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Cluster or Diversify?
A Dilemma for Sustainable Local Techno-Economic Development

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Abstract

By highlighting the efficiencies gained from regional specialization, the cluster concept has distracted economic development officials from their traditional role of diversifying regional and local economies. Clustering was a viable strategy for much of the 18 years following its original appearance in the literature. Now, two events cast doubt on the continued viability of cluster-based specialization. First, the digital convergence has blurred the boundaries that once separated one industry from another. An industry cluster strategy becomes difficult when the industry cannot be defined. Second, many cluster initiatives fail. Combining literature search with the system-theoretic notions of efficiency and redundancy, we find many factors moderate cluster success. This implies regions facing uncertain success in their cluster-building efforts should thoroughly understand their unique circumstances and build upon them. Regions with successful clusters are advised to aim for multiple related clusters or superclusters.

Keywords

Industry cluster; Economic development; Industrial diversification

1. INTRODUCTION

Traditionally, city and economic development officials strived to diversify their local economies, in order to protect jobs and tax base against economic shocks (See, e.g., Callen et al., 2014). More recently, economic development (ED) practice has been dominated by the cluster concept (Porter, 1998). This idea focuses on attracting to the locale companies that contribute to a value chain that serves one industry or a small number of interdependent industries.

System theory tells us there is a trade-off between efficiency and flexibility (Phillips and Tuladhar, 2000). An efficient system turns investment into maximum results, under current circumstances. Such a system does not contain the redundancy, back-up, or surplus input resources that allow it to adapt when circumstances change. A flexible system on the other hand sacrifices some current efficiency in order to build resilience to potential changes in its circumstances. The purpose of traditional economic diversification was to give communities this resiliency.

A one-industry cluster strategy is efficient, as it allows ED resources to be focused on a well-defined target. It raises the question, however, of whether a cluster strategy is resilient against shocks, that is, whether the development is sustainable. How do communities handle the apparent tension between cluster and diversification strategies? What combinations of strategies succeed or fail? Do best strategies differ by the "technopolis maturity level"?[1] Do cities' efforts to "brand"

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[1] See, e.g., http://www.generalinformatics.com/TechnopolisMaturityModel.pdf

themselves and differentiate themselves from others cause excessive and dangerous specialization? This paper examines these research questions by means of a literature review, with special emphasis on technology-based regional ED, examples from Austin, Texas, and an illustrative case study of the Daedeok Innopolis.

We find that answers differ according to the wealth of the region, its history, its pre-existing resources, and its geographical situation. There is no "one rule fits all." Some cities cannot build clusters, while others pursue multiple clusters, either serially or simultaneously. Success depends on perceptive and creative management and leadership.

2. ECONOMIC DEVELOPMENT: DIVERSIFICATION AND RISK

At one end of the diversification spectrum is the historic company town, in which a single company is the sole employer and owns all the town's retail establishments and housing. These communities were vulnerable because labor had no alternative employment prospects (Clemenson, 1992). A logging or mining company town would disappear when the forest or the coal seam was depleted. A factory company town would disappear when technological change made its product obsolete, the classic example being the closing of buggy-whip factories when the automobile appeared on the scene. Company towns were efficient, at least from the producer's perspective, but highly vulnerable to changed environments. Modern examples include regions solely dependent on military, tourism, mining, or foreign aid revenue.

Table 1. Causes of economic shocks affecting the fate of a community

Exhaustion of a natural resource
Departure or bankruptcy of a major employer
Loss of a critical transportation link
Loss of markets
Loss of critical suppliers
Regulatory or legislative changes
General economic recession
Natural disaster

At the other end of the spectrum are modern cities like Chicago and Seoul that house manufacturing, financial, and marketing functions serving a great variety of product and service areas, and support research institutions and innovation districts (Katz and Wagner, 2014) that help keep local enterprises on the technological leading edge.

