to handle cross-border data transfers. These firms must go through a certification process overseen by a data protection office, which involves audits and company visits. As of May 2015, only 66 companies had obtained BCRs, and most of them are large multinational companies.
24. IATA 2015.
25. A study by Aguiar and Martens (2013) finds that illegal music downloads do not displace legal music sales. The individuals in the study would not have purchased the music they downloaded illegally if it was not available on the illegal downloading website.
26. van Pottelsberghe de la Potterie and Mejer 2010.
27. See Easterly 2006, 2014; Andrews, Pritchett, and Woolcock 2013; Ramalingam 2013; Whittle 2013; Booth and Unsworth 2014.
28. Andrews, Pritchett, and Woolcock 2013; Whittle 2013.
29. The correlation shown in figure 6.8 could potentially have a spurious component, if the ex post M&E rating influences the outcome rating. However, the correlation holds when the independent M&E rating is related to the self-rating of outcome. Moreover, a review of 195 in-depth project evaluations looked at positive and negative mentions of the specific roles of problem-solving, frequency of supervisory visits, and M&E design quality. It found them to be highly associated, in magnitude and statistical significance, with better and worse project outcomes.
30. OECD 2014a.
31. IEG 2011.
32. OECD 2014a, 22.
33. Lobell, Cassman, and Field 2009.
34. Nakasone, Torero, and Minten 2014.
35. Nakasone 2013.
36. World Bank 2015.
37. Ali, Deininger, and Goldstein 2014.
38. Assunção, Gandour, and Rocha 2013; Assunção and others 2013.
39. Government of Brazil 2015.
40. See UN 2013.
41. del Granado, Coady, and Gillingham 2012.
42. Devarajan 2013.
43. Espey 2015.
44. Espey 2015.
45. Hallegatte 2012.
46. Rogers and Tsirkunov 2013.
47. Rogers and Tsirkunov 2013.
48. See http://www.globalforestwatch.org.
49. Ranger, Chandler, and Arscott 2015.
50. Demombynes and Sandefur 2014.
51. Aid Transparency Index 2014. http://ati.publishwhatyoufund.org/findingapproaches-to-publishing-results-information/.

References

Abelson, Brian, Kush R. Varshney, and Joy Sun. 2014. "Targeting Direct Cash Transfers to the Extremely Poor." Paper presented at the 20th Association for Computing Machinery's Special Interest Group on Knowledge Discovery and Data Mining's International Conference on Knowledge Discovery and Data Mining, New York City, August 24–27.

Aguiar, Luis, and Bertin Martens. 2013. "Digital Music Consumption on the Internet: Evidence from Clickstream Data." Working Paper 2013/04, Institute for Prospective Technological Studies Digital Economy, Seville, Spain.

Ali, Daniel Ayalew, Klaus Deininger, and Markus Goldstein. 2014. "Environmental and Gender Impacts of Land Tenure Regularization in Africa: Pilot Evidence from Rwanda." *Journal of Development Economics* 110: 262–75.

Andrews, Matt, Lant Pritchett, and Michael Woolcock. 2013. "Escaping Capability Traps through Problem-Driven Iterative Adaptation (PDIA)." *World Development* 51: 234–44.

Assunção, Juliano, Clarissa Gandour, and Romero Rocha. 2013. "DETERring Deforestation in the Brazilian Amazon: Environmental Monitoring and Law Enforcement." Technical report, Climate Policy Initiative, PUC-Rio.

Assunção, Juliano, Clarissa Gandour, Romero Rocha, and Rudi Rocha. 2013. "Does Credit Affect Deforestation? Evidence from a Rural Credit Policy in the Brazilian

Amazon." Technical report, Climate Policy Initiative, PUC-Rio.

Bauer, Johannes, and Bill Dutton. 2015. "Addressing the Cybersecurity Paradox: Economic and Cultural Challenges to an Open and Global Internet." Background paper for the *World Development Report 2016,* World Bank, Washington, DC.

Bauer, Matthias, Hosuk Lee-Makiyama, Erik Van der Marcel, and Bert Verschelde. 2014. "The Costs of Data Localization: Friendly Fire on Economic Recovery." ECIPE Occasional Paper 3/2014, European Centre for International Political Economy, Brussels.

Booth, David, and Sue Unsworth. 2014. "Politically Smart, Locally Led Development." Discussion paper, Overseas Development Institute, London.

Brazil, Government of. 2015. "Cadastro ambiental rural: Boletim informativo Setembro de 2015." http://www.florestal.gov.br/download-document/2739-boletim-informativo-setembro-de-2015.

CIGI (Centre for International Governance Innovation), and Ipsos. 2014. "Global Survey on Internet Security and Trust." https://www.cigionline.org/internet-survey.

del Granado, Francisco Javier Arze, David Coady, and Robert Gillingham. 2012. "The Unequal Benefits of Fuel Subsidies: A Review of Evidence for Developing Countries." *World Development* 40 (11): 2234–48.

Demombynes, G., and J. Sandefur. 2014. "Costing a Data Revolution." Working Paper 383, Center for Global Development, Washington, DC.

Devarajan, Shantayanan. 2013. "Africa's Statistical Tragedy." *Review of Income and Wealth* 59 (S1): S9–S15.

Dutton, William. 2015. "Multi-Stakeholder Internet Governance." Background paper for the *World Development Report 2016*, World Bank, Washington, DC.

Easterly, William. 2006. *The White Man's Burden: Why the West's Efforts to Aid the Rest Have Done So Much Ill and So Little Good.* New York: Penguin Books.

———. 2014. *The Tyranny of Experts: How the Fight against Global Poverty Suppressed Individual Rights.* New York: Perseus Books Group.

EC (European Commission). Various years. Eurostat (database). European Commission, Brussels, http://ec.europa.eu/eurostat/data/database.

