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Market dynamics and innovation management on Performance in SMEs: Multi-agent simulation approach

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Abstract

Small and medium enterprises (SMEs) make a significant contribution to economic growth. However, how to improve their performance through innovation management in the long term is a big challenge. Innovation and performance issues in small and medium enterprises (SMEs) are growing exponentially. Innovation is considered to be one of the most important engines for a company growth, and successful innovation can propel a company forward in its sector. Based on contingency perspectives, this study is focused on investigating effective ways to design Innovation management and maximize firm performance according to market dynamics levels. Considering the SMEs as an agent, the study employed a multi-agent simulation method to understand the progress of performance improvement in SMEs, by observing the innovation activity of SMEs over certain periods of time. The results first reveal that the level of firm diversity influences the amount of performance manifested by SMEs' innovative activities. Second, managers have to properly facilitate innovative activity depending on task importance and market dynamics.

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1. Introduction

We recognize Small and medium enterprises (SMEs) as one of the most critical drive for economic improvement in the country. They have distinct characteristics not the same as large organization. These gap is mainly concerned with such definition of SMEs as bearing responsive and challenging mind, limited resource, creative strategy, and the structure ready for being modified in accordance with the environment they face [1-2]. There is no doubt that SMEs is more subject to market dynamism than large enterprises. Accordingly, to understand the fact they have generated diverse innovation in market dynamics is significant. The method to

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make the best use of such innovative activity in increasing the level of performance matters in their survival [2-3].

The activity for innovation performed by progressive innovators is followed by organizational and technological change without exception [4-5]. Business works on and off requires collaboration for effective innovation [3, 6]. The collaboration paying attention to capability access works very well in case of smaller business even if some potential weakness is to be found in the process of equipping in-house capability [7]. The characteristics such as variety and intensity derived from working together have positive influence on innovation outcomes. What is more, such relationship allows the enterprise to get useful information made by complex resources, which are directly connected to desirable innovation [8].

In this sense, innovative activity processes are generally influenced by both the characteristics of the innovation of SME itself and by the cooperation networks among SMEs. Accordingly, this study focused on examining existing research and determining how to establish proper strategies for situation-appropriate innovative activities. The aim is to maximize SMEs performance by taking into consideration market dynamics as a situational factor and firm diversity (diversity among SMEs) as an organizational characteristic. In particular, the study applied an agent-based simulation method to understand the progress of performance through innovative activities by SMEs according to the passage of time. The objectives of the study are as follows: to investigate how market dynamics and firm diversity affect a SME's innovative processes in terms of the SMEs' innovative activity behavior, and, in turn, SME performance; and to find strategies for innovation management that can maximize SME performance in any given circumstance.

2. Literature review

2.1. innovation and collaboration of SMEs

(1) SMEs

The literature review deals with SMEs exclusively. They are classified into heterogeneous group with variety in size and sector [9]. However, in turn, it is impossible to define SMEs in a definite way, for each country in the world has its own criteria in defining it. In most cases, they define SMEs as having the employees ranging from 100 up to 500 [10].

Meanwhile, the literature concerned pays attention to SMEs' downfalls such as limited resources, absence of the plan fixed, and barrier in financial aspect. These factors would make it difficult to take part in innovation process on positive lines [9, 11]. For this reason, supported by most research, they seem to have reactive attitude in terms of environment and social issues. However, other literatures argue that they have strengths of being characterized following the owner's style in management [e.g. 12-13], which means that they will have stronger tendency to seek for creating value with robust effectiveness [e.g. 14-15].

As a result, in terms of progressive innovation and running business taking advantage of niche markets with sustainability-oriented innovation of SMEs, they have more advantage than larger companies [e.g. 16].

(2) Innovation

The business area harboring various threat and uncertainty requires the high degree of innovation as successful factor. Their strong degree of innovation can cover diverse risks they must face in the market.

Their manufacturing sector regarding innovation should concentrate on the effective process system, which implies it must be performed with formalized system for the sake of cost savings. The large manufacturing companies in general gain success in such strategy by formalization, leading to process improvement [2, 17]. In this context, for SME competitiveness, both formality and informality play a key role.

The two-phase innovation theory suggested by Schumpeter [2, 18] indicates the conditions for both formality and informality applying to manufacturing SMEs as significant factors. The owner's innovation phase is concerned with new product development requiring informal structure. The managed innovation phase is about effectiveness in terms of costs being spent on process improvement. According to his theory, the competition environment of SMEs came to turn to the price as market mature, where the process improvement should serve as agent reducing costs.

The Resource-Based View (RBV) focuses on firm's unique in house resources having influence in part on its level of performance [19-20]. It sets correspondent relationship between the distinct resources and capabilities belonging to the firms and their levels of performance. Such an internal perspective allows innovation to be derived from more effective routine of organization in addition to other core functions. In the boundary of RBV, Barney [20] recognized wide-range of resources such as entire types of assets, organizational processes, the strength in expertise concerned and other adventurous core sources. In a complementary way, the relational perspective explains that the resources necessary for its improvement are not limited to firm's internal condition and that collaboration among the companies creates higher result coming from such relationship [21]. These strategic resources make it possible to share information, resulting in learning effect by means of interrelationship and this positive aspect has positive impact on innovation [19, 22-23].