Between these extremes we find technopoles like Austin and Daejeon that have committed to a multi-cluster strategy. Elsewhere in the spectrum are smaller, newer, often poorer, "wannabe technopole" communities searching for their distinctive technological strengths and their best ED strategy.

2.1 Clusters

A cluster strategy is also efficient because of the lock-in effect: Once a critical mass of companies is attained, more companies relocate to the city, not because of the city's ED expenditure, but because of the other companies that are already there. The same effect makes it difficult for companies to leave the community. This implies great (efficient) savings in the city's ED budget.

Yet it implies also that a cluster may not diversify the local economy sufficiently to insulate it against unforeseen shocks.

We found one article (Castillo et al., n.d.) that took the curious view that clustering is diversifying. This appears to apply when a single-industry town first attempts to leverage its (previously ignored) attractions and strengths to hedge against economic shock.

2.2 Vulnerable technopoles

Mature clusters and technopoles are not invulnerable to the kinds of shocks listed in Table 1. Often an anchor firm is lost due to its acquisition by a firm that wishes to consolidate operations elsewhere. Austin suffered the loss of Texas Instruments and Motorola for this reason. Austin's Dell Corp. moved to neighboring Round Rock, Texas, to benefit from cheaper real estate. (Stories of the departures of these companies appear, respectively, in Orman, 1997; Ladendorf, 2015; and Lappin, 2013). Feldman (2016) shows how regulatory changes in Washington, DC, decimated the advertising cluster in St. Louis, Missouri.

Cluster strategies depend on an "anchor firm" (Porter, 1998), a large company that is an aggressive exporter. While the loss of an anchor firm leaves behind the smaller firms it may have spun out (in the case of Texas Instruments in Austin, this includes National Instrument), it implies that cluster strategies can lead to vulnerabilities.

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Table 2. Levels of tech-based ED initiatives

Naïve	Produce more patents, licenses, and journal articles. Try willy-nilly to attract technology companies. Over-emphasize military-to-civilian tech transfer.
	Target and pursue companies that might form a viable cluster and enhance a distinctive regional identity.
	Balance recruitment, retention, and entrepreneurship initiatives regionally.
	Balance self-investment in hard and soft infrastructure, university and federal-lab tech transfer, and marketing efforts to attract and build companies.
Sophisticated	"Integrate and partner the academic, business, government, foundation, and not-for-profit sectors… [to mobilize technology as] a means of attaining economic, social and cultural status for individuals, as well as a way of achieving institutional objectives and ensuring the general welfare of society" (Kozmetsky, 2003).

Source: Phillips (2006)

The high failure rate of technopolis initiatives (Phillips, 2014) suggests these losses can be game-changers for communities. This fact motivates the present research.

2.3 Economic development strategies

Like the technopoles themselves, the locale's ED strategies can be mature or immature. (See Table 2)

It is understandable that a small community may spend resources attracting any companies, regardless of industry, that show interest in the city. This paper's research questions become relevant to the city when it has enough economic surplus to consider a strategy. The strategy will specify the city's desire to specialize, differentiate, or diversify.

3. LITERATURE REVIEW

Amin (1999) provides a theoretical context:

> *The neo-liberal approach… sought to stimulate entrepreneurship… and to deregulate markets, notably the cost of labour and capital. The common assumption… is that top-down policies can be… applied universally to all types of region…. [Its] achievements … have been modest in terms of stimulating sustained improvements in the economic competitiveness of the less favoured regions (LFRs). Keynesian regional policies, without doubt, helped to increase employment and income in the LFRs, but they failed to secure increases in productivity comparable to those in the more prosperous regions, and more importantly, they did not succeed in encouraging self-sustaining growth….*
>
> *Partly in response to these failings, more progressive policy communities have begun to explore a third alternative, designed to secure economic competitiveness by mobilising the endogenous potential of the LFRs through efforts to upgrade the local supply-side infrastructure for entrepreneurship…. This is not an approach with a coherent economic theory behind it, nor is there a consensus on the necessary policy actions. However, its axioms contrast sharply with those of the policy orthodoxy, in tending to favour bottom-up, region-specific, longer-term, and plural-actor based policy actions. In addition… it recognises the collective or social foundations of economic behaviour.*

These efforts show that localization is a partial counter-force to globalization, according to Hines (2003). Eitzen (2012) notes that post-Soviet economies, as well as those in the developed West, rely on inter-regional competition for economic development, and some of these competitive initiatives are government-driven while others are bottom-up. Indeed Moore and Pierre (1988) show that while UK and Sweden maintain divergent macroeconomic policies, their respective grassroots and community-level initiatives are quite similar. Nearly 20 years later, we may conclude that the similarity is due to near-optimality of the approach, rather than to simple imitation.

Studying American regions, Cox and Mair (1988) show how these diversification initiatives can threaten the established

industry by diverting resources to the new entrepreneurial infrastructure, causing organized opposition to the initiatives.

What do empirical studies show, concerning diversification vs. specialization and clusters? Most of the studies are, in fact, somewhat equivocal, listing several qualifications to their results. They do agree that diversification is imperative for regions suffering from the "natural resource curse."

Killian and Hady (1988) come down tentatively on the side of diversification, their results clouded by the fact that higher education and government both, in essence, produce exports from the local economy. "About half of the [USA]'s rural economies are dominated by a few industries and about half are diversified. The diversified economies fared better overall than the rural average, but so did economies that specialized in education and government. The strength of both was their stability. They did not grow especially fast, but they grew steadily. Other specialized economies enjoyed good employment growth or good in- come growth, but their growth was more erratic, making it difficult for local officials to plan for the changing needs of the area."

Desrochers (2001) argues strongly for diversification, showing knowledge spillovers from one industry benefit unrelated industries. Desrochers and Sautet (2004) further argue that a strict construction of "cluster" (which they claim is a fuzzy concept to begin with) inhibits industrial innovation. They would find support for this argument in Doeringer and Terkla (1995), who claim cluster policies "run the risk of wasting development resources by neglecting important linkages among firms that cut across industries."

Appolo et al. (2016) note that the European Commission, following the cluster concept, established a Smart Specialization program "promoting the efficient and effective use of public investment" in R&D. OECD endorsed this program. By analyzing patent data for 268 European regions, classifying the patents according to Fraunhofer categories, and comparing patent activity with regional growth, Appolo et al. (ibid) obtained results "suggesting that regions need… a sufficient degree of diversification in their technological activities in order to remain economically prosperous." Their results run contrary to the premise of the EC's Smart Specialization.

Using the term "natural capital" to denote natural resources, especially in extraction-dependent economies, Gylfason (2001) writes, "Economic growth since 1965 has varied inversely with the share of natural capital in national wealth across countries." That is, diversification is imperative. Pisa et al. (2015) confirm this for the case of South Africa's Northwest Province: "Both the NWP and the South African economies were adversely affected by a prolonged strike in the platinum sector." In their case, a first industrial cluster was a diversification from the mining economy. Their analysis indicated a positive effect of industrial cluster formation on economic activity in the NWP. We should note that this may be possible only in countries where extraction profits are not all remitted overseas. If they are, then the mining region may be too poor to finance a cluster strategy.

This raises an important point, namely, that following a strategy means saying "no" to certain opportunities. Clearly then, there are regions that cannot yet afford to have a strategy, that is, cannot afford to say "no" to a profitable relocation or FDI opportunity. Regions that cannot afford a strategy must be opportunistic, until opportunism has yielded sufficient revenue to support formulation of a strategy.

On the anti-diversification side, Porter (2003) emphasizes exports as the drivers of prosperity – even though clusters might be the precursors of exports. "Traded industries account for only about one-third of employment but register much higher wages, far higher rates of innovation and influence local wages." "Regional wage differences are dominated by the relative performance of the region in the clusters in which it has positions, with the particular mix of clusters secondary."

Shearmur and Polése (2005) claim "There is no clear link between the process of diversification and growth. Also, proximity to a large diversified economic unit (metropolitan areas) tends to be associated with growth; thus, it is not only the local characteristics of regions that determine their growth levels. Our evidence suggests that economies associated with diversity can occur concurrently with economies associated with specialisation. In the light of these complex relationships, we conclude that diversification policies are difficult to justify on the grounds of employment growth [in the 382 Canadian areas studied]."

Oita, Japan's "one village, one product" program (Haraguchi, 2008; Natsuda et al., 2011) shows specialization can be successful, if regulated by the prefectural government.

Richer regions aim for multiple clusters. The question then is, how related must these clusters be? Hagenauer (2012) lists the five clusters of Lower Austria: Logistics, Food, E-Mobility, Green Building, Plastics, and Mechatronics. Leleur (2009) maintains that diverse and multiple clusters were a success factor in Bangalore. Phillips (2014) describes Austin, Texas' succession of clusters. General Informatics (2015) shows how

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Austin's clusters coalesce around the "digital supercluster."

According to Neffke et al. (2011), "regions are most likely to branch into industries that are technologically related to the preexisting industries in the regions." Suggesting that "most likely" is always supplemented by human decision, Wiggins and Gibson (2003) note the consequences of incubator admission criteria on Austin's regional diversification. We detail a Korean example in the next section of this paper.

Turok (2009) warns of the dangers of specialization without differentiation. He found that UK cities specialize in identical arenas, reducing municipal and national competitiveness.

Satell (2015) comments,

> *Competitiveness is no longer determined by how efficiently we move around men and materiel, but in how we connect to informational resources. Enterprises need to manage organizational resources, but no longer derive the same scale advantages they used to.*
>
> *[Therefore] we are no longer sure what businesses we are in. There was a time when being in banking or electronics or manufacturing had a specific meaning. Now, bankers must understand algorithmic trading, techies lend money, pharma companies invest and manufacturers design computerized devices just to do their work. We often have little idea where the next opportunity or threat may come from. And not knowing what business you are in, from year to year or less, makes it harder to figure out exactly what competitive advantage, exactly, we hope to sustain.*

This blurring of boundaries causes the specialization versus diversification question to be investigated even within individual firms (Huang et al., 2016) — also without simple or clear answer.

4. CASE STUDY: THE CONDITIONS IN DAEDEOK THAT ALLOW VARIOUS CLUSTERS TO FORM AND DEVELOP

4.1 Overview

Daedeok Innopolis, which began as a research institute in 1973, has grown into Korea's prestigious R&D hub with 26 government research institutions, 44 private research organizations, 9 institutional investors, 7 universities, 13 public institutions and 1,516 companies (105 high-tech companies), according to 2014 data. Daedeok Innopolis laid the foundation for development of science and technology capacity in Korea. In addition, it has developed and commercialized world-class technology in the fields of information technology, biotechnology and nuclear technology (Ki and Park, 2007).

However, Daedeok Innopolis was separated from production functions until late 1990s, geographically far from necessary functions to utilize the created research results, and corporate support functions, e.g. finance and marketing. Knowledge services were nonexistent (Kim et al., 2015). As the center of the National Innovation System, Daedeok Innopolis has carried out many research projects to reduce Korea's technology gap with the developed countries. But due to poorly established virtuous circulation of the Regional Innovation System based on industry-academia cooperation, the attempts at innovative activities, such as development of regional companies and stimulation of start-ups, were very weak.

The national financial crisis in the late 1990s had sparked a movement of new innovation production from research results in Daedeok Innopolis by overcoming the limitations as the R&D cluster. In support of this, the local government had constructed Daedeok Technovalley, the urban high-tech industrial park and the infrastructure required for technology transfer and commercialization, and designated the areas including Daedeok Innopolis, Daedeok Technovalley, nearby high-tech industrial parks and planned development sites as the research and development specialized district. The expanded production capabilities in Daedeok and the industry-academia cooperation promoted the joint research, technology transfer and commercialization, and entrepreneurship. It was an opportunity for Daedeok to develop as the innovation cluster.

As a result, Daedeok has developed into an R&D-driven Innovation Cluster with production and marketing capacities, and the sectoral clusters have been developed with the research and development capabilities as a core function of the value chain.

4.2 The Clusters of Specialized Industry: IT & BT Cluster (2002~2012)

There are currently IT Cluster, Bio Cluster, Food Cluster, National Defense Industry Cluster and Cultural Industry Cluster that formed and developed in Daedeok. IT Cluster and Bio Cluster are considered among other clusters representing the

region.

(IT Cluster) Korea Electronics and Telecommunications Research Institute (ETRI) is considered as the starting point of the IT Cluster of Daedeok, and it is no exaggeration that ETRI has led the early IT industry in Daedeok. From the 1980s to the late 1990s, 45% of IT start-ups founded in Daedeok were either based on or spin-off products from the research results of this research institute. The IT industry by these research results experienced a growth surge because of the strategic industry development policy of the local government. Laboratory entrepreneurship, technology commercialization, human resource development and SME support were strengthened by the industry-academia cooperation, which led to an opportunity to further develop into a cluster. In particular, 8 universities and 7 public institutions in the region provided the technology commercialization programs to tenant companies in Daedeok through the IT-oriented business incubators, while supported the research and development and technology commercialization with government policy funds. Golf Zone is the exemplary IT company that has grown on the basis of this support that carried out the government-supported business challenges at KAIST Business Incubator, co-founded the simulator core technology with KAIST Digital Media Lab, and has grown into a company with annual sales of 300 billion won (Figure 1).

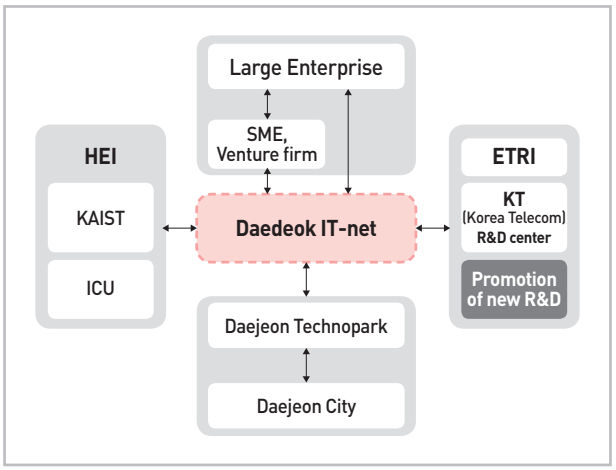

Fig. 1. Structure of IT Cluster

Source: Oh (2014)

These increase in innovation activities, along with the expansion of research and development and education of outstanding human resources, have provided great support for growth of the cluster. As the 8 research-focused universities have conducted joint research with the research institutions and enterprises in the IT technology research and specialized district, in 2010, 2905 IT professionals (1520 Masters, 1108 PhD, 277 combined programs) were trained who now serve as a key power source for the growth of IT cluster. In addition, IT-related communities, such as Daedeok IT Forum, high-frequency industrial research association, information and communication enterprise development, and industrial cooperative complex, promote a close industry-university cooperation.

