한국경제지리학회지 제27권 제2호 2024(95~119)

Industrial Composition and Spatial Distribution of Entrepreneurial Clusters in Seoul Metropolitan Area*

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서울대도시권 기업가 집적지의 산업구성과 공간분포*

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Abstract: While several recent studies have investigated the spatial distribution of entrepreneurship within the Seoul metropolitan area, they have not thoroughly examined the relationship between the industrial composition and spatial distribution of entrepreneurial clusters. To address this gap, this study initially identified entrepreneurial clusters through hotspot analysis using Getis-Ord Gi* with venture capital investment data from 2021. Subsequently, to analyze the industrial composition of the identified clusters, we measured not only their industrial diversity and specialization, but also the share of software and non-software industries. Additionally, we examined the government policies related to the formation of the clusters. As a result, we identified fourteen prominent entrepreneurial clusters within the Seoul metro area and revealed that the clusters located closer to the city centers exhibited higher levels of industrial diversity and a greater share of software industries. Conversely, clusters situated farther from the city centers demonstrated a higher share of non-software industries. Furthermore, we found that government policies affect the industrial specialization of suburban clusters. Nevertheless, we observed several exceptions that diverged from the general trends due to policy interventions. These findings underscore that formulating policies for entrepreneurial clusters in metropolitan areas should be based on these insights.

Key Words: entrepreneurship, industrial diversity, industrial specialization, software industry, venture capital

요약: 최근 서울대도시권 내 기업가정신의 공간분포에 관한 여러 연구가 있어 왔지만, 기업가 집적지들의 산업구성과 공간 분포 사이의 관계를 면밀히 살펴보지 못했다. 이에 본 연구는 2021년 벤처 캐피털 투자액 자료를 이용해 먼저 핫스팟 분석을 통해 기업가 집적지를 식별하였다. 이어서 집적지의 산업구성을 분석하기 위해 산업 다양성 및 전문화, 소프트웨어 및 비소프트웨어 산업 비중을 측정하였고, 집적지 조성 관련 정책도 검토하였다. 그 결과, 서울대도시권 내 14개의 기업가 집적지를 확인하였고, 도심에 인접한 집적지일수록 산업 다양성과 소프트웨어 산업 비중이 높으며, 정책이 교외 집적지의 산업 전문화에 크게 영향을 미치는 것을 확인하였다. 본 연구는 이러한 이해를 바탕으로 집적지 정책이 수립되어야 함을 시사한다.

주요어: 기업가정신, 산업 다양성, 산업 전문화, 소프트웨어 산업, 벤처 캐피털

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* An earlier version of this paper was submitted to the 62nd European Regional Science Association Congress 2023 in Alicante, Spain.

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https://doi.org/10.23841/egsk.2024.27.2.95

1. Introduction

Entrepreneurship represented by startups has become an essential driving force for innovation-based economies. Schumpeter (1911), who first emphasized entrepreneurship and innovation, believed that economic development is driven by innovation through entrepreneurs (Chung, 2020). Thus, many scholars have examined the geography of entrepreneurship and innovation over the last several decades.

Their common results were that entrepreneurial activities tend to be more concentrated in specific metropolitan areas than activities related to patents as well as traditional manufacturing industries (Acs and Audretsch, 1988, 1990; Chatterji *et al.*, 2014; Feldman and Kogler, 2010; Kerr and Robert-Nicoud, 2020). Furthermore, at the micro-geographic level, such entrepreneurial activities have been found to be agglomerated in particular areas forming clusters within metropolitan areas (Adler *et al.*, 2019; Duvivier *et al.*, 2018). Among such clusters, not only have the city centers of the major metropolitan areas emerged as key locations for entrepreneurial activities, but suburban areas have also continued to attract firms with different demands (Florida, 2014; Hutton, 2004). Meanwhile, some studies have explained the mechanism through which such entrepreneurial clusters were spatially distributed within metropolitan areas through life cycle models and agglomeration externalities (Audretsch and Feldman, 1996; Duranton and Puga, 2001; Neffke *et al.*, 2011).

Along with these, several studies on the geography of entrepreneurship were also conducted in the context of South Korea (Hwang and Kang, 2021; Kwon and Nam, 2022).[1)] They identified the spatial distribution of startup clusters within the Seoul metro area at the micro-geographic level and explained the mechanism. Hwang and Kang (2021) examined the location of manufacturing and service startups through agglomeration externalities, and Kwon and Nam (2022) categorized startup clusters into four types and explained the locational characteristics of the clusters by type. However, there is room for further development of their research to gain a more comprehensive understanding of the spatial distribution of entrepreneurship in the Seoul metropolitan area.

To begin with, since Hwang and Kang (2021) explained the sptial distribution based on specific industries, the explanation was limited to these industries. In addition, although Kwon and Nam (2022) accounted for the spatial distribution through the characteristics of clusters, they merely confirmed the degree of industrial specialization of clusters by type at broad industrial classification level. However, given that industrial diversity as well as specialization are important factors to explain the spatial distribution of clusters, it would be necessary to confirm both industrial features of clusters, and more detailed industrial classification should be applied. Furthermore, the spatial distribution could be also elucidated through not only the share of software and non-software industries within clusters but also government policies for the formation of clusters. Consequently, these supplementary analyses are expected to enhance our understanding of the spatial distribution of entrepreneurial clusters

within the Seoul metro area.

The following section reviews the literature regarding the geography of entrepreneurship, and the third section delineates the data and methods employed for analyses in this study. Subsequently, the fourth section elaborates the findings on the geography of entrepreneurship in the Seoul metro area. Finally, the last section discusses the core issues and concludes with policy implications.

2. The Geography of Entrepreneurship

1) Spatial Concentration and Distribution of Entrepreneurial Activities

The regions where entrepreneurship and innovation are concentrated have several titles, but Kerr and Robert-Nicoud (2020) referred to them as "tech clusters." They defined such clusters as a place where new products, services, and production processes affecting the economy in diverse aspects are created. Looking at several studies that investigated the geographical concentration of entrepreneurship at the inter-metropolitan level (Kerr and Robert-Nicoud, 2020; Adler *et al.*, 2019), they confirmed that the San Francisco metro area overwhelmingly received the most venture capital investments in the United States, followed by New York, Boston, and Los Angeles. They showed that 93.8% of venture capital investments were concentrated in the top 15 metro areas. Adler *et al.* (2019) also investigated the spatial distribution of high-tech startups in Sweden and observed that the Stockholm metro area received most venture capital investments, followed by Malmö/Lund and Gothenburg. As a result, they confirmed that 90.6% of venture capital investments were concentrated in these three metro areas within Sweden. These findings exhibited that entrepreneurship could be highly agglomerated in specific metropolitan areas in some countries.

Then, how does the spatial concentration and dispersion of entrepreneurial activities appear at the intra-metropolitan level? Adler *et al.* (2019) additionally confirmed the spatial distribution of entrepreneurial activities in the United States and Sweden at the micro-geographic level. They found that venture capital was more invested in downtown areas compared to the suburbs within the major metropolitan areas of the United States, such as the Mission District in San Francisco, Cambridge in Boston, and Manhattan in New York. In addition, they observed that more than two third of venture capital invested in Stockholm was concentrated in the postal code near the busiest central business district (CBD) and most of the investments in Lund around the postal code where Lund University and IDEON Science Park were located. These results demonstrated that entrepreneurial activities tend to be agglomerated around city centers or research universities in metro areas.

Meanwhile, