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كيف تؤثر تجميعات الابتكارات ونوع التكنولوجيا الأساسية على الأداء الاقتصادي للشركات

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الخلاصة

تعتبر نظرية التجميع إحدى أكثر الإستراتيجيات الصناعية المشهورة. وبعد النجاح الذي تحقق من خلال تجميعات مختلفة في الدول المتقدمة في سوق الصناعة وتكنولوجيا المعلومات العالمي، فقد حاول عدد من البلدان الناشئة إنشاء تجميعات خاصة بالصناعة. وقد تشكلت تجميعات عديدة حول العالم. وعلى الرغم من ذلك، يركز معظم الباحثين على الدول المتقدمة بدلاً من الدول النامية عند التحليل التجريبي لتأثير التجميعات على الأداء الاقتصادي للشركات على أساس نوع التكنولوجيا الأساسية الخاصة بالشركات. لذلك، تهدف هذه الدراسة إلى البحث في تأثيرات تجميعات الابتكارات ونوع التكنولوجيا الأساسية (أي تكنولوجيا المعلومات والتكنولوجيا الحيوية وتكنولوجيا النانو والتكنولوجيا الطبية) على الأداء الاقتصادي للشركات في واحدة من تجميعات الابتكارات في كوريا الجنوبية. تُستخدم إحدى الطرق الإحصائية، وهي سلسلة من التحليلات العاملية للاختلاف، لتحليل بيانات العينات على الشركات الواقعة في منطقة دايجيون دايديوك إنوبوليس، وهو أكبر تجميع في كوريا الجنوبية. تُظهر النتائج تأثير ملحوظ للتجميع على الأداء الاقتصادي للشركات وخلق وظائف جديدة. بالإضافة إلى ذلك، يؤثر نوع التكنولوجيا الأساسية بشكل كبير على شدة تأثير التجميع على خلق الوظائف الجديدة والأداء الاقتصادي للشركات. وأخيرًا، تقدم هذه الدراسة تضمينات للمؤسسات الأكاديمية والصناعية على السواء.

Effects of innovation cluster and type of core technology on firms' economic performance

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ABSTRACT

Cluster theory is considered one of the most well-known industrial strategies. Following the success attained by several clusters in developed countries in the global manufacturing and information technology market, a number of emerging nations have attempted to build up industry-specific clusters. Numerous clusters have been formed across the world. However, most researchers focus on developed nations rather than developing ones, when empirically analyzing the impact of clusters on economic performance of firms, based on core-technology type. Therefore, this study aims to investigate the effects of innovation clusters and core-technology type (namely, information technology, biotechnology, nanotechnology, and medical technology) on the economic performance of firms in one of South Korea's innovation clusters. A widely employed statistical method, a series of factorial analyses of variance, is used to analyze sample data on firms located in Daejeon Daedeok Innopolis, the biggest cluster in South Korea. The results show a notable clustering effect on firms' economic performance and new job creation. In addition, the type of core technology significantly affects intensity of effect of the cluster on new job creation and economic performance of the firms. Finally, this study presents implications for both academia and industries.

Keywords: Daedeok Innopolis; economic performance; new job creation; South Korea; technology type.

INTRODUCTION

Presently, economic growth and new job creation are considered the most important and critical issues facing an economy (Audretsch & Thurik, 2001; Wong *et al.*, 2005). Following the global economic recession, governments have been seeking to identify various methods of achieving economic recovery (Mortensen & Pissarides, 1994). In addition, due to rapidly increasing unemployment rate, academic and industrial researchers are striving to find possible ways of job creation (Neumark, 2013).

However, firms generally perceive new job creation and economic growth as significantly important factors for value growth. Most firms define their growth as annual net profit, because they consider sales and exports as revenue and employment as cost. Therefore, these two factors should be considered and revised by adopting a sensible perspective toward the roles of the public and private sectors in accomplishing new job creation and economic growth (Trigari, 2009).

As part of national policies that aim to stimulate these two factors, several advanced countries have employed supporting plans and policies to construct innovation clusters (Pietrobelli & Rabellotti, 2011). Innovation cluster is generally defined as "a union of technical and engineering organizations as well as other elements and factors of innovation and industrial infrastructure constructed and designed to encourage innovation activities through collaboration" (Smirnova, 2012) or "the innovation environment and set which appears simultaneously in multi-technical and multi-industrial sectors" (Feng, 2005). Within these innovation clusters, abundant resources of participatory organizations are integrated. The government, national institutes, universities, private companies, and educational and research institutes can cooperate intensively for forming such clusters. Universities and educational institutes cultivate and train talented students by encouraging them to take part in research projects of research institutes and companies, who can then hire these individuals. Moreover, institutes, companies, and universities can collaborate in developing necessary or promising technologies and products with complementary relationships and tangible advantages. Furthermore, technologies developed by universities and research institutes can be easily commercialized by companies and other institutes located in the cluster area, while research institutes and private companies can use professional education provided by educational institutes and universities for training their employees (Salvador *et al.*, 2013; Yu & Jackson, 2011).

These advantages of innovation clusters have prompted a large number of academic studies. Cluster theory suggests that companies in a cluster not only gain a competitive advantage owing to their core capabilities and resources, but also owing to the additional resources available at their location (Lundvall *et al.*, 2009). Several previous studies have proved that company productivity, growth, and formation can

be significantly improved, when a company experiences clustering effects (Beaudry & Breschi, 2003; Boschma, 2005; Gordon & McCann, 2000; Porter, 2000; Rosenfeld, 1997).

Acknowledging the advantages of clusters, various sectors, including the public sector, have been implementing cluster theory since the early 1990s to augment their global competitive capacity and their ability of absorbing innovation (Furman *et al.*, 2002). In particular, several governments, including those of the United States, Germany, and South Korea, have employed the overall concept of clustering as one of the most efficient ways of improving regional and national competitiveness and growth (Porter & Stern, 2001; Lundvall *et al.*, 2006).

However, as seen in the case of successful innovation clusters, their effects vary by the technology type, industry characteristics, and geographical features. For example, in Daejeon Daedeok Innopolis, one of the most representative innovation clusters in South Korea, firms have different types of core technology. Nanotechnology-oriented companies have failed to achieve success compared to the dramatically significant growth of information technology (IT)-oriented companies in the 1990s. However, during the same period, nanotechnology-oriented companies of Hsinchu Science Park, Northern Taiwan have been successful and have enjoyed competitive advantages in the global market (Chen & Choi, 2004; Lai & Shyu, 2005). Thus, we can infer that locational circumstance and technological characteristics of firms significantly affect their growth and improvement.

A number of prior studies have explored factors associated with innovation activities and growth of innovation clusters, such as competitiveness index, growth rates, and R&D efficiency and effectiveness (Nishimura & Okamuro, 2011; Porter, 2000). However, no prior empirical research has investigated the effects of different core technologies on growth of firms and new job creation in innovation clusters. Therefore, in order to explore the effects of innovation clusters on economic growth and new job creation, a comparative analysis on companies with different core technologies should be conducted.

To fill this gap in the literature, this study explores the following research questions:

(1) Which types of core technology deployed by firms in innovation clusters are significantly associated with economic growth and new job creation? Does the degree of innovation clustering effects vary according to the type of core technology?

(2) Is there any difference in economic growth and new job creation between firms with in and those outside the clusters?

This study employs empirical data on one of the largest and most significant innovation clusters in South Korea to explore the causal relationships among innovation clusters, firms' core-technology types, and economic growth with new job creation, and to interpret the derived results based on cluster theory and industry characteristics.

LITERATURE REVIEW

History of cluster theory

After the successful growth of the Silicon Valley in California, many academic and industrial researchers have examined the effects of industrial innovation clusters on society (Freeman, 1997; Porter, 1990, 1998). From an academic perspective, Porter (1990, 1998) introduced the general concept of cluster theory, while the deep understanding of firms' strategies as micro perspectives and national policy with industrial regulations as macro perspectives should be employed.

As shown by Porter (1990, 1998), firms' overall productivity, competitiveness, and capacity could be improved by employing innovation activities. In particular, developing the cluster region is one of the most efficient ways of promoting firms' innovation activities. Thus, the background of the innovation cluster is considered a notable competitive advantage (Porter, 1990, 1998). Studies in the early stages of the innovation cluster defined a cluster as "a regional collaborative zone which includes and contains suppliers, related organizations, distributing industries, consumers, research and education institutes, governments, and supporting organizations" (Porter, 1990, 2000; Lin *et al.*, 2006). Prior studies showed the positive effects of clusters on financial performance and manufacturing productivity of firms (Brusco, 1990; Lin *et al.*, 2006).

Several international scholars have indicated that local advantages and regional co-operation are the main advantages of clusters (Pinch & Henry, 1999; Malmberg & Maskell, 2006; Marais, 2011). This finding shows that the main motivation behind competitiveness of firms in national and industry clusters is to provide innovation activities by securing new information and collaborations.

In other words, the improved competitiveness of firms in clusters leads to better financial conditions, higher productivity, and innovativeness. Gibbs & Bernat (1998), and Wheaton & Lewis (2002) indicated that organizations in clusters could pay higher wages than those outside because their financial and overall status is generally better in comparison.

Citing these advantages, numerous nations have strategically formed clusters for reviving particular industries. The automobile industry of Detroit; the Silicon Valley, dedicated to computer technology (Klepper, 2010); and the Cambridge Cluster in

the United Kingdom, dedicated to IT, electronic technology, and biotechnology are considered as the most impressive examples (Casper & Karamanos, 2003). Of these, the Cambridge Cluster is one of the largest in Europe for high-technology businesses. In particular, this cluster aims to catalyse the convergence of electronics, software, nanotechnology, and biotechnology. Besides supporting the University of Cambridge, a globally renowned educational and research organization, this area is considered as one of the most important technology engines of the United Kingdom and Europe. The Silicon Valley is one of the most significant clusters in information and computer technology. With a large number of venture capitalists and companies, this area rapidly improved in the mid and late 1990s. Many major international IT companies such as Google Inc., Apple Inc., and Microsoft have been developed in this cluster and are considered as the mainstream companies of the IT industry (Kenney, 2000).

Following these examples from advanced nations, countries in East Asia are attempting to build up strategic clusters for reviving stagnant industries. The Hsinchu Science Park of Taiwan for semiconductors (Chen & Choi, 2004; Lai & Shyu, 2005), Zhongguancun Science Park of China for high-technology manufacturing (Meng & Li, 2002), Toyota City of Japan for automobiles (Arikan, 2009), and Gumi industrial cluster of South Korea for electronic engineering are considered successful latecomers (Park *et al.*, 2012). Of these, Toyota City in Aichi area is mainly organized by Toyota Inc., national research institutes, engineering-based universities, and automobile component manufacturers. As demonstrated by the success of Toyota Inc. in the global automobile market, this cluster built its own ecosystem for manufacturing automobiles and distributing them in the market. In addition, South Korea set up several clusters for its domestic economy.

Thus, we see that a number of clusters with unique technological or industrial themes are being operated for the benefit of the national economy. However, a comparative study on the economic performance of different technology-oriented clusters has not been conducted. For contributing to national strategic decisions and industrial planning, such a study will be helpful as it would present guidelines for government officers, when they employ the clustering concept in promoting a particular industry. Therefore, the current study hypothesizes as follows:

H1. Firms' economic performance is significantly determined by the type of core technology they deploy.

Clusters in South Korea

The local cluster theory has been one of the most useful and significant industrial policies for the balanced economic development of South Korea and its successful national ecosystem for industries (Brenner, 2004). After the 1980s, when the

Government of South Korea enacted a law and developed a policy for innovation clusters, these enabled the local community and region to have self-developing engines for economic growth and a regional innovation system. Furthermore, the law and policy have consistently encouraged national and foreign investment, presented local development plans, and alleviated the limitations imposed by restrictions for the cluster (Sohn & Kenney, 2007).

The current innovation clusters in South Korea have been established by the financial system and local-dominated industrialization policy. Since the inception of two specialized manufacturing zones, Guro (textile and sewing) and Ulsan (petrochemical), in the 1960s, several other notable zones on heavy industries have been established (e.g., electronic engineering in Gumi, iron and steel in Pohang, and machinery in Changwon). In the 1980s, zones on transport equipment (Asan, Daebul, and Gunjang), and components and materials (Banwol, Sihwa, and Namdong) were built to cope proactively with the changing global circumstances. Thus, it can be concluded that South Korean clusters are the reflections of the rapidly changing national industry policies over time.

At present, innovation clusters in South Korea focus on regional industry development, and therefore, the clusters are receiving great attention from both industry and academia. Because of this interest and involvement in regional development, the Government of South Korea is actively promoting the replacement of industrial zones with innovation clusters. The government is employing the cluster concept as its growth strategy for joining the ranks of advanced countries. In addition, by using this concept, the government aims to transform the economy from "factor inputs type" to "a virtuous cycle eco-system." The following paragraphs briefly and sequentially present three successful innovation clusters that operate in South Korea (Kwon, 2004).

Initial period: The processing construction technology cluster - Changwon cluster

In order to boost the economic status of South Korea, from 1962, the government strategically started nurturing the growth of a heavy chemical industry by setting an economic development plan for export-led industrialization. The general construction of the industrial complex had to be intensive and centralized in a particular area for a series of related industries, while also taking economies of scale into account. Therefore, the Korean government selected Changwon city. The Changwon cluster is one of the oldest innovation clusters in South Korea (Lee & Lee, 2008).

Growth period: The global base of supply chain in the hi-technology industry - Banwol Sihwa cluster

Originally, this cluster was established to reduce the overcrowding in the capital, Seoul, and in Gyeonggi-do. The South Korean government intentionally moved a large number of supply factories and small and medium-sized enterprises originally located

in the capital. In addition, as this cluster is located near the ocean, the government planned to strategically develop this area as the base of the supply chain of the high-technology industry. Since 1978, when the Water Resources Development Corporation of South Korea was established in the Banwol cluster, many manufacturing factories have moved into this cluster, such as the Daeil heavy industry that has been operational since 1979. In 1979, more than 60 companies moved to this cluster, while the number of relocated companies steadily increased. Because of limited constraints, the cluster expanded to cover the Sihwa administrative district, which is land reclaimed from the sea. Currently, more than 3,000 companies are located in this cluster (Kim, 2011).

Prosperity period: One of the largest digital electronic bases - Gumi cluster

The Gumi cluster is termed a symbol of the electronics industry, including liquid crystal display and plasma display panel industries, established to transform South Korea into a global leader. Most big South Korean electronics manufacturing companies, research institutions, and academic organizations are located in this cluster (Lee & Lee, 2008; Park & Chung, 2012).

There are four more national clusters, namely, at Wonju (medical devices), Gusan (automobile machinery), Ulsan (total automobile industry), and Gwangju (optical electronics industry), and one convergence Innopolis of Daedeok. Unlike the initial clusters in South Korea, Daedeok Innopolis has been established for encouraging firms using different core technologies to collaborate.

Although the cluster concept is one of the most significant economic engines of South Korean industrial policies, no study has investigated the effect of innovation concepts on the growth of the country's firms. In addition, given that the majority of firms in each cluster have the same technological features, the effect of firms' core technological features on their growth should be explored to investigate whether the intensity of the effect varies. In view of this, the current study hypothesizes the following:

H2: Firms' economic performance is significantly determined by whether the firms are located in the innovation cluster.

STUDY DESIGN

Data and sample collection

This study employed cluster data from the 2012 Daejeon Regional Economic Reviving Survey administered by Daejeon Technopark, a national institute in South Korea. This survey collected firm-related information, including on financial state, opinion on government support and private equity and support, and innovation activities, R&D activities, and economic performance of firms in Daejeon Daedeok Innopolis (recent

two years), the biggest innovation clusters in South Korea. As a comparative group, this study used the 2012 NICE Credit Information Business database. This database includes information on financial state, the number of employees, R&D investment, main market, and economic performance of firms.

Procedure and variables

First, of the 300 samples in the cluster and 37,000 samples in the comparative group, we eliminated invalid or incomplete samples. Second, in order to determine the effects of cluster theory based on firms' core-technology types, we categorized firms into four groups: information technology (IT), biotechnology (BT), nanotechnology (NT), and medical technology (MT). Third, we calculated the growth rates of revenue, profit, and the number of employees during 2011-2012. These rates were used as dependent variables. Table 1 shows the categorized results.

Table 1. The number of selected samples in this study.

Group / Category	IT	MT	BT	NT	Total
Firms in a cluster group	43	40	31	29	143
Firms in a comparative group	4,110	1,186	57	14	5,367
Total	4,153	1,226	88	43	5,510

RESULTS

A series of 4 × 3 factorial analyses of variance (ANOVA) was used to investigate the impacts of cluster theory (called as cluster circumstance in the following sectors) and technology type on the dependent variables, followed by post-hoc analyses (Student's t-test). The statistical results from the series of ANOVA and post-hoc analysis showed that firms in the cluster (M = 172.54%, SD = 421.28) reported a significantly greater degree of revenue growth than firms in the comparative group (M = 26.63%, SD = 119.34), $F(1, 5502) = 120.237$, $p<0.001$ (Fig. 1). The effect of firms in the cluster (M = 147.42%, SD = 229.33) on the rate of new employment growth was also higher than that of firms in the comparative group (M = 1.56%, SD = 68.27), $F(1, 5502) = 275.514$, $p<0.001$ (Figure 2). However, the cluster had no significant effect on the firms' profit growth rate (Figure 3). Therefore, H2 is supported in terms of the growth rates of firms' revenue and the rates of new employment growth.

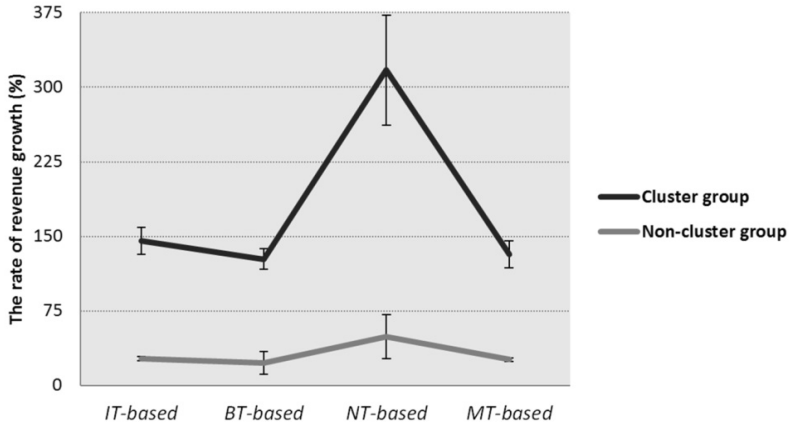

Fig. 1. Effects of cluster circumstance and technology type on the rate of revenue growth.

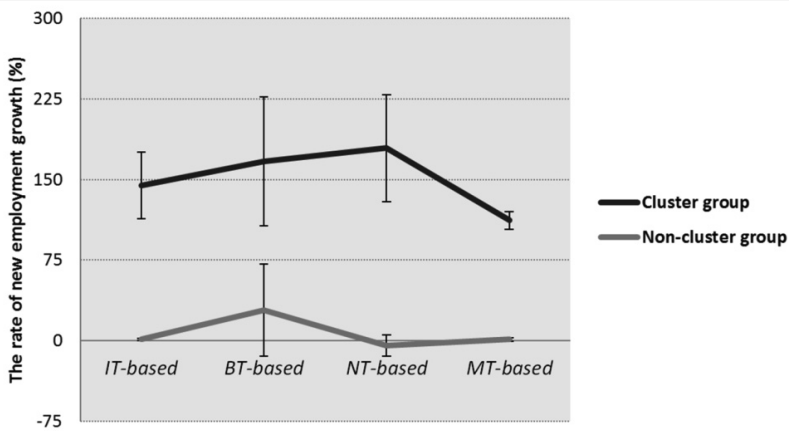

Fig. 2. Effects of cluster circumstance and technology type on the rate of new employment growth.

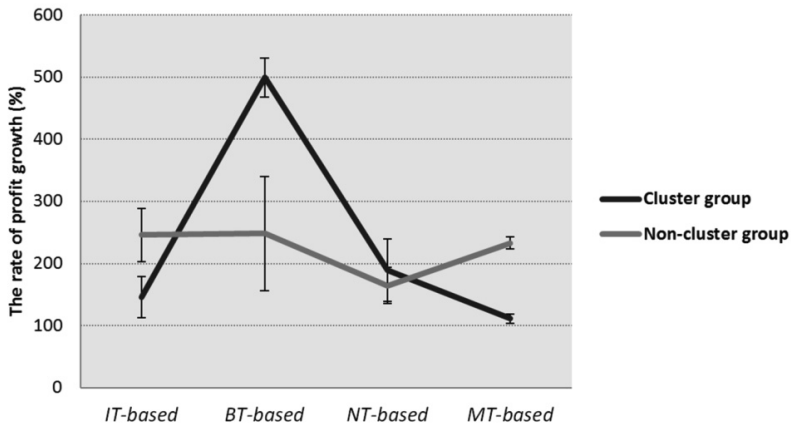

Fig. 3. Effects of cluster circumstance and technology type on the rate of profit growth.

The core-technology type of firms also had significant effects on the growth rates of their revenue and the rates of new employment growth; NT-based firms (M=229.84%, SD=763.84) showed a greater growth rate than BT- (M=59.50%, SD=92.90), MT- (M=29.51%, SD=70.88) and IT-based firms (M=28.01%, SD=131.11), $F(3, 5502) = 8.446$, $p<0.001$ (Figure 1). NT- (M = 119.44%, SD = 237.68) and BT-based (M = 77.43%, SD = 332.09) firms also indicated higher rates of new employment growth than MT- (M = 4.79%, SD = 55.34) and IT-based firms (M = 2.80%, SD = 67.08), $F(3, 5502) = 5.628$, $p<0.01$ (Figure 2). However, the firms' core technology was not significantly related to the growth rate of firms' profit (Figure 3). Therefore, H1 is supported in terms of the growth rates of firms' revenue and the rates new employment growth.

The interaction between the type of firms' core technology and cluster circumstance had notable effects on the growth rates of firms' revenue and the rates of new employment growth ($F(3, 5502) = 5.020$, $p<0.01$ (Figure 1), $F(3, 5502) = 2.714$, $p<0.05$ (Figure 2). It meant that effects of cluster circumstance were significantly different in the case of firms' core-technology type. As shown in Figure 1, effects of cluster circumstance on firms' revenue growth rate in NT-based firms were stronger than those in IT-, BT-, and MT-based firms. Although this tendency was also found in the firms' growth rates of creating new employments, the gap did not exceed that of the revenue growth rates.

DISCUSSION AND CONCLUSION

The findings of this study reveal worthwhile insights related to the utility of cluster theory and effects of firms' core technology for policy makers, industrial researchers, and academic researchers. Although the effects of clustering were not significantly related to the growth rate of profit, they can trigger better growth rates of firms' revenue and higher rates of new employment growth. In other words, cluster effects are useful to expand the size of firms in the cluster areas.

There may be two possible reasons behind the different intensity of cluster effects. First, the unique characteristics of firms may lead to such differences. For example, there can be physical obstacles in studying and comparing data on nanotechnology with that on other organizations, while the cooperation aspect of software R&D, which is one of the subjective parts in IT, is considered to be easier than that of other technological R&D activities. Second, the variance can be due to the different degree of growth of different industries. In South Korea, the IT industry is just maturing into a growth phase, while other industries are considered to be in a period of growth.

From an academic perspective, the current study empirically examined the effects of cluster circumstance and core-technology types on the economic performance of firms. The results indicated not only that the effects of cluster circumstance generally

improve firms' economic performance, but also that the intensity of effects varies in accordance with the core technology of firms. In addition, this study found that both economic performance and creation of new employment of firms could be motivated by cluster effects. The difference in intensity of cluster effects for different technology-based firms may be caused by the characteristics of core technologies.

From an industrial perspective, the results can be of use in establishing the locational and detailed plans of firms. The notably positive cluster effects on the growth of firms encourages the firms to set their head office in the cluster area. Moreover, high-technology firms can more easily grow in scale on locating with in, rather than outside, cluster areas.

Because only a few studies have investigated the effects of cluster circumstance on economic performance in South Korea, the current study would serve as a foundation for future studies on this aspect and that of the social, industrial, and economic performance of clusters in South Korea. Although there are several cluster areas in South Korea, it is difficult to find studies on comparative or evolutionary analysis in these areas. This study presents empirical evidence on effects of cluster circumstance on firms' economic performance.

LIMIATIONS AND FUTURE STUDIES

Although this study presents several implications, it has significant limitations. First, the findings can be difficult to generalize. The samples for this study are companies in Daedeok Innopolis, one of the dedicated cluster areas in South Korea. However, the results can be different, when the target sample is changed (Kwon *et al.,* 2014; Kwon *et al.,* 2015; Yoo *et al.*, 2014). Second, considering that the sample of the cluster was largely organized by venture as small or mid-sized companies, the companies in this group can be mainly considered as those undergoing a growth period or as being in the initial stage. Therefore, the companies may pay more attention toward increasing the scale of their organizations (Korsching & Borich, 1997). Third, the current study does not consider several important factors that can significantly relate to the dependent variables. For instance, previous studies indicated that people, organizational factors, environmental factors (Hansen & Wernerfelt, 1989), and political competition (Park *et al.*, 2014; Pinto & Timmons, 2005) affected the economic performance of institutes and firms. Therefore, future studies would need to address these limitations.

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