Strategy for Fostering Regional Innovation Ecosystems

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1. Introduction

Investment in research and development (R&D) in Korea has multiplied dramatically in recent years, yet a number of factors have limited an increase in productivity from R&D initiatives. Public research institutions in Korea show lower levels of R&D productivity, fewer records of technology transfer, and less ability to produce results that can be commercialized in comparison with their counterparts in other advanced economies. The public R&D sector in Korea has even had the effect of replacing private R&D (Ju, 2015).

The Korean government's R&D Innovation Plan, released in May 2015, shows that the government sees this situation as a "crisis of innovation resulting from R&D investment without a strategy." The fields of R&D overlap extensively among government programs, private-sector businesses, universities, and research institutions, and other public research organizations, with little effort

being made towards effective collaboration. Governmental/public research institutions and universities continue to pursue R&D projects isolated from market demand, while researcher-centered and complex systems of evaluation and management continue to undermine the efficiency of their R&D projects.

Local level R&D in Korea shares and amplifies the severity of all of the problems associated with national level public R&D because of the country's uneven state of development across regions. Numerous local governments have launched ambitious policies to foster innovation, based chiefly on theories of regional innovation systems and clusters. Investment in local R&D has risen significantly since 2000 under a wide range of local policies intended to foster the production, diffusion, and application of knowledge. These policies have supported the development and expansion of special R&D zones, Techno Parks and local R&D clusters, created innovation centers through which local universities can support local businesses, strengthened local universities R&D ties with corporations, set up centers of technical support for local industries, and increased support for local businesses specializing in local strategic industries.

The theories of regional innovation systems and clusters predict that increases in local resources for regional innovation and in support of regional innovators will naturally lead to systems for generating, diffusing, and applying sustainable examples of innovation. The current reality of local and regional level R&D, however, demands that we question this fundamental assumption. This study therefore analyzes the working mechanisms of innovation and innovative activities at a local level from an innovation ecosystem ap-

proach. The concept of an innovation ecosystem is relatively new and has yet to develop into a systematic theory. Even though the term "ecosystem" is increasingly used today in discussions about interconnected business, corporate, industrial, and entrepreneurial networks, there is little discourse or in-depth literature on innovation ecosystems available in Korea today.

Local innovation policies have so far focused on developing, strengthening or supplementing the elements that regions are lacking and that are necessary for generating, diffusing, and applying knowledge in those regions. As a result, Korea's regional innovation systems have all the elements they need. However, the absence of strategies for filling in the gaps of regional innovation systems has limited significant enhancements to the productivity of local innovative endeavors. It is thus high time that we began to explore and develop a new model of regional innovation policy.

The objective of this study is neither to point out the theoretical shortcomings and policy defects concerning regional innovation systems and clusters, nor to replace the conventional approach with a novel theory of innovation ecosystems. Rather, it is to demonstrate that once we start to perceive regional innovation from an ecosystemic point of view rather than as a matter of system or structure, we will be able to create regional innovation ecosystems that are highly compatible with regional societies and capable of sustainable evolution. Our study is rooted in the belief that an ecosystemic perspective can help regional innovation policies become more realistic, performance-centered, and effective for regional conditions and circumstances.

The main purpose of our study, then, is to review problems with regional innovation from an ecosystemic perspective by examining factors critical to regional innovation that have been overlooked by the conventional approach to regional innovation systems and clusters.

2. Theoretical Review of Innovation Ecosystems

(1) Concept

Theoretical discourse on innovation ecosystems has only emerged quite recently. Although it is gaining in volume and rigor, no universal consensus on its core concept has been established. The attempts so far to theorize innovation systems can be divided into two camps. One involves conceptualizing innovation ecosystems as part of a management strategy. The other involves understanding innovation systems in continuity with the theory of innovative systems and the surrounding socioeconomic fabric.

Ron Adner, who first coined the term "innovation ecosystems," conceives of them as part of the management strategies of businesses, which he deems as central actors of innovation. With Adner (2006), we may understand innovation ecosystems as consisting of the cooperative arrangements that businesses form in an attempt to make their products and services customer-oriented.

Others approach innovation ecosystems as communities encompassing economic and non-economic factors of innovation, including the relations among economic actors, such as businesses,

universities and research organizations that perform innovative activities, as well as technology, institutions, social interactions, and culture (Mercan and Goktas, 2011; Durst and Poutanen, 2013). This approach sees innovation ecosystems as hybrids of different networks and systems. In line with the theory of open innovation, such innovation ecosystems expand the scope of participants in the innovation process to include not only those directly involved in R&D, but also diverse co-creators and co-innovators that stand outside the immediate R&D process.

Innovation in these ecosystems occurs as a result of the actions of interactions among countless actors in the same environment. Rubens et al. (2011) thus calls these systems "creation nets" that provide mechanisms by which (1) innumerable institutions and individual actors, (2) through horizontal collaboration, (3) create new products and services that cater to the rapidly changing market demands. The concept of creation nets is equivalent to that of "communities of innovation."

In sum, an innovation ecosystem can be understood as the totality of interacting factors that facilitate and promote the dynamic community of innovative actors or innovation of businesses that interact with one another in a given economic, industrial, and social environment. An innovation ecosystem is akin to a living organism in that it can evolve into diverse manifestations depending on surrounding conditions. That is why we may understand regional innovation ecosystems as "communities of innovation" strongly continuous with, and continually evolving, in the regions in which they are rooted.

(2) Basic model of innovation ecosystems

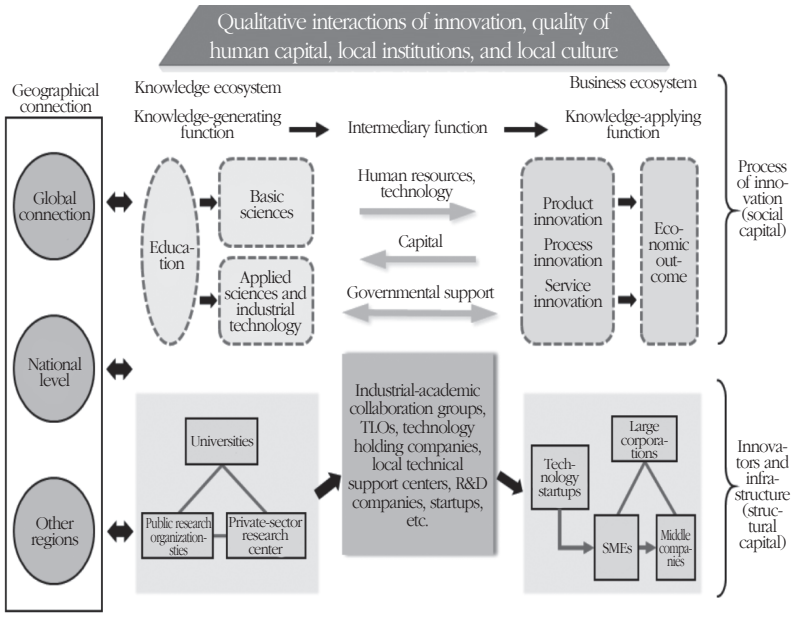
Innovation is a process that takes place along an organic network of relations among sources and actors that generate, intermediate, diffuse, and apply new knowledge. An innovation ecosystem is not simply just an amalgamation of these actors of innovation and a well-equipped innovation infrastructure (consisting of research organizations, technical support centers, R&D equipment, Techno Parks, industrial-academic collaboration clusters, and the like). Rather, it also depends for its success upon how active the state of knowledge exchange is among diverse innovators and how effective the interactions are among the research workforce, financial resources, policy support, and public services.

The quality interaction of innovative factors requires both the presence of resources for innovation and an environment, culture, and governance structure that effectively supports innovation. It also needs to have a solid strategy and leadership, a systemic plan for human resource management, the right human resources, the right partners, the right technology, and an appropriate clustering effect. Contrary to what the theory of innovative systems emphasizes, an innovation ecosystem is not merely the sum of innovators and innovative structural capital (infrastructure) but actually encompasses human capital (institutions, cultures, mutual trust, governance, etc.) and social capital together.

An innovation ecosystem is therefore a complex of knowledge and business ecosystems, intermediary functions and interactions, local culture and social capital, and support from the national and local governments. A knowledge ecosystem consists of high-

er-learning institutions that generate and impart basic knowledge, such as universities, public research organizations that perform basic and applied research, corporate and private research centers, and R&D-specializing companies. A business ecosystem obtains the technological and human resources it needs from the knowledge ecosystem and supports the network of businesses that generate new values through the innovation of products, processes, and services. The intermediary functions of an innovation ecosystem are typically handled by industrial-academic groups at universities, technology licensing organizations (TLOs), public innovation centers, local technical support centers, technology-holding companies, and technology licensing brokers. These intermediaries play a

Figure 1. Basic Model of Innovation Ecosystems



crucial role in connecting the technological, human, and financial resources offered by knowledge and business ecosystems.

This emphasis on the intermediary functions that promote the diffusion and application of knowledge is what sets innovation ecosystems apart from the theory of innovation systems. For an ecosystem to be innovative, it is crucial to have a sustained and balanced cross-pollination of ideas, questions, knowledge, and technology among different communities (Estrin, 2009). Intermediaries play the central role of making this cross-pollination possible.

(3) Importance of intermediary functions in innovation ecosystems

Knowledge, once generated by a knowledge ecosystem, undergoes multiple steps before it actually finds usage in a business ecosystem. In the linear model of innovation, a new technology becomes a product through processes involving basic research, applied research, and commercialization research. The process of knowledge transfer is thought to go through six nodes, i.e., data → information → knowledge → understanding → wisdom → action (Major and Codrey-Hayes, 2000).

Of these six nodes, those of data, information, and knowledge are principally handled by outside bodies, such as public research organizations, that serve as intermediaries of knowledge. The remaining nodes, from understanding to action, are handled by businesses that are recipients of knowledge (Bae, 2008). The most important of these nodes is the transition from knowledge to understanding, which is the stage when most new values are

created. This process of transferring knowledge from a knowledge ecosystem to a business ecosystem is likely to be uncertain and incomplete, giving rise to the so-called knowledge translation gap. For the transfer of knowledge to be successful, it is critical to support and enhance the activities of knowledge intermediaries that bridge the sources and recipients of knowledge. Intermediaries, in other words, play a central role in filling the knowledge translation gap (Yun and Lee, 2004).

Intermediaries are required in a number of stages, including the exploration and planning, R&D, and commercialization stages. The core role of intermediaries is to minimize the uncertainty of the profit prospects of inventions by reducing the costs of search and transaction on businesses and universities looking for partners to work with, thus boosting the exchange of knowledge (Kodama, 2008). The costs of search and transaction include all financial and non-financial expenses and the time spent looking for, enlisting, and negotiating with partners. According to Lopez and Vanhaverbeke (2010), innovation intermediaries actively assist clients by (1) helping them uncover and develop the potentials of their business models; (2) facilitating the commercialization of both extroverted and introverted technologies; (3) matching diverse needs for innovation with potential innovators; (4) searching for outside markets for entrepreneurs in the making; and (5) analyzing the requirements of clients and connecting them to suitable suppliers.

Considering these roles, we can define innovation intermediaries as "institutions or organizations that serve as proxies or brokers between two or more participants in various aspects of the process of innovation." We can summarize their function as "provid-

ing information on potential partners, intermediating transactions between two or more parties, coordinating and mediating relations among organizations and institutions already cooperating, and providing advice, financial support, or policy support to maximize the effect of innovative cooperation" (Howells, 2006).

3. Regional Innovation Ecosystems in Korea Today

□ Significant growth of investment in regional R&D activities and infrastructure

Our survey of changing amounts of regional R&D investment over the years 2007 through 2013 reveals that investment in the Seoul-Gyeonggi region doubled, from KRW 20.1 trillion to KRW 40.1 trillion, as did investment in the Chungcheong provinces, from KRW 5.46 trillion to KRW 9.82 trillion. Korea's southeastern provinces, which showed the least margin of growth, also saw investment grow by almost 150 percent, from KRW 2.51 trillion to KRW 3.78 trillion. Thanks to these increases, the number organizations and agencies providing technical support, knowledge and information, human resources and infrastructure support, and entrepreneurial support nationwide had reached 517 by 2014. The majority of such organizations outside Seoul-Gyeonggi came into being after 2000.

Local governments in Korea have been pursuing ambitious policies to enhance the innovative capabilities of their respective regions over the last several years, particularly by developing and expanding systems of knowledge generation, diffusion, and application. Most regional R&D investment has thus been focused on creating

and expanding special R&D zones, Techno Parks, local scientific research clusters, on-campus innovation centers supporting local businesses (TICs, RICs, etc.), channels of local industrial-academic collaboration, industrial technical support centers, and support programs for businesses specializing in local strategic industries. Outwardly at least, the regional infrastructure supporting actors and systems of innovation in Korea has achieved significant growth.

□ Concentration of investment and human resources in certain regions

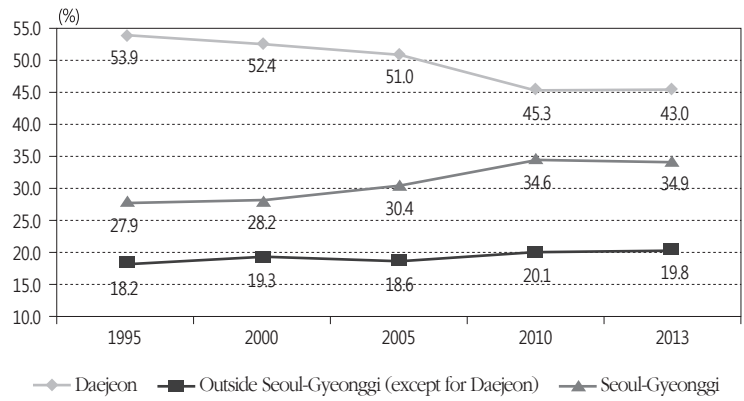
The private sector is now leading R&D investment in Korea. Private-sector companies accounted for 63.4 percent of total nationwide R&D investment in 2007, and the figure had risen to 78.6 percent by 2013. Private-sector investors concentrate almost all of their investment in the Seoul-Gyeonggi region, where the headquarters of major corporations are located. As of 2013, 74.7 percent of private-sector R&D investment was concentrated in this region, and another 11.9 percent in the nearby Chungcheong provinces, increasing the total to 86.6 percent.

What is worrying, however, is that public-sector R&D investment is also increasingly being concentrated in the Seoul-Gyeonggi region. From 1995 to 2013, the public sector's share of nationwide R&D investment grew from 27.9 percent to 34.9 percent. Since the private sector has tended to concentrate most of its R&D investments in the Seoul-Gyeonggi region, the public sector should have been responsible for evening out the distribution of R&D investment and of strengthening the already vulnerable innovation eco-

systems in other regions. But instead the public sector has also been increasing its investment in the Seoul-Gyeonggi region in the recent years.

Moreover, a greater ratio of the technical workforce is concentrated in the Seoul-Gyeonggi region. From 2008 to 2012, the total size of the relatively highly skilled technical workforce in Korea grew by approximately 130,000, 92.4 percent of which came from Seoul-Gyeonggi and only 7.6 percent from regions outside Seoul-Gyeonggi. In the meantime, the relatively low-skilled technical workforce showed significantly greater growth outside Seoul-Gyeonggi, indicating a growing regional disparity of access to skilled human resources. The return of workforces to major urban centers is a noted trend worldwide in this day and age of industrial convergence. But the influx of skilled workforces to Seoul-Gyeonggi region is also because of its greater number of R&D clusters and

Figure 2. Distribution of Public-sector R&D Investment by Region



Source : Ministry of Science, ICT, and Future Planning (MSIP), R&D Activity Survey Reports.

the relative weaknesses of universities outside the region as centers of industrial-academic collaboration (Kim, 2013).

Should the concentration of R&D investment and skilled workforces in Seoul-Gyeonggi and Daejeon continue, alongside the exodus of investment and workforces from other regions, the innovation ecosystems in other regions, except in major cities, will likely contract drastically. Regions outside Seoul-Gyeonggi and Daejeon will become mere bases of production, despite their significant shares in nationwide output and employment.

□ Incapacity of regions to serve as effective intermediaries of technology

Regions outside Seoul-Gyeonggi have a wide range of specialized regional technology centers (RTCs).[1] The majority of RTCs, however, simply provide shared or rented equipment. Korea is at a stage of industrial development that requires more advanced and sophisticated technical support than that of simply making high-end pilot plans more affordable and providing tests and analyses. But unfortunately, RTCs that ought to be the most effective and immediate intermediaries of technology for local small-and-medium enterprises (SMEs) refuse to do more than simple tests and analyses, certification evaluations, and supplying shared equipment for prototype development.

1) RTCs centers include local branches of public research institutions, specialized production technique research centers, 82 region-specialized centers, 19 research institutes of local governments, and 105 on-campus regional innovation centers (RICs).

A major cause of this phenomenon is the Korean government concentrating its support for regional R&D and innovation on the purchase of expensive equipment to be shared. RTCs, for their part, insist on providing supplier-centered programs of technical support, which fail to cater effectively to the actual needs and demands of local SMEs.

The RTC's project-centered structure of support also prevents increased investment in skilled workforces, while the insecurity of contract-based and part-time work at RTCs means that skilled researchers tend to avoid them. In addition, rather than enhancing the capabilities of exiting RTCs, local governments prefer to create new organizations and institutions to make themselves look good. As a result, the kinds of support provided by RTCs continue to overlap.

Now that open innovation has become a norm and the pace of technological innovation is ever quickening, it is critical for RTCs to perform a much wider range of intermediary functions from the planning stage through to the manufacturing stage. Despite the growing importance of RTCs as central intermediaries of regional innovation ecosystems, Korean RTCs remain outdated and vulnerable.

□ Inability of regions to promote private sector-led innovation

The intermediary functions of the public sector are just as indispensable to regional innovation ecosystems as the roles and functions of private-sector accelerators of innovation, such as venture capital investors, R&D service companies, and entrepreneurial

training agencies. The problem is that the vast majority of these accelerators are concentrated in Seoul-Gyeonggi, as well as a few other major cities, but are almost nonexistent in other regions in Korea.

Notwithstanding the governmental support program for venture capital investors, it is important to foster private-sector venture capital investment as part of an effort to revitalize regional innovation ecosystems. The number of regional knowledge service businesses should also be increased to promote innovation and create jobs. As well, regional cultures should be made more open, diverse, and supportive of innovation.

4. Case Study of Regional Innovation Systems in Korea

(1) Overview

Based on the results of a corporate survey, we compared and analyzed the current circumstances of two of Korea's leading regional innovation ecosystems, the Pangyo Techno Valley and Innopolis Daedeok. Our objectives were to gain a detailed understanding of their dynamic structure and working mechanisms and to determine how effectively the two ecosystems are working at present.

Participating in our survey were business service companies (in information technology, biotechnology, software development, etc.) located across Pangyo and Daedeok. There were 150 businesses from Pangyo and another 150 from Daedeok. We chose these 300 samples through a random sampling process based on

a list of businesses found in the two areas. Our survey involved interviewing representatives of these businesses either in person or via e-mail using a structured questionnaire. Gallup Korea ran the survey from September 24 to October 13, 2015.

For our survey, we first divided businesses by year of establishment, main areas of business, size, type, main products, location, amounts of revenue, and R&D investment, number of employees, and number of R&D-specialized employees. Second, we assessed the status of resources, geographic conditions, and networks for innovation in the given areas. The assessment involved ascertaining the level and effectiveness of available resources, the favorability of geographic conditions toward clustering, the activities of regional networks, the presence and functions of network intermediaries, and the obstacles to networking among businesses in each area. Third, we surveyed the status of commercialization, financing, consulting, and relations with other businesses, authorities and organizations. Finally, we surveyed businesses' needs for governmental support for the commercialization of technology.

(2) Assessment of the conditions and resources of regional innovation ecosystems

Our comparative analysis on the characteristics and differences of the two regional innovation ecosystems can be summarized as follows.

First, the innovation ecosystem at the Pangyo Techno Valley features a number of large and middle corporations as well as a multiplicity of small businesses. Innopolis Dadeok, on the other

hand, features a business ecosystem centered on small businesses, supported by public, national, and private research organizations. The two regional innovation ecosystems, in other words, comprise fundamentally different makeups.

Second, as the leading clusters of innovation in Korea, Pangyo Techno Valley and Innopolis Dadeok offer sufficient amounts of resources for innovation and clustering for tenant businesses. Both ecosystems provide superior resources for prompting technology development and commercialization and have more favorable geographic conditions than do other regional innovation ecosystems. Both ecosystems share in common fewer marketing innovation resources. Pangyo Techno Valley, however, offers better clustering conditions than Innopolis Dadeok, as it features both companies/clients with demand and suppliers/producers. Daedok, on the other hand, offers better entrepreneurial training facilities than Pangyo.

Third, businesses at both Pangyo and Daedeok are well aware of the importance of networking, and they desire networking activities and support that go well beyond mere social functions and exchanges of information. These businesses stressed that the public sector must play a greater role in promoting and supporting industrial-academic collaboration. Market-based coordinators, accelerators, and intermediaries of technology are needed to enable businesses to generate new values-added and to seize new opportunities.

Fourth, both Pangyo and Daedeok showed average results in terms of commercialization of technology, with Daedeok showing a slightly greater record of success than Pangyo. More businesses at Daedeok reported having received support from the public

sector for commercialization of technology than was the case at Pangyo. The types of actors supporting and aiding commercialization of technology differed from ecosystem to ecosystem. Whereas research organizations, large corporations, and intermediary and consulting agencies were the main actors of support at Pangyo, research organizations, public agencies, and SMEs were the main actors of support at Daedeok.

Finally, at both Pangyo and Daedeok, businesses pointed out

Table 1. Survey Results Summary

	Pangyo Techno Valley	Daedeok Innopolis
General makeup	Large and middle corporations and small businesses	Public and private research organizations and SMEs
Resources and conditions for innovation	Adequate conditions for innovation and clustering; lack of marketing resources; relative favorability of conditions for clustering clients and suppliers	Adequate conditions for innovation and clustering; lack of marketing resources; relatively better entrepreneurial support facilities
Networking and intermediaries	Need for public sector to play a leading role in promoting and supporting industrial-academic collaboration	Need for public sector to play a leading role in promoting and supporting industrial-academic collaboration
Commercialization of technology and support	Average record of commercialization; relative lack of experience with support for commercialization; research organizations, large corporations, and intermediary and consulting agencies serving as main actors	Relatively better record of commercialization and transfer of technology; relatively greater experience with support for commercialization; research organizations, public agencies, and SMEs serving as main actors
Policy needs	Insufficiency of support and intermediary functions; need for enhanced capabilities of support and intermediary functions; need for improved urban living environment (education, culture, amenities, etc.)	Insufficiency of support and intermediary functions; need for enhanced capabilities of support and intermediary functions; need for attracting large corporations and strengthening platform functions
General assessment	More of a business ecosystem, consisting of large and middle corporations and SMEs	More of a knowledge ecosystem led by research organizations and SMEs

the ineffectiveness or insufficiency of intermediaries in promoting technological innovation, emphasizing that the enhancement of the capabilities of these intermediaries was in need of urgent policy attention and support. As for other issues in need of policy support, businesses at Pangyo picked the improvement of the urban living environment (education, culture, amenities, etc.) as the most important, while those at Daedeok saw attracting larger corporations as tenants and strengthening the function of Innopolis as a business platform as most important.

(3) Implications for regional innovation ecosystems in Korea

Our comparative analysis of Pangyo Techno Valley and Daedeok Innopolis carries a number of implications, some converging and others diverging, on the development of effective regional innovation ecosystems in Korea. These ecosystems illustrated the need to ensure continuity between the knowledge and business ecosystems in order for an innovation ecosystem to become self-sufficient and work effectively. A regional innovation ecosystem requires both a well-functioning knowledge ecosystem, featuring universities and public and private research organizations, and a business ecosystem consisting of startups, SMEs, and large corporations.

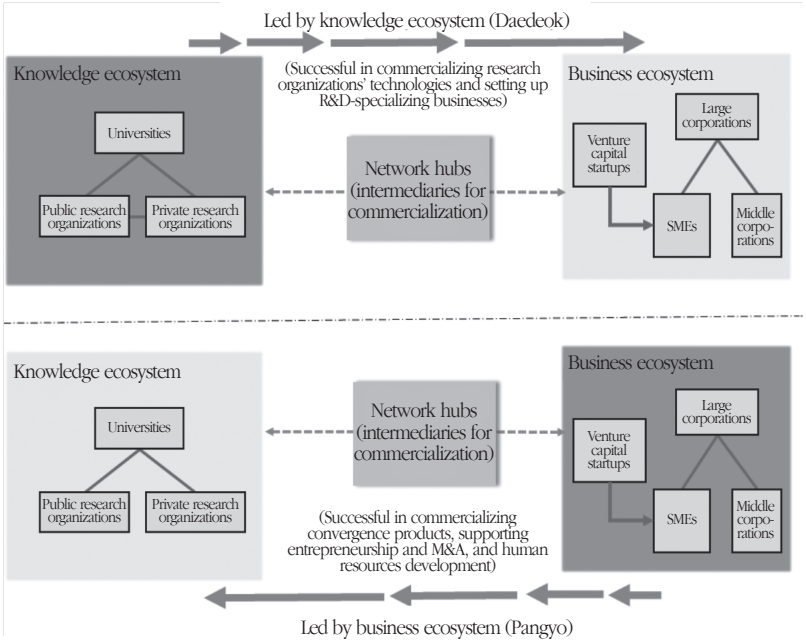
Pangyo and Daedeok both showed the importance of industrial-academic collaboration as the central means of connecting knowledge and business ecosystems, and they also showed the necessity of intermediary agencies to serve as hubs and brokers of such collaboration and networking. Businesses in both regions cited the insufficiency and ineffectiveness of intermediary and sup-

port agencies as the chief issue in need of policy support.

However, differences in the makeup and evolution of Pangyo Techno Valley and Daedeok Innopolis had different strategic implications for the formation and management of innovation ecosystems. The Pangyo Techno Valley is a business ecosystem-led strategy, in which much of the innovation is carried out by large tenant corporations and SMEs. Industrial-academic collaboration at Pangyo has produced a number of successes by supporting existing tenants' businesses and expanding the basis for technological innovation. Products of this collaboration at Pangyo include the development and commercialization of a smart home platform featuring service robots and capable of dominating the emerging global smart home market (Future Robot Inc.'s R&BD business, supported by the MSIP and the Gyeonggi Institute of Science and Technology Promotion, or GSTEP); the successful merger and acquisition between Alpha Chips, a leading medium-sized corporation of its field, and Spotfi Inc., an entrepreneurial training company (at the Electronics and Telecommunication Research Institute, or ETRI, at Pangyo, for KRW 11 billion); and the joint development and coordination of business training curricula through the collaboration of education and training agency tenants at the Pangyo Techno Valley (featuring GSTEP and six other education and training agencies).

Daedeok Innopolis, on the other hand, is a knowledge ecosystem catering to small businesses and led by public and private research organizations. As a result, it has been more successful with respect to collaborations between public research organizations and local businesses in setting up new consortia and the creation of research-centered businesses that support the development and

Figure 3. Characteristics and Differences: Pangyo and Daedeok



commercialization of new products at other companies.

Examples of success at Daedeok include Kolmar BNH, the first R&D company that a public research organization (Korea Atomic Energy Research Institute, KAERI) set up in Korea which specializes in the R&D of immunity-strengthening and anti-cancer health supplements; and another R&D company specializing in researching the applications of Daedeok Innopolis' electronic paper technology, which was set up with the participation of multiple research organizations and businesses, including ETRI, Biogenics, Image and Materials, and Silicon Works. As of July 2015, there were 67 such R&D companies at Daedeok Innopolis and a number

of R&D companies established in other regions with the help of Daedeok Innopolis' technologies.[2)]

5. Policy Support for Fostering Regional Innovation Ecosystems

(1) Policy aims and directions

The consensus on innovation policies in the 20th century among the member states of the Organization for Economic Cooperation and Development was to increase R&D investment (OECD, 2011). The linear model of innovation emphasizes the supply side of knowledge and technology and prioritizes increased R&D investment as the basis for enhancing the capability for generating knowledge. As the center of emphasis has been shifting from innovation to interaction and from the supply side to open innovation, non-technological technology and management have emerged as equally important. Today, policymakers know that simply increasing R&D investment is not the answer to increasing innovation.

Since the 1990s, the Korean government has been steadily increasing its R&D investment with a view to enhancing regional innovation. Most regional R&D investment has therefore been concentrated on equipping regions with the innovative infrastructure and resources they lacked. Over the past two decades, the Korean government has been earnestly supporting the R&D activities of

2) As of July 2015, there were a total of 118 R&D companies at local R&D zones, with 67 at Daedeok, 14 at Gwangju, 27 at Daegu, and 10 at Busan (Innopolis Foundation's internal statistics).

local universities, setting up local branches of public research organizations, establishing specialized production technique research centers, creating industrial-academic collaboration groups/technology support centers/special R&D zones/local scientific research clusters, assisting technology development at local businesses, supporting networking among actors of innovation, and improving the education and training of skilled workforces.

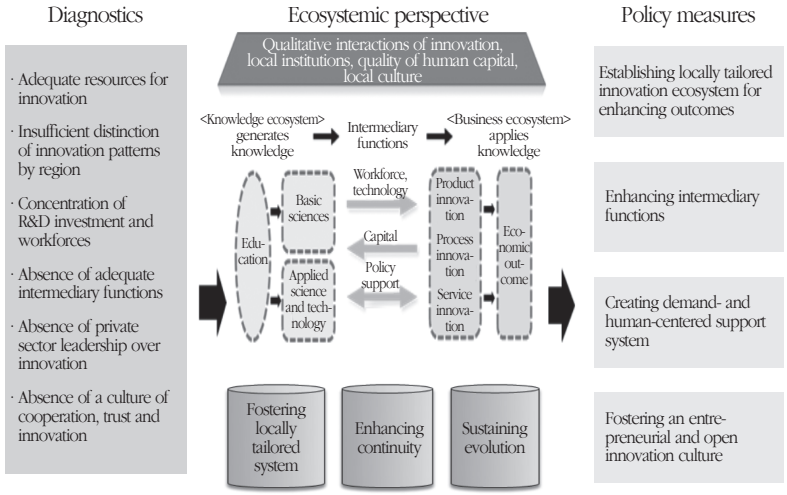
The government has also tried diverse policy measures to promote the generation, diffusion, and application of knowledge. The problem, however, is that the majority of these policy measures have been implemented in a fragmented manner and have thus failed to produce desired levels of innovation. Universities focus on multiplying the number of academic articles and patents to their name, while dealing short shrift to the commercialization and transfer of technology. A number of knowledge ecosystems have cropped up across Korea thanks to increased investment, but their research findings have still not resulted in feasible products at business ecosystems. While the amount and range of support for technology development at local SMEs has multiplied dramatically over the years, their innovative activities are conducted in a rather exclusive manner and they refuse to share and diffuse their discoveries with innovation ecosystems at large. RTCs, endowed with the task of intermediating the distribution of technology, focus steadfastly on purchasing and renting out expensive research equipment. Thanks to RTCs, businesses are able to use expensive testing and prototype equipment, but this benefit has yet to yield a significant enhancement in the ability of businesses to develop new products or collaborate with large corporations and research organizations.

The foremost task for regional innovation policy in Korea today is to bring disparate factors and resources of innovation together into an organic and expanding ecosystemic network. The key to that lies in enhancing intermediary functions. An ecosystem must have a continuity of innovation from knowledge ecosystems to business ecosystems, or vice versa, so that innovative findings lead to tangible improvements in people's lives with increased income and jobs. Ensuring this ecosystemic approach is crucial for the sustainable growth and evolution of innovation.

A sustainable and lively regional innovation ecosystem runs on three main principles. First, we need to make sure that regional innovation ecosystems are sufficiently tailored to local conditions and patterns of innovation. Unlike a structural system, an ecosystem varies from region to region. Different types of ecosystems may develop depending on the conditions, characteristics, paths of development, and strategies of local communities. Any innovation ecosystem is acceptable insofar as it fulfills the purposes of innovation—that is, enhancing the global competitiveness of its community, creating quality jobs for locals, and improving the quality of life for locals. This requires, in turn, the development of locally tailored operating systems for managing the many factors and resources of innovation involved.

Second, we need to enhance the continuity flow of innovation in regional innovation ecosystems. This requires enhancing the intermediary functions that bridge the knowledge ecosystem, which generates knowledge, and the business ecosystem, which applies knowledge to practical use. It also involves strengthening relations and cooperation among diverse actors within each ecosystem, with other

Figure 4. Policy Measures for Fostering Regional Innovation Ecosystems



regional ecosystems, and with the global village at large. Strengthening continuity is crucial to promoting interactions within a given ecosystem. The task should be approached not only from the perspective of software and networks, but also from the perspective of hardware and the enhancement of geographical/spatial proximity. The government has to provide cultural and spatial measures to promote open innovation in addition to enhancing intermediary functions.

Third, we need to make sure that a given regional innovation ecosystem continues to evolve and adapt amid changes in the surrounding environment and competition with other ecosystems. It is critical to free certain groups and actors from being locked in path dependency, enabling them instead to adapt to the changing environment in active and dynamic ways. To give an innovation ecosystem openness and flexibility, it should be centered on the application rather than the generation of knowledge, while bene-

fitting from the flexibility of the research and skilled workforces involved. It is also important to foster tech startups and entrepreneurialism in the given region.

A successful regional innovation ecosystem that runs on these three principles can be summed up as a community of innovation that is locally tailored, highly continuous, and sustainably evolving.

(2) Policy advice

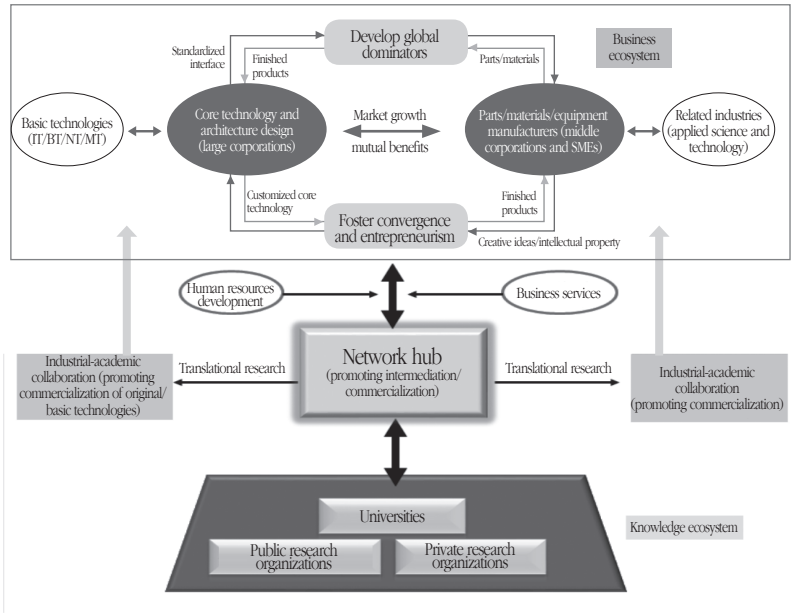
① To establish locally tailored and highly productive regional innovation ecosystems

□ Let business ecosystems take center stage

The real objective of establishing an innovation ecosystem is to ensure the sustainability, competitiveness, and vitality of local industries and businesses in the constantly changing and competitive global environment. Accordingly, regional innovation ecosystems need to balance and support collaboration between regional knowledge and business ecosystems. Such regional ecosystems should be tailored to the regional industrial basis and business ecosystems.