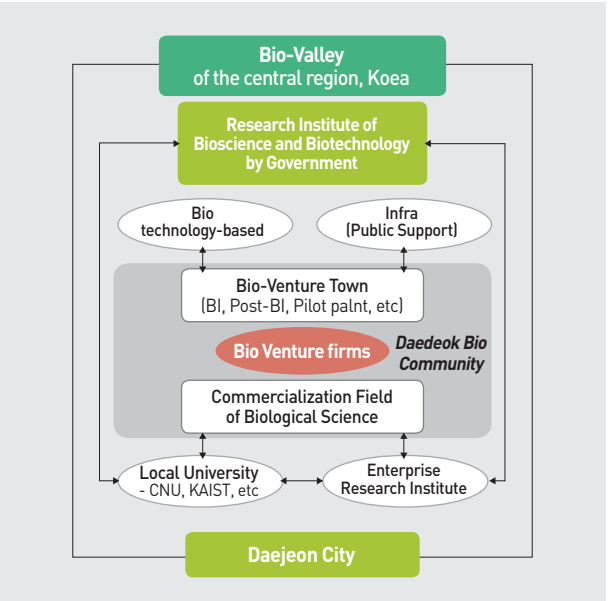

Fig. 2. Structure of Bio Cluster

Source: Oh (2014)

(Bio Cluster) Even in the bio-industry, a cluster formation began through the start-up and spin-off by researchers and research results from the government-funded research and private research institutions, such as Korea Biotechnology Research Institute, Korea Research Institute of Chemical Technology, Korea Institute of Oriental Medicine, and LG Life Sciences. The government policies and the support of the local government for development of the bio-pharmaceutical industry with abundant R&D infrastructure and excellent research results of Daedeok allowed Korea's first bio-industrial cluster to take place.

Daedeok has the infrastructure that is optimal for start-up companies to grow. The infrastructure is capable of executing

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a one-stop process ranging from discovery of new materials, drug manufacturing, drug development device support, and clinical experiment. Daedeok is praised for its optimal conditions for industry development that is established by the technology infrastructure, such as entrepreneurship support, business support, equipment rental, and trial production, which is provided by the Bio Venture Center, a venture incubator facility, supported by the Bio-Venture Town and Biotechnology Institute. In addition, the industry-academia cooperation consisted of 4 regional universities, e.g. Korea Advanced Institute of Science and Technology (KAIST), Chungnam National University, Hannam University, that are equipped with bio-pharmaceutical related research facilities and business incubation facilities, can be considered as one of many success factors.

The aforementioned cooperation encourages life science researchers to meet regularly and form a network through a variety of communities, such as biotechnology research council and Daedeok bio community. According to the data in 2015, the cooperation network resulted in 153 high-tech bio venture companies were founded or attracted, produced 450 billion won annual sales and 255 billion won added value, and induced 3,156 employments.

4.3 The Establishment of the Convergent Cluster: National Defense Software Cluster (2013~)

(Convergent Cluster) In recent years, there is a convergence project to develop a new industrial cluster through the fusion of software technology and strategic industry in the region. A new ecosystem for the national defense software industry is to be established through the convergence of IT and software industry ecosystem with the national defense industry ecosystem in Daedeok. At the same time, the foundation for development of software industry is to be created, which can lead to formation of a foundation for further convergence with other clusters. The growth of software industry is expected through the establishment of industrial ecosystem, which is a product of the convergence of software industries with great ripple effect or growth potential and the national defense industries. At the same time, with possibilities in convergence with machinery, biotechnology, energy, and nanotechnology, the technology convergence in Daedeok will become more active, and the growth of related clusters will receive benefit.

Local government has already established Daejeon Information and Culture Industry Promotion Agency in Daedeok, which provides with the entrepreneurship incubation and business support for development of IT and SW industries in the region. The establishment of the 'D-cube Center', which is a dedicated institution for planning and supporting the development of convergent cluster for the national defense software, will support industry-academia cooperation among National Defense Research Institute, university, and enterprises and strengthen the business support activities, such as incubator, business support, human resources education, and infrastructure support. In addition, the 'D-cube Center' will increase the revenues of the defense industry by supporting the commercialization and technology convergent research of the national defense-related technology, and establish the SW convergence ecosystem by promoting the ICT Top Junior development project (SW convergence Hidden Champion), which produces two-fold of small hidden champions.

The future goals of the 'D-cube Center' are to produce more than 300 start-ups, 8,000 employments, over 300 billion won sales, and 53 companies with 10 billion sales in the National Defense Software industry.