———. 2014. "The Future of the Multistakeholder Model." European Commission, Brussels.

———. 2015. "Digital Single Market Factsheet." http://ec.europa.eu/priorities/digital-single-market/docs/dsm-factsheet_en.pdf.

Espey, Jessica. 2015. *Data for Development: A Needs Assessment for SDG Monitoring and Statistical Capacity Development*. Paris: Sustainable Development Solutions Network. http://unsdsn.org/resources/publications/a-needs-assessment-for-sdg-monitoring-and-statistical-capacity-development/.

Gandhi, Rikin, Rajesh Veeraraghavan, Kentaro Toyama, and Vanaja Ramprasad. 2009. "Digital Green: Participatory Video and Mediated Instruction for Agricultural Extension." *Information Technologies and International Development* 5 (1): 1–15.

Gasser, Urs, Ryan Budish, and Sarah Myers West. 2015. "Multistakeholder as Governance Groups: Observations from Case Studies." Berkman Center Research Publication 2015-1. http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2549270.

Haklay, Mordechai, Vyron Antoniou, Sofia Basiouka, Robert Soden, and Peter Mooney. 2014. "Crowdsourced Geographic Information Use in Government." Report prepared for the World Bank, Global Facility for Disaster Reduction and Recovery, London.

Hallegatte, Stéphane. 2012. "A Cost-Effective Solution to Reduce Disaster Losses in Developing Countries: Hydro-Meteorological Services, Early Warning, and Evacuation." Policy Research Working Paper 6058, World Bank, Washington, DC.

Haushofer, Johannes, and Jeremy Shapiro. 2013. *Household Response to Income Changes: Impacts of Unconditional Cash Transfers*. Cambridge, MA: Abdul Latif Jameel Poverty Action Lab.

Heinzelman, Jessica, and Carol Waters. 2010. *Crowdsourcing Crisis Information in Disaster-Affected Haiti*. Special Report 252. Washington, DC: U.S. Institute of Peace.

Holderness, Tomas, and Etienne Turpin. 2014. "Assessing the Role of Social Media for Civic Co-management during Monsoon Flooding in Jakarta, Indonesia." Smart Infrastructure Facility, University of Wollongong, New South Wales, Australia.

IATA (International Air Transport Association). 2015. "E-Freight Fundamentals." IATA presentation. http://www.iata.org/whatwedo/cargo/e/efreight/Pages/index.aspx.

IEG (Independent Evaluation Group). 2011. "Project Performance Assessment Report: India—Cluster Assessment of Forestry and Watershed Development Activities." World Bank, Washington, DC.

ITU (International Telecommunication Union). 2015. "Facts & Figures." http://www.itu.int/en/ITU-D/Statistics/Documents/facts/ICTFactsFigures2015.pdf.

Judy, Henry, and David Satola. 2014. "Business Interests under Attack in Cyberspace: Is International Regulation the Right Response?" *Business Law Today*. http://www.americanbar.org/publications/blt/2011/12/02_judy.html.

Kummer, Markus. 2013. "Multistakeholder Cooperation: Reflections on the Emergence of a New Phraseology in International Cooperation." *Internet Society Public Policy* (blog). http://www.internetsociety.org/blog/2013/05/multistakeholder-cooperation-reflections-emergence-new-phraseology-international.

Kurbalija, Jovan. 2015. *An Introduction to Internet Governance.* 6th ed. Geneva: DiploFoundation.

Lobell, David B., Kenneth G. Cassman, and Christopher B. Field. 2009. "Crop Yield Gaps: Their Importance, Magnitudes, and Causes." *Annual Review of Environment and Resources* 34: 179–204.

Mandel, Michael. 2013. "Data, Trade and Growth." Working paper, Progressive Policy Institute, Washington, DC.

Matheus, Ricardo, and Manuella Maia Ribeiro. 2014. "Case Study: Open Government Data in Rio de Janeiro City." http://www.opendataresearch.org/projects/2013/cities.

Nakasone, Eduardo. 2013. "The Role of Price Information in Agricultural Markets: Experimental Evidence from Rural Peru." Paper presented at the Agricultural & Applied Economics Association's 2013 AAEA & CAES Joint Annual Meeting, Washington, DC, August 4–6.

Nakasone, Eduardo, Maximo Torero, and Bart Minten. 2014. "The Power of Information: The ICT Revolution in Agricultural Development." *Annual Review of Resource Economics* 6 (1): 533–50.

National Board of Trade. 2015. "No Transfer, No Production: A Report on Cross-Border Data Transfers, Global Value Chains, and the Production of Goods." *Kommerskollegium* (Swedish Board of Trade). http://www.kommers.se/In-English/Publications/2015/No-Transfer-No-Production/.

Nicholson, Jessica, and Ryan Noonan. 2014. "Digital Economy and Cross-Border Trade: The Value of Digitally Deliverable Services." *ESA Issue Brief* 01-14, U.S. Department of Commerce, Economic and Statistics Administration.

OECD (Organisation for Economic Co-operation and Development). 2014a. *Measuring and Managing Results in Development Cooperation: A Review of Challenges and Practices among DAC Members and Observers*. Paris: OECD.

———. 2014b. *Principles for Internet Policy Making*. Paris: OECD. http://www.oecd.org/sti/ieconomy/oecd-principles-for-internet-policy-making.pdf.

Ramalingam, Ben. 2013. *Aid on the Edge of Chaos*. London: Oxford University Press.

Ranger, Pippa, Julia Chandler, and Beatrice Arscott. 2015. *DFID Review of Digital in Development Programmes.* London: Department for International Development.

Rogers, David P., and Vladimir V. Tsirkunov. 2013. *Weather and Climate Resilience: Effective Preparedness through National Meteorological and Hydrological Services*. Washington, DC: World Bank.

Sadowsky, George. 2014. *Accelerating Development Using the Web: Empowering Poor and Marginalized Populations.* Washington, DC: World Wide Web Foundation.

Satola, David, and Michael Kelly. 2014. "Internet Governance Overview: How Snowden Didn't Really Change Anything After All." *Business Law Today* (November). http://www.americanbar.org/publications/blt/2014/11/01_satola.html.

UN (United Nations). 2013. *A New Global Partnership: Eradicate Poverty and Transform Economies through Sustainable Development*. New York: United Nations Publications.

———. 2014. *Open Working Group Proposal for Sustainable Development Goals.* New York: United Nations Publications.

UNESCO (UN Educational, Scientific and Cultural Organization). 2015. "Keystones to Foster Inclusive Knowledge Societies: Access to Information and Knowledge, Freedom of Expression, Privacy, and Ethics on a Global Internet." http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/CI/CI/pdf/internet_draft_study.pdf.

USITC (U.S. International Trade Commission). 2014. *Digital Trade in the U.S. and the Global Economies, Part 2*. Washington, DC: USITC.

van Pottelsberghe de la Potterie, Bruno, and Malwina Mejer. 2010. "The London Agreement and the Cost of Patenting in Europe." *European Journal of Law and Economics* 29: 211–37.

Vasilaky, Kathryn, Kentaro Toyama, Tushi Baul, Mohak Mangal, and Urmi Bhattacharya. 2015. "Learning Digitally: Evaluating the Impact of Farmer Training via Mediated Videos." Columbia University Earth Institute, New York.

Wang, Wei, David Rothschild, Sharad Goel, and Andrew Gelman. Forthcoming. "Forecasting Elections with Non-representative Polls." *International Journal of Forecasting*.

Whittle, Dennis. 2013. "How Feedback Loops Can Improve Aid (and Maybe Governance)." Center for Global Development, Washington, DC.

World Bank. 2015. *Asia: Urban Transport and ICT Capacity Building*. Washington, DC: World Bank.

World Summit on the Information Society. 2005. "Tunis Agenda for the Information Society (paragraph 33)." http://www.itu.int/net/wsis/docs2/tunis/off/6rev1.html.

Wu, Tim. 2010. *Is Internet Exceptionalism Dead? The Next Digital Decade: Essays on the Future of the Internet*. Washington, DC: Tech Freedom.

SECTOR FOCUS 6

Environmental management

The internet is transforming how policy makers and citizens meet the challenge of environmental management. New technologies have greatly improved monitoring of environmental quality and helped free data from the obscurity of closed government offices, instead making them instantly accessible. This is having profound effects. Not only are these technologies improving the ability of public authorities to monitor pollution, but they are also pushing the boundaries for civic engagement. This is happening in many areas of environmental policy making, including forest monitoring, water quality assessments, identification of natural hazard risk, and air quality management—the emphasis of this sector focus.

Air pollution is a growing threat to health the world over. Exposure to particulates with a diameter of less than 2.5 micrometers ($PM_{2.5}$)—which are capable of penetrating deep into the lungs—increased in all regions between 1998 and 2012, with the exception of North America and Europe. Health risks include heart disease, stroke, lung cancer, and respiratory infections. Exposure to outdoor $PM_{2.5}$ pollution was the ninth leading cause of death and disability worldwide in 2010, accounting for 3.2 million deaths (6 percent of global mortality). There is also growing evidence that $PM_{2.5}$ pollution could harm cognitive functions and contribute to diseases such as Alzheimer's and Parkinson's. The economic costs of deaths and debilitating illnesses related to PM pollution, measured by reduced labor productivity, amount to 4 percent of GDP for some developing countries.[1]

This sector focus was contributed by Chris Sall and Urvashi Narain.

The benefits of the internet in managing air quality

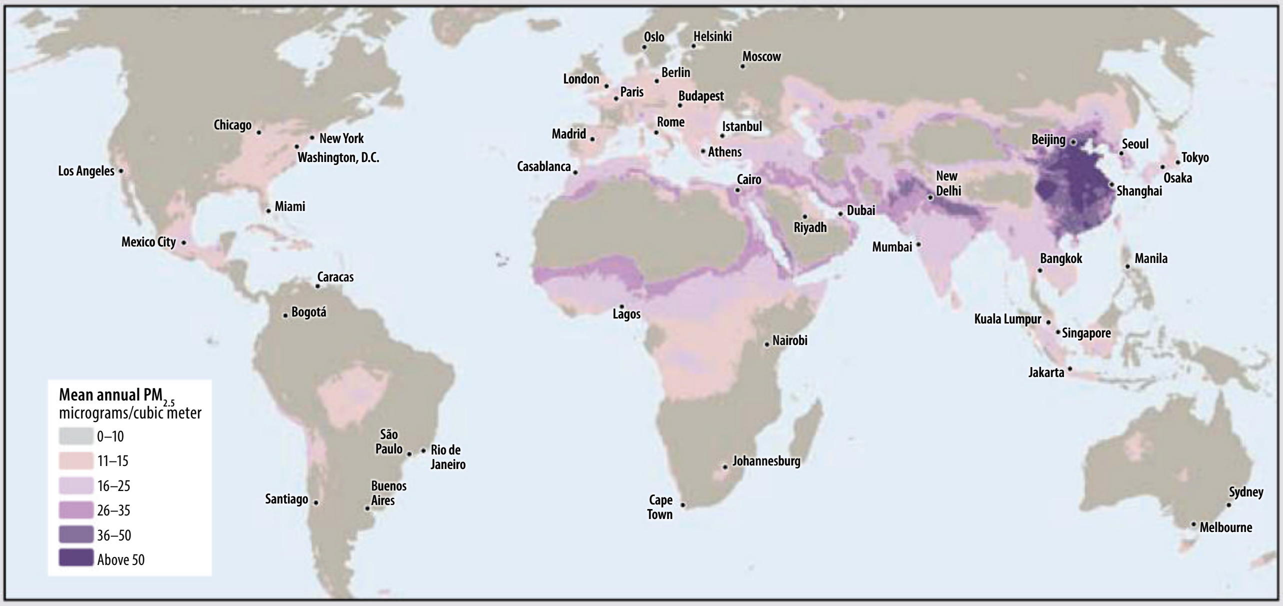
Enabling comprehensive monitoring

Countries now have new tools to monitor the concentration of ambient pollutants, the first critical step in devising an air quality management plan. Ground-level monitoring is common in high-income countries and some middle-income countries such as China, but there are large parts of the globe where monitoring of $PM_{2.5}$ is rare. Barriers include the high cost of installing and maintaining monitoring networks and a shortage of technicians and experts with specialized skills.

New satellite-based sensors measure pollution concentrations from space.[2] In combination with models of particulate movement through the atmosphere, satellite data supplement information provided by sparse ground-level monitors to produce estimates of pollution concentrations over larger areas (map F6.1). In the United States, public agencies are investigating using satellite-based measurements to enhance air quality forecasts for areas where gaps exist in the monitoring network. Remotely sensed data will prove especially helpful for regions where there is currently very little on-the-ground monitoring, such as in Africa.

Personal mobile technologies could also improve pollution monitoring. One California startup has created a wearable monitor primarily intended for developing countries such as China, India, and Mexico. The keychain-size device, called Clarity and costing between US$50 and US$75, uses an optical sensor to measure concentrations of $PM_{2.5}$, nitrogen

Map F6.1 **Satellite estimates of average $PM_{2.5}$ concentrations provide global coverage, 2010**



IBRD 42014

Source: Data from Brauer and others 2012 for the Global Burden of Disease study (Lim and others 2012).

Note: Includes only anthropogenic emissions; concentrations of dust and sea salt are not shown. $PM_{2.5}$ = particulates with a diameter of less than 2.5 micrometers.

oxides, ammonia, and volatile organic compounds. Data will be gathered and analyzed in the cloud so that users can view real-time, crowdsourced maps of pollution in their neighborhood or city.

Improving policy design

Singapore is one of the first cities to pioneer the use of "big data" to help fight congestion and thus reduce pollution from idling vehicles. The city is testing new satellite positioning technologies to improve its existing Electronic Road Pricing (ERP) scheme. The system tracks the exact locations of vehicles and measures their distance traveled on congested roadways. By pinpointing traffic congestion, ERP tariffs can be automatically adjusted to individual driving behavior, providing drivers with incentives to find less congested routes.

Empowering regulators

New, lower-cost sensors and information technologies are reducing the cost to regulators of enforcing limits on emissions from sources such as factories, farms, and energy producers. Sensors can be placed within facilities, at fence lines, or in downwind communities to continuously monitor emissions and transmit data via the internet to regulators. This makes it possible to gauge actual pollution loads (such as kilograms of PM emitted) over time, instead of occasionally sampling gases in smokestacks. Such data support emissions trading schemes and other market-based policies to reduce pollution. An example is the successful sulfur dioxide (SO_2) permit trading system in the United States, which nearly halved SO_2 emissions within a year and saved industries at least US$255 million in annual compliance costs. In India, regulators in the states of Gujarat, Maharashtra, and Tamil Nadu are installing low-cost sensor technologies at industrial facilities for a new pilot trading scheme for PM pollution.

Empowering citizens

Publicly accessible data on pollution concentration levels enable citizens to take preventive measures to reduce their personal risk of exposure and pressure governments to enforce existing emission standards. The AIRNow program of the U.S. Environmental Protection Agency (U.S. EPA) provides hourly, real-time maps and forecasts of air quality. The program illustrates recent changes in data policies. In the early 1990s, local, state, and federal agencies collected air quality data from monitoring stations and sent the data to the U.S. EPA for processing. Concerns over data quality, potential misuse of data, and limited technical capabilities meant that data were released with long delays. Today, AIRNow gathers real-time data from 1,300 ozone and 300 PM monitoring sites, performs automated data quality checks, and provides hourly maps and forecasts of local, regional, and national air quality. Cloud-based computing and mapping, combined with new mobile platforms, make local air quality reports and forecasts accessible to everyone, everywhere. And open data standards allow developers and public interest groups to pull information from AIRNow into their own web services.

Public information disclosure programs that monitor and publicize the environmental performance of firms empower communities to pressure otherwise weak regulatory institutions to enforce environmental standards. These programs now rely on the internet to improve the free flow of information and reduce the cost of data collection and dissemination. Online registries that compile information on pollutant releases by industrial facilities and other sources have been set up in at least 20 nations, including in Japan, the Republic of Korea, Mexico, the United States, and the countries of the European Union. Disclosure programs that rate the environmental performance of firms have also been implemented in about 60 countries. Ratings programs in countries such as India and Indonesia have had a significant, measurable impact in reducing pollution by the worst-performing plants.

China offers an example of how information technologies can leverage mandatory public disclosure programs and expand citizen engagement.[3] Public disclosure of environmental monitoring data in China has expanded rapidly in the last few years in what could be characterized as a virtuous cycle made possible by information technologies. The attention generated by Tweets of air quality data from unofficial monitoring sites in Beijing and other cities prompted programs by public agencies to build official monitoring systems and make the data publicly available in real time. In 2013, the Ministry of Environmental Protection issued rules mandating the disclosure of real-time pollution data by key enterprises and local authorities.

The next year, the Institute of Public and Environmental Affairs (IPE) in Beijing, a public advocacy group, released a free mobile app to put these data directly in the hands of the public. Users of the Pollution Map (*wuran ditu*) app can see current emission levels of local factories and other entities and ascertain whether the readings exceed legal limits. They can share this information on popular social media apps and submit reports and photos of companies that are violating emission limits. According to IPE's founder, Ma Jun, the app gives citizens the hard data they need to put pressure on enterprises and local authorities when environmental standards are being violated. There are already some signs of success. On several occasions in 2014, authorities in the city of Yantai, Shandong Province, publicly responded to social media posts that enterprises in the area were violating emissions limits and resolved the complaints within a few days.

Smart public policy can help make the most of new technologies for monitoring and reducing pollution. Apart from stronger requirements for public disclosure of monitoring data, governments play an important role in setting standards for data collection, reporting, and sharing; offering guidance on best practices for use of technologies; and rating the performance of devices used by consumers. To keep up with the pace of technological change, it is vital for governments to regularly review policies and standards in recognition of new data services. Such policies for encouraging the innovative use of information technology may form an important part of a broader air quality management strategy.

Notes

1. Global Commission on the Economy and Climate 2014.
2. van Donkelaar and others 2015.
3. Li 2011.

References

Brauer, M., M. Amman, R. T. Burnett, A. Cohen, F. Dentener, M. Ezzati, S. B. Henderson, M. Krzyzanowski, R. V. Martin, R. Van Dingenen, A. van Donkelaar, and G. D. Thurston. 2012. "Exposure Assessment for Estimation of the Global Burden of Disease Attributable to Outdoor Air Pollution." *Environmental Science & Technology* 46. doi: 10.1021/es2025752.

Global Commission on the Economy and Climate. 2014. *Better Growth, Better Climate*. New Climate Economy. http://2014.newclimateeconomy.report.

Li, Wanxin X. 2011. "Self-Motivated versus Forced Disclosure of Environmental Information in China: A Comparative Case Study of the Pilot Disclosure Programmes." *China Quarterly* 206. doi: 10.1017/S0305741011000294.

Lim, S. S., and others. 2012. "A Comparative Risk Assessment of Burden of Disease and Injury Attributable to 67 Risk Factors and Risk Factor Clusters in 21 Regions, 1990–2010: A Systematic Analysis for the Global Burden of Disease Study 2010." *Lancet* 380: 2224–60.

van Donkelaar, A., R. V. Martin, M. Brauer, and B. L. Boys. 2015. "Use of Satellite Observations for Long-Term Exposure Assessment of Global Concentrations of Fine Particulate Matter." *Environmental Health Perspectives* 123 (2): 135–43. doi: 10.1289/ehp.1408646.

SPOTLIGHT 6

ENABLING DIGITAL DEVELOPMENT

Six digital technologies to watch

This Report looks at what countries can do to get more out of the internet and other digital technologies. Although it looks ahead to a world in which the internet is universally available and affordable, the analysis largely takes the technology for granted. But technological change is continuous and frequently disruptive. This spotlight examines a range of technologies, identified in the technology forecasting literature that promise to be far-reaching in their impact on development.[1] They are at different stages of the "hype" cycle (figure S6.1). Like the internet, they are likely to be encountered first in the developed world, but will spread quickly to the developing world, where their impact may be even greater.[2]

Fifth-generation (5G) mobile phones

The development of cellular mobile phones from the earliest incarnation of commercial service in the late 1970s has proceeded in generations. First-generation (1G) analog cellphones were replaced with 2G digital phones, starting in Finland in 1991, while 3G phones, which provide faster internet access, were launched at the opening match of the 2002 FIFA World Cup in the Republic of Korea. By the end of June 2015, there were 2.33 billion 3G mobile subscriptions worldwide, and a further 757 million subscribers to data-optimized 4G, or Long Term Evolution (LTE), technology.[3]

5G wireless networks are the next generation of mobile networks. 5G networks are expected to outperform current 4G networks by providing data at a speed several hundred gigabits per second (Gbit/s). In 2015, researchers at the University of Surrey's 5G Innovation Centre (5GIC) managed one terabit per second (Tbit/s) during their speed tests—many thousands of times faster than current data connections.[4]

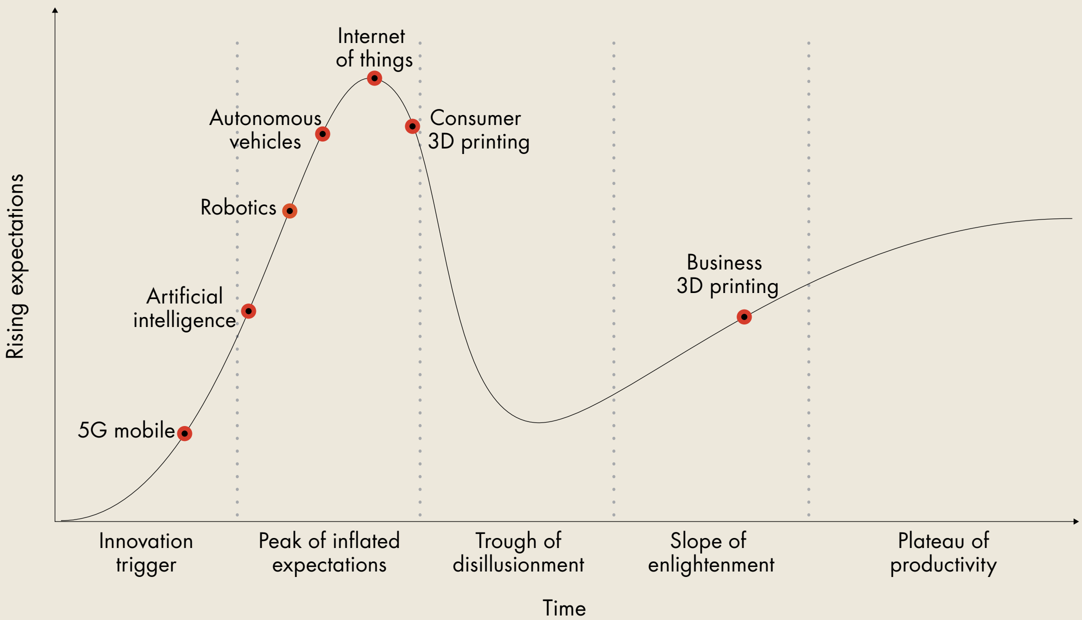
Accommodating 5G will require using parts of the spectrum that have not previously been considered commercially useful, in particular above 3 gigahertz (GHz), and in the millimeter band that stretches from 30–300 GHz. It will also require new kinds of antennae.[5] Developments in smartphones have increased capabilities about 25 percent per year in the past five years. Even though mobile itself is hardly a new technology, it is its combination with the internet that makes it a disruptive force and one of the technologies with potentially the greatest impact for the developing world. Developing countries will need to closely follow developments taking place in 5G and start preparing for its eventual rollout.

Artificial intelligence

Definitions of artificial intelligence (AI) differ widely, but generally refer to computer systems that can perform tasks that normally require human intelligence—including visual and speech recognition, decision making, and language translation. Faster computing, "big data," and better algorithms have helped propel recent breakthroughs in AI.[6] Algorithms are now better able to recognize language and images, for example, thanks to the availability of huge torrents of data from interconnected phones, tablets, and computers. Firms like Narrative Science have automated the writing of financial reports using AI.

Contributed by Wajeeha Ahmad, Hallie Applebaum, Naomi Halewood, Arturo Muente-Kunigami, Marcela Sabino, Randeep Sudan, and Darshan Yadunath.

Figure S6.1 Gartner "hype" cycle applied to selected digital technologies



Source: WDR 2016 team, adapted from Gartner 2015.

IBM's Watson computer uses AI to provide diagnostic assistance to doctors, providing customized medical advice. Virtual assistants with voice recognition capabilities like Apple's Siri and Microsoft's Cortana are increasingly used in personal and business contexts. A venture capital fund based in Hong Kong SAR, China, Deep Knowledge Ventures, has even appointed an algorithm to its board of directors![7]

Rapid advances in AI have also resulted in concerns about machine intelligence overtaking human intelligence, and becoming a threat to the future of humanity itself. An example is Nick Bostrom's 2014 book on superintelligence, which considers AI to be potentially an "existential risk" for mankind.[8] Luminaries like Elon Musk, Stephen Hawking, and Bill Gates have weighed in on the dangers of AI. While recognizing the potential risks of AI, such technologies can provide important insights and generate value in virtually every sector relevant to development. The benefits of AI are beginning to be seen in education, with personalized learning; in health, with deep diagnostics; in agriculture, with crop planning, precision farming, and optimized resource application; and in banking and insurance, in areas like customer service, risk management, and compliance.

Advances in AI will prove to be disruptive, resulting in new opportunities for collaboration between humans and machines, as well as a loss of traditional jobs such as legal analysts, financial and sports reporters, online marketers, anesthesiologists, diagnosticians, and financial analysts.[9] Similarly, a large number of call centers previously offshored to developing countries could be affected by increasingly sophisticated natural language processing systems that can substitute for human workers. The Spanish Bank BBVA, for example, has introduced Lola, a virtual assistant capable of handling many routine customer requests previously handled by call center agents.[10]

Robotics

Robotics, which refers to machines or mechanical systems that can automatically handle tasks, can be generally divided into industrial robots (automotive, chemical, rubber, plastics, and food industries) and service robots (logistics, medicine, assisting the elderly, agriculture, floor-cleaning, civil construction, and exoskeletons). Robots can provide benefits through their computing power, precision, strength, and sensing capabilities. The worldwide stock of operational industrial robots at the end of 2014 was up to 1.5 million, with around 4.7 million service robots sold for personal and domestic use.[11]

While robots have been primarily used in physically difficult or dangerous jobs, they are now becoming more advanced and gaining senses, dexterity, and intelligence. They are more compact, adaptable, and

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intelligent, have manipulation capabilities, and are increasingly able to work alongside humans. Eventually they may displace or augment humans, primarily in low-skilled areas like manufacturing, cleaning, and maintenance, but also in high-tech fields, like surgery and prosthetics.[12] A number of leading information technology (IT) companies have made investments in robotics and are driving development of smart robots. Amazon acquired Kiva Systems and is using Kiva robots for order fulfillment. Google acquired Boston Dynamics and several other robotics companies.

Demand for industrial robotics is driven by the desire to reduce labor costs and by the need for accuracy in undertaking repetitive processes. Robots are not paid, they do not get sick, and they can work as long as there is power. They can also take on dangerous or risky tasks, such as detecting landmines. The take-up of robots is expected to rise as a function of their falling costs and growing intelligence, including in developing countries. China is the world's biggest importer of industrial robots. Guangdong province recently announced a program to automate 80 percent of its factories by 2020, by substituting human labor with robots.[13] Robots have been deployed in the Democratic Republic of Congo, in Kinshasa, to manage traffic.[14]

Autonomous vehicles

Autonomous vehicles (AV), or self-driving cars, attract major research spending from car companies as well as internet firms. Their proponents argue that they will reduce road accidents (for instance, through lane-keeping systems, auto-parking, and cruise control), ease congestion, reduce fuel consumption, improve the mobility of the elderly and disabled, and free up commuting time for other tasks.[15] But they also threaten the jobs of millions of people currently employed as drivers. They also raise complex legal issues, including for liability insurance, and onboard networked computers would be at risk of hacking. The European project SARTRE is piloting the concept of "autonomous car platoons," which allows multiple vehicles to drive autonomously within meters of one another at highway speeds, guided by a professional pilot vehicle. This approach is expected to reduce fuel consumption and emissions by up to 20 percent, improve road safety, and reduce traffic congestion.

Drones (unmanned aerial vehicles, and a specialized type of AV) are growing in popularity as prices fall. They have many potential applications, including police work, assisting the disabled, home delivery, farming, entertainment, safety, wildlife conservation, and even providing internet service in remote areas. Rwanda plans to be home to the world's first drone airport, or "droneport," to facilitate the delivery of medical and emergency supplies, quickly and cost-effectively, across geographical barriers.[16]

The introduction of AVs is likely to be gradual, with many cars and planes already incorporating elements of assistive technology. The impact on jobs will ultimately be a function of price (self-driving cars are currently prohibitively expensive), legislation (will they always require a human with manual override?), and time.

Internet of things

The "internet of things" (IoT) refers to the interconnection of objects to internet infrastructure through embedded computing devices, such as radio frequency identification (RFID) chips and sensors. IoT products can be classified into five broad categories: wearable devices, smart homes, smart cities, environmental sensors, and business applications.[17] Cisco estimates that by 2020, 50 billion devices and objects will be connected to the internet.

IoT is quickly redefining service delivery and unlocking opportunities in multiple areas. Smart fitness sensors and trackers are transforming health care and improving personal fitness and health. Embedded sensors accurately relay moisture, air and water pollution levels, and resource levels, allowing for closer monitoring of environmental problems. Factories and supply chains use smart sensors to improve the efficiency of manufacturing and distribution of goods. Globally, there has been a rise in spaces where people can gather to build and learn with electronics, software, and digital fabrication. Known as makerspaces, these spaces have democratized access to tools and empowered participants to build and learn on their own.

One of the key applications of IoT is in combating climate change and its effects. Farms in developing countries can use intelligent sensors to monitor soil conditions and guide autonomous irrigation systems. Smart traffic synchronization systems in cities save on travel time and fuel consumption. Countries such as Singapore are deploying smart networks that use global positioning systems (GPS), sensor information from monitoring cameras, and other sources to sense population movement, ease traffic congestion, and re-route traffic in the case of special events and emergencies.

Some experts believe that the IoT will mark a new stage of the internet's development, since it has the

Box S6.1 Using cellphones for medical diagnosis, thanks to 3D printing

Doctors in developing countries often lack the necessary equipment to diagnose diseases, but they do have smartphones. Dr. Aydogan Ozcan, an engineering professor at the University of California Los Angeles (UCLA), has created software and hardware that can convert smartphones into microscopes and diagnostic machines. He uses 3D printing to create a fluorescent microscope device that can be attached to the phone. The device includes an app that connects the smartphone to a server at UCLA and transmits raw images of DNA molecules to detect and diagnose cancer, nervous system disorders such as Alzheimer's disease, and drug resistance to infectious diseases.[a] Similarly, a 15-year-old girl from Cupertino, California, has designed a spirometer, a device that can diagnose respiratory illnesses such as chronic obstructive pulmonary disease and asthma. She designed this tool using open hardware and 3D printing, at a fraction of the cost of a commercial spirometer.[b]

a. http://newsroom.ucla.edu/releases/ucla-engineers-first-to-detect-and-measure-individual-dna-molecules-using-smartphone-microscope.
b. https://cogito.cty.jhu.edu/43295/maya-varma-final-device-and-app-design/.

potential to revolutionize the way people live, work, interact, and learn. However, there are still significant barriers to full commercialization of IoT, such as the fragmented landscape of standardization, which is preventing interoperability; and the relatively high cost of embedded devices. The maker movement offers a possible solution for the standardization challenge, empowering individuals to adjust devices to fit the local context. There are also significant privacy and security concerns. As more devices are connected to networks, hacking unsecure devices could have repercussions that far exceed the damage posed by conventional security threats.

3D printing

3D printing, a process whereby machines can print objects from digital files or scans, consists of adding successive layers of material to make a three-dimensional (3D) object. This technology has transformational potential for manufacturing, since it enables users to create smaller batches of highly customizable products at declining prices. In recent years, 3D printing has advanced to printing of body parts (titanium jaws, spines), exoskeletons, rocket parts, and even food.[18] As prices have fallen, consumer-oriented devices have appeared on the market in recent years, allowing individuals to make three-dimensional solid objects locally, often using a computer-assisted design (CAD) file that can be downloaded from the internet. The "ink" used in the printer is usually plastic, but other materials—including epoxy resins, silver, titanium, steel, and wax—are also available.

The revolutionary aspect of 3D printing lies in its digital nature: physical objects become digital information that can be remixed, reformulated, improved, and shared. However, desktop 3D printers are still relatively expensive, and use between 50 and 100 times more energy per unit of weight than conventional injection molding. Other concerns include potentially negative uses such as gun and drug printing, and infringement of intellectual property.[19] However, as the performance improves and the cost of the printers and their inputs decline, 3D printers could be adopted more widely (box S6.1). The most relevant immediate progress may be in industrial printers for highly customizable objects that are relatively expensive and require replicable results. This is most suited to the construction industry, where 3D printed buildings can provide lower-cost housing solutions.

3D printing is expanding in developing countries. In Uganda, for example, the technology is used to create 3D-printed prosthetic limbs. The startup Protoprint, a social enterprise in Pune, India, helps waste pickers turn the waste plastics they collect into 3D printer filament. iLab Haiti has used 3D printing to design basic medical supplies for local clinics (such as umbilical clamps, finger splints, and casts) and produce them using on-demand manufacturing.[20]

Notes

1. Sources used in the analysis of technology trends include Gens and IDC Predictions 2015 Team; Deloitte Consulting 2015; McKinsey Global Institute 2013; and Meeker 2015.
2. Muente-Kunigami and others 2015.

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3. GSMA databases, https://gsmaintelligence.com/.
4. http://www.bbc.com/news/technology-31622297.
5. One gigahertz represents 1 billion cycles per second; see http://spectrum.ieee.org/telecom/wireless/smart-antennas-could-open-up-new-spectrum-for-5g.
6. http://www.wired.com/2014/10/future-of-artificial-intelligence/.
7. http://www.bbc.com/news/technology-27426942.
8. Bostrom 2014.
9. http://fortune.com/2015/02/25/5-jobs-that-robots-already-are-taking/.
10. http://cloudlendinginc.com/lending-blog/will-banks-survive-the-era-of-digital-disruption/.
11. International Federation of Robotics 2015.
12. Bugmann, Siegel, and Burcin 2011.
13. http://www.china-briefing.com/news/2015/04/22/automation-chinas-labor-force.html.
14. http://www.theguardian.com/travel/2015/mar/05/robocops-being-used-as-traffic-police-in-democratic-republic-of-congo.
15. http://www.economist.com/blogs/economist-explains/2013/04/economist-explains-how-self-driving-car-works-driverless.
16. http://www.theguardian.com/technology/2015/sep/30/rwanda-chosen-for-worlds-first-drone-port-to-deliver-medical-supplies.
17. Perera, Liu, and Jayawardena 2015.
18. http://www.digitaltrends.com/cool-tech/3d-food-printers-how-they-could-change-what-you-eat/.
19. http://www.techrepublic.com/article/the-dark-side-of-3d-printing-10-things-to-watch/, accessed March 2014.
20. Dotz 2015.

References

Bostrom, Nick. 2014. *Superintelligence: Paths, Dangers, Strategies.* Oxford, U.K.: Oxford University Press.

Bugmann, Guido, Mel Siegel, and Rachel Burcin. 2011. "A Role for Robotics in Sustainable Development?" IEEE (Institute of Electrical and Electronics Engineers) Africon 2011, September 13–15, Livingstone, Zambia. http://www.tech.plym.ac.uk/soc/staff/GuidBugm/pub/SustainableRobotics_Africon_2011.pdf.

Deloitte Consulting. 2015. "Tech Trends 2015: The Fusion of Business and IT." http://www2.deloitte.com/global/en/pages/technology/articles/tech-trends.html.

Dotz, Dara A. 2015. "A Pilot of Printing 3D Medical Devices in Haiti." In *Technologies for Development: What Is Essential?* edited by Silvia Hostetller, Eileen Hazboun, and Jean-Claude Bolay, chapter 4. Springer International Publishing.

Gartner. 2015. "Hype Cycle for Emerging Technologies." https://www.gartner.com/doc/3100227.

Gens, Frank, and IDC Predictions 2015 Team. 2015. "IDC Predictions 2015: Accelerating Innovation and Growth on the Third Platform." http://www.idc.com/getdoc.jsp?containerId=252700.

International Federation of Robotics. 2015. "World Robotics: Industrial Robotics 2015 and Service Robotics 2015." http://www.ifr.org/service-robots/statistics/.

McKinsey Global Institute. 2013. "Disruptive Technologies: Advances That Will Transform Life, Business, and the Global Economy." McKinsey & Company. http://www.mckinsey.com/insights/business_technology/disruptive_technologies.

Meeker, Mary. 2015. "Internet Trends 2015." http://www.kpcb.com/internet-trends.

Muente-Kunigami, Arturo, Naomi Halewood, Marcel Sabino, and Hallie Applebaum. 2015. "The Future of Digital Technologies." Background paper for the *World Development Report 2016*. World Bank, Washington, DC.

Perera, Charith, Chi Harold Liu, and Srimal Jayawardena. 2015. "The Emerging Internet of Things Marketplace from an Industrial Perspective: A Survey." *IEEE Transactions on Emerging Topics in Computing*. doi: 10.1109/TETC.2015.2390034.

ECO-AUDIT

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DIGITAL DIVIDENDS

Digital technologies are spreading rapidly, but digital dividends—the broader benefits of faster growth, more jobs, and better services—are not. If more than 40 percent of adults in East Africa pay their utility bills using a mobile phone, why can't others around the world do the same? If 8 million entrepreneurs in China—one-third of them women—can use an e-commerce platform to export goods to 120 countries, why can't entrepreneurs elsewhere achieve the same global reach? And if India can provide unique digital identification to 1 billion people in five years, and thereby reduce corruption by billions of dollars, why can't other countries replicate its success? Indeed, what's holding back countries from realizing the profound and transformational effects that digital technologies are supposed to deliver?

Two main reasons. First, nearly 60 percent of the world's population are still offline and can't participate in the digital economy in any meaningful way. Second, and more important, the benefits of digital technologies can be offset by growing risks. Startups can disrupt incumbents, but not when vested interests and regulatory uncertainty obstruct competition and the entry of new firms. Employment opportunities may be greater, but not when the labor market is polarized. The internet can be a platform for universal empowerment, but not when it becomes a tool for state control and elite capture.

The *World Development Report 2016* shows that while the digital revolution has forged ahead, its "analog complements"—the regulations that promote entry and competition, the skills that enable workers to access and then leverage the new economy, and the institutions that are accountable to citizens—have not kept pace. And when these analog complements to digital investments are absent, the development impact can be disappointing.

What, then, should countries do? They should formulate digital development strategies that are much broader than current information and communication technology (ICT) strategies. They should create a policy and institutional environment for technology that fosters the greatest benefits. In short, they need to build a strong analog foundation to deliver digital dividends to everyone, everywhere.

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