The central focus of regional innovation ecosystems should therefore be on increasing the tangible outcomes of regional business ecosystems. Policymakers can help achieve this goal by enhancing regional hubs of networking and industrial-academic collaboration. Finally, policymakers can also help by ensuring the strong connection of regional business ecosystems to knowledge ecosystems, both in and outside of a given region.

Figure 5. A Model of Regional Innovation Ecosystems Centered on Business Ecosystems



□ Establish fair partnership between large corporations and SMEs

The vitality and strength of business ecosystems is crucial to the ability of regional innovation ecosystems to foster industries and local communities. Regional business ecosystems can vary greatly depending on what a region's main industries are, who plays the keystone role in each ecosystem, and what the business relations are like. In Korea, it is often the effectiveness and strength of partnerships between large corporations and SMEs that determine the success or failure of business ecosystems.

Large corporations must gain greater capabilities for develop-

ing core technologies and architecture based on collaboration with academic communities, on the one hand, and develop successful products on the global market by incorporating the specialized parts and materials supplied by SMEs, on the other. SMEs, for their part, should enhance the competitiveness of their parts and materials and pursue innovation convergence through partnerships with academic establishments and large corporations. Only when the innovative and convergence-based products of SMEs find suitable recipients in large corporations can these businesses achieve product innovation, foster entrepreneurship, and create more jobs.

□ Develop technology support systems tailored to regional specialties

For this study, we divided regional innovation ecosystems into three types, i.e., science- and technology-based ecosystems (Type A), application-based ecosystems (Type B), and emulation-based ecosystems (Type C). Types A and B are each again subdivided into two parts. For regional innovation ecosystems to work effectively, it is necessary to identify the industries or technologies they specialize in best and concentrate support on them.

Each metropolitan city or province in Korea is designated, by the national government, as having five main industries to specialize in and three industries for inter-regional cooperation. The Korean government gave each metropolis or province two more regional specialty industries upon introducing regulation-free zones in December 2015. New and emerging industries will also be supported by regional industrial based support projects. In other words, ma-

jor cities and provinces in Korea have far too many industries to focus on. Meanwhile, RTCs remain scattered and uncoordinated with multiple specialties, and none of them is big enough to reach the critical point in R&D innovation.

Therefore, it is important to reduce by two or three the number of specialized industries for each metropolis or province and to restructure/streamline RTCs accordingly to enhance regional innovation capability. RTCs, once streamlined to serve core regional industries better, should go over and beyond providing R&D equipment to performing research services on a contractual basis upon request from local businesses. RTCs, moreover, need to start providing technological support not only for local businesses, but also for businesses outside of their region that have special relations with core regional industries. RTCs should serve as a nationwide network of technological support for each industry, not just for specific regions.

② To foster and strengthen intermediary functions in regional innovation ecosystems

□ Foster translational research and network hubs

The main way the Korean government can enhance industrial-academic collaboration and the ability of regional innovation networks to serve as hubs of industrial networks is by fostering translational research. Translational research refers to the intermediate phase of research that forms the bridge from basic/original research to commercialization research. Translational research is

critical for identifying what strategic technologies should be developed and determining the additional research activities necessary to enhance commercialization prospects. The Korean government needs to support and foster translational research by changing the target of its R&D investment. To date it has concentrated on commercialization and prototype development at individual businesses, but it now needs to shift its focus onto the industrial-academic collaboration at the heart of translational research.

A two-track strategy is necessary to activate and boost the function of regional innovation ecosystems as hubs of innovation networks. Such a strategy combines both top-down strategic projects and bottom-up demand-centered projects. Its goal is to foster major and core industries with great ripple effects on the rest of the economy, while simultaneously satisfying the diverse needs of individual businesses. Top-down strategic projects should be undertaken in the intermediate to long term to enable regional ecosystems to specialize systematically in their core industries and technologies. Bottom-up demand-centered projects should take place in the short term to expedite the commercialization of various technologies.

□ Provide software support for regional innovation ecosystems

The majority of public support for RTCs and regional ecosystems is concentrated on developing initial hardware, with little regard for the software resources needed for the effective management of centers and ecosystems. The current situation prevents the evolution of RTCs into specialized institutions of research with specific industrial interests and objectives. So it is critical to allow RTCs

to attract skilled workforces so they can achieve such an evolution. This, in turn, requires fiscal subsidization and support for some of the RTC operating costs, such as wage and labor-related expenses.

Although this would increase the already heavy fiscal burden on the government, the burden could be alleviated by introducing a meritocratic and competitive system that encourages RTCs to improve their productivity in proportion to the fiscal support they receive. The government could assemble a council of RTCs, akin to the Fraunhofer-Gesellschaft of Germany, complete with a list of eligibility criteria. RTCs that satisfy these criteria would be able to join the council in exchange for fiscal support and incentives. Member organizations would then conduct annual performance reviews, and those RTCs failing to produce certain results on a repeated or cumulative basis would lose their standing on the council, thereby vacating spots that other qualifying RTCs would fill.

□ Enhance the contract research service function of RTCs.