4.4 Evaluation: The Successful Factors for Cluster Development in Daedeok

The clusters formed around Daedeok can be referred to as the advanced 'innovation clusters' because they are founded upon research and development and high-quality human resources, creates related industries through entrepreneurship and technology commercialization, and attracts innovation companies. The 'innovation cluster' is different from the 'industry cluster', which is formed by similar companies and organizations to enhance network and synergistic effect. Clusters of diverse industries can be created in Daedeok because of the continuous supply of innovation resources, e.g. research and development results and excellent workforce in Daedeok, optimal conditions (innovation infrastructure) that can commercialize the innovation resources, and various support policies. These characteristics differentiate Daedeok from the 'industry cluster', which simply creates an industrial cluster in a region.

The success factors for the growth of innovation-based clusters from a variety of industries in Daedeok can be summarized as below.

1) The Creation of a Variety of Innovative Sources became the Foundation of Cluster Development

One of the success factors that served as growth engine was the excellent R&D achievements, technology, idea, and out-

standing human resources produced from the close industry-academia cooperation among 7 research universities, 26 government-funded research institutions, and 44 private research institutes in Daedeok. Moreover, the R&D of Daedeok was a key factor in the formation and growth of clusters because of its role as an important support infrastructure for promoting the recent policies on the development of convergent cluster with software industries.

2) The Close Industry-Academia Cooperation and the Innovation Community

Open innovation can be very important for deriving outstanding achievements from research. Promotion of continuous collaboration from a strong industry-academia cooperation, that consisted of university, companies, and research institutes, can generate excellent research results. Moreover, entrepreneurship can be stimulated and technology transfer and commercialization can be facilitated from the innovative ideas and technology created by educating excellent human resources, Thus, the innovation community built upon the strong industry-academia cooperation among universities, research institutions, and companies plays a key role in the development and growth of related industries. The universities play a central role in the innovation community.

3) The Systematic Support System

Daedeok became the hub of clusters encompassing the surrounding metropolitan areas because of the synergistic effect created by the R&D achievement and research capabilities of excellent human resources in Daedeok with the policies of government. The role of agencies that promote government policies and support is very important in the development of clusters that are created from excellent research achievements and outstanding personnel. These agencies act as an intermediary among universities, research institutes, and enterprises for commercialization of research achievements, and serve as a "platform" for helping growth of companies by incubators, related industries support, and infrastructure support. Daedeok supports innovation through platforms that are managed by universities, government-funded research institutes, private research institutes, and support institutions. In recent years, the foundation of innovation cluster is being strengthened by reinforcing the platform dedicated to the cooperation and support activities for development of new industries created from the convergence of innovative ideas, technology, and industries.

5. SYNTHESIS

Literature search reveals that the relationship between diversification or specialization/clustering is moderated by a number of factors: National or provincial regulation; social capital; history, including crises; presence of education and government; and proximity to a major metropolis.

Daedeok benefited from excellent research institutes and universities. Its government presence is growing, as Korea's central ministries relocate to nearby Sejong City, new administrative capital of Korea. The Innopolis wisely added manufacturing and business support organizations to its mix, after some years without them. Daedeok now aims at multi-cluster convergence, with continued social and business support from government and non-government organizations.

In line with Shearmur and Polése's (2005) statement that "not only the local characteristics determine growth levels," Austin from the beginning of its technopolis initiatives reached out to metropolises in the corridor from Dallas to Monterey, Mexico.

A very small locale (of less than about 1000 in the workforce, according to Callen et al. 2014) will find it impossible or excessively expensive to overcome the entrenched power of its historic single industry. Most such locales, say Callen et al. (2014), fail to diversify their economies. They cannot, in any event, adhere to a strategy in the business sense. Next-level locales, somewhat more wealthy, must heed the moderating factors in order to forge a strategy that is appropriate for their population and geography. They are advised to pursue steady, rather than fast, growth. Still better-endowed regions will achieve critical-mass clusters and pursue critical mass in related clusters.

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