The related literature commonly makes an agreement on the fact that the firm equipping with formal strategies generates more outcomes than the one without it [24]. But in actual world, most of SMEs have informal strategies coming from the decision by their boss, compared to large enterprises having formalized plans for each condition [25]. O'Regan et al. [24] saw culture as kind of interruption in performing innovation. SMEs have a tendency to bear flexible innovation cultures, which indicates that they are less resistant against change, have more courage to challenge, and show more tolerance in ambiguity [2, 26].

One of the essential curiosity on dealing with management refers to the strategic decision making under the condition of new product development, services, processes, organization, and marketing, etc. [27]. Such strategic decision is responsible for sustaining balance among companies' ability and opportunity in cooperative condition for the purpose of realizing the long-term goals. In this regards, to make definition of innovation strategy serves as critical role in managing successful innovation in the enterprise [27-28].

(3) Collaboration

In general, SME is expected to possess benefit with collaboration in terms of innovation because they can establish cornerstone for their knowledge and enhance the level of problem-solving ability. The new product and service with respect to their quality and quantity are influenced with great benefit by means of collaboration intensity [8]. The ideas come up with by innovation can be materialized within the boundary of more safety. In addition, working together also contributes to finding out significant resources. Such an evidence supports that they can get over their size with working in cooperative way in the course of achieving innovation [3].

The networking is regarded as helpful tool for SMEs, for it provides supportive working condition enough to offset their natural downfall made by their size [29-30]. They usually experience shortage in resources and capabilities essential to achieve successful innovation which is unavailable through their in-house activities only [31]. With network system, SMEs can offset their limitation in internal resource and knowledge by means of making use of external resources. This acts as a great help in achieving innovation impossible only through their own internal capacity [29]. SMEs' trial to cooperate with other relevant companies is developing at a high rate and this is considered to occur owing to the change in economy and technology in the world lately. In particular, cooperative working through network among SMEs is in part considered as not being in need due to inappropriate capitalism influence in terms of economy and technology, However, the effort to cooperate one another to achieve innovation demonstrates a lot of change in industrial structure [32]. Thus, creating advanced innovation network along with other companies, research centers, providers as well as customers is nothing different with mandatory element for being royal in sharing information and strengths of potential skills [29, 32].

The cooperation networks among enterprises being able to facilitate the flow of information, resources, and trust required are serving as a key strategy [33]. To achieve appropriate economic scale and/or integrate different skills, technology, and competence all together, the network can be complemented to support these tasks [34]. The capabilities and external resources available by means of putting external innovations all together can be considered as core motivation in getting rid of negative impact coming from shortage of innovation as well as creativity [29, 35]. Summing up, the systematic mutual innovation can be achieved with the help of cooperation among SMEs and organization in cooperating with network system.

2.2. Market dynamism

Market dynamism simply can be defined as the degree of change in the market [36-37]. The essential factors of describing market dynamism are rapid changes in technologies, changes in market structure, the instability of market demand, intense fluctuations in supply of materials, and the probability of market shocks [38-39]. Market dynamism is fundamentally characterized as volatility and unpredictability [40]. In the environment with the high level of market dynamism, it is not easy to distinguish the market boundaries, develop clear successful business models, and identify market participants such as competitors, customers, and suppliers [41]. Thus, firms usually suffered from these external uncertainty caused by highly dynamic market environment, which making them more difficult to predict future market situation, plan and organize their resources, and respond with their own knowledge and related processes [38]. In addition, firms are required to improve and modify their products and services with innovation continuously to meet customers' needs in high market dynamism. On the contrary to highly dynamic market, less dynamic markets are characterized by infrequent changes which market players' can usually anticipate or regular changes that occur along roughly predictable and linear paths. In these market environments, market boundaries are relatively clear and the market participants (e.g. competitors, customers, suppliers) are well known, customer demand is relatively stable and therefore modifications of firm's products and services are relatively less required [41-42].

As the level of market dynamism is relatively high, firms are face an unpredictable environments characterized by rapid technological changes, intense fluctuations in customer demand, and the instability of market structure [36, 41]. In the context of high dynamic market, firms are required to scan emergent customer preferences, expands the boundary of information and develop adaptive quick responses so that they can deal with the customers' needs properly, cope with the turbulent market situations to remain competitive. Therefore, market dynamism have been studied extensively and previous literatures indicate that market dynamism is one

of the essential factors of impacting firm performance and investigate the moderating role of market dynamism [42-45].

Kamasak and Yavuz [43] attempt to investigate the combining moderating effect of market dynamism and learning capability on the relationship between knowledge management capabilities and innovation performance. The result shows that higher levels of market dynamism made the positive linkage between them stronger. According to the Park and Ryu [44]'s study, market dynamism was found to moderate the relationship between technology commercialization and business outcomes. In addition, the result of Chan, Yee [45]'s study indicates that the moderating role of market dynamism in the green product innovation – firm profitability relationship was marginally significant. Schilke [42] proposed a non-linear, inverse U-shaped moderation effect of market dynamism on the relationship between new product development capability and competitive advantage and tested with the data of 279 firms. The results demonstrate that the firms' new product development capabilities are more strongly associated with competitive advantage in moderately dynamic than in stable or highly dynamic market.

2.3. Agent-based simulation

An intelligent agent (or simply “agent”) is basically a computer system that is capable of flexible autonomous action in dynamic, unpredictable, and typically multi-agent domains, though it has various definitions because of the multiple roles it can perform [46-47].

Agent-Based Simulation (ABS) is an important approach in the field of complex system analysis and simulation; its key idea is the complex adaptive system theory [48]. In other words, ABS is generally used as the research method in the field of social emergence and social complexity, which predicts macro-level or meso-level changes based on the attributes of micro-level behaviors and their interactions [48-50]. Within ABS, multi-agents with diversified purposes and competencies collaborate with one another to resolve specific problems in circumstances such as innovation and market dynamics [48, 51-52].

We employed ABS by regarding an intelligent agent as a SME in order to conduct a longitudinal analysis on innovative activity and performance, according to market dynamics and firm diversity. Agents will be able to freely communicate with partner SMEs, and to conduct business by establishing diversified cooperation networks. The level of performance of SMEs can be a measure indicating how effectively multiple agents can resolve a task through innovative activities. For this research, we developed a program to simulate real situations using NetLogo, a well-known multi-agent system.

3. Simulation model

In order to conduct simulation experiments, we designed ABIS (Agent-Based Innovation Simulator) using NetLogo (available at <http://ccl.northwestern.edu/netlogo>) as seen in figure 1.

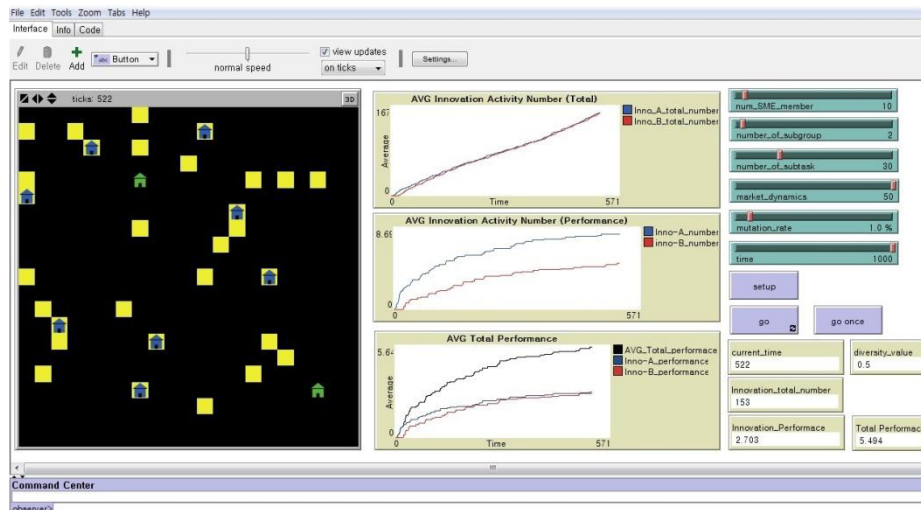


Fig. 1. Agent-Based Innovation Simulator (ABIS)

To cope with the competitive and uncertain business environment more effectively, SMEs are required to manage the innovative activity. Especially, it is widely recommended that SMEs are organized from the perspective of boosting up the firm diversity such as different product, experiences, and knowledge, etc. Basically, each SME needs to interact with other partner SMEs to resolve their task depending on the task complexity. Our simulation was based on the following assumptions: (1) every SME attempts to execute innovative activity to efficiently accomplish their work; (2) depending on the diversity within partner SMEs, each SME prefers to work with those SMEs in a similar category; (3) a single SME tends to be divided into a number of subgroups; (4) diversity in a SME influences the firm's decision to collaborate with others in order to complete their work in an effective manner; and (5) performance is needed to solve the given task.

After 300 simulated instances using NetLogo, the following results (see 4. Conclusion) were obtained. Firm diversity values were distributed from 0.14 to 0.92. Market dynamics was manipulated by the length of the bit string in the solution of the task with 3 (low) and 30 (high)

4. Conclusion

Considering an SME as an agent, this study analyzed the effects that market dynamics and firm diversity have on innovative activity and firm performance by using an ABS approach. Specifically, NetLogo was utilized to conduct the ABS. We analyzed the pattern of the average values of innovative activity, and firm performance, based on different levels of market dynamics (high and low) and firm diversity (high, middle, and low), over the various periods of time and using the MAS. As a result of the analysis, the following information was identified. First, the level of firm diversity influences the amount of performance manifested by SMEs' innovative activities, such as exploration and creativity. When the level of firm diversity is in the middle range, firm performance value is relatively low compared to SMEs with high or low diversity. Second, when market dynamics is high, innovative activities play a more crucial role in contributing to the revelation of performance after a certain period of time has passed, whereas exploitative activities are comparatively important in the early time periods. Finally, when the SME deals with a low market dynamics, exploitative activity is more influential to the manifestation of performance.

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