Now that open innovation is regarded as the norm of innovation, it is crucial to foster research collaboration among diverse actors of innovation. SMEs that struggle with shortages of financial and other resources especially need to make better use of external resources and support for innovation. The government needs to incentivize SMEs to participate more actively in collaboration with RTCs and other pursuers of innovation

The key to minimizing the crowding effect[3] is for businesses

3) The crowding-out effect arises when a business replaces the R&D investment it

to invest the fiscal support they receive in the more adventurous and risky projects aimed at discovering new technologies and opportunities. Participants in these adventurous R&D projects can reduce the associated risks by actively working with universities, research organizations, and other such outside parties. To this end, businesses could plan and propose new R&D projects that involve contracting out R&D services, and, for its part, the government could channel its technological support to such projects. The government should encourage multiple SMEs to participate together in such projects and to actively seek out the service of external research agencies.[4)]

③ To provide technology- and workforce-centered regional R&D support

□ Increase demand-centered support through the Innovation Voucher Program

Innovation vouchers entitle businesses to the benefits of R&D

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is supposed to make with fiscal/policy support it receives in developing a new technology it has intended to develop on its own.

4) The Ministry of Trade, Industry and Energy (MOTIE) intended to introduce the Program for Supporting the Sharing of Common Technological Bases Among SMEs, i.e., the Innovation Voucher Program, in 2014. The program provides vouchers for R&D with common technological bases that is developed by specialized R&D organizations upon request by two or more SMEs. The SMEs enlisting the service of a specialized R&D organization need to jointly submit a confirmation of the plan to match the government's voucher in applying for the Program. The intellectual property created as a result belongs to the R&D organization, but the SMEs gain the right to the exclusive and free use of the property for two decades.

services from specialized knowledge-providing agencies and organizations. The Innovation Voucher Program allows businesses to choose which knowledge-providing organizations to work with in developing and commercializing innovative technologies. The intent behind the program is to make RTCs more demand-oriented and thereby more effective intermediaries of technology in their regions. SMEs that receive these vouchers also benefit from the simplified process of applying for and obtaining the innovative services they need.

RTCs, such as regional specialization centers, use various kinds of shared equipment to provide a wide range of services (testing, analysis, certification, performance evaluation, prototype development, etc.). Innovation vouchers are expected to enhance the demand-orientation of RTCs and induce greater competition among them, thereby improving the quality of services on offer. Once applied not only to short-term service projects, but also to long-term R&D projects, innovation vouchers could boost the capability of RTCs for performing contract research services, and thereby strengthen their ability to serve as intermediaries of technology.[5)]

□ Increase jobs for skilled workforces at RTCs

The conventional model of policy support for R&D is centered on individual R&D projects. However, technologies are products of

5) Hwang and Lee (2015) emphasizes the need for policymakers to outgrow the supply-centered approach to innovation and to grant the right to businesses to decide whether or not to purchase R&D services. The authors propose that the vouchers be extended to general applied R&D projects as well.

human endeavor, so it is important to increase policy support for skilled research workforces as well. Human resources play a decisive role in the commercialization and transfer of the innovative achievements of the public sector, but up until now their role has been largely underestimated. The movement of people across sectors and industries is what diffuses knowledge and enhances the R&D productivity of businesses (Han, 2014). People that use and internalize technologies, and if barriers inhibit the free movement of skilled research workforces it is likely limit the transfer, diffusion, and application of knowledge.

RTCs should no longer be mere reservoirs of high-end research equipment but be transformed into centers of the industrial and technological specialization. RTCs can achieve this transformation by attracting more skilled research workforces. The Korean government should increase the fiscal support for the employment of better and more skilled human resources at RTCs, helping these centers become attractive workplaces for local researchers. RTCs could form partnerships with local universities and businesses to hire exemplary graduates with engineering backgrounds as contract-based researchers. These researchers can then help with RTC research or be dispatched to local businesses as research fellows to assist R&D in the field. After the contract period elapses, these researchers could then find work at corporate research centers or branch out on their own. Public research centers in Germany, for example, hire university graduates on five-year contracts and encourage them to find research careers elsewhere, or set up their own research agencies, after 15 years or so of work in the public sector.

④ To foster tech startups, entrepreneurism, and open innovation in regions

□ Centralize the source of services and support for local startups

Prospective regional startups need a comprehensive range of business services, such as market research and analyses, legal protection for intellectual property rights in progress, assistance with prototype development, help for seizing upon market opportunities, support for developing business plans, laboratories and other incubating facilities, financial assistance and investment, and performance monitoring. The Korean government could assist these local startups and foster entrepreneurism with demand-oriented tech startup vouchers.

□ Develop and promote regional innovation zones

In order to promote entrepreneurism and tech startups, it is critical to bring together early-stage startups in geographical proximity so they can all benefit equally from nearby resources and programs of entrepreneurial support. Entrepreneur cafés, for example, provide office spaces for tech startups on a lease basis. The Teheran Valley in Gangnam and the Cheku Café in the Zhongguancun, Beijing, have played a major role in providing much needed spaces for new enterprises with prospective technologies (Kim et al., 2014).

Entrepreneur cafes, as excellent locations for rendezvous between entrepreneurs and investors, also give tenant startups the

opportunity to present their ideas and visions on a regular basis. As the example of WeWork shows, entrepreneur cafes in serving a wide range of roles are effective accelerators of entrepreneurism and innovation around the world.

These entrepreneurism cafes and innovative research laboratories should be clustered in innovation districts in the heart of urban centers. They need to be easily accessible by public transit or on foot and popular with the young and talented. Highly connected physical spaces play an indispensable role in promoting open innovation.

□ Foster institutions and cultures that favor open innovation

Social capital, based on trust, openness, and diversity, is central to innovation. It is important for local governments to develop projects that foster and cultivate the institutions and culture of social capital. Max Planck Institutes in Germany, renowned for their basic science research, regularly organize public events with scientific and cultural themes to help local citizens become more acquainted with science and technology. Korea's local governments could also strengthen the software components of primary and secondary school curricula to familiarize students with computer coding and software programming from a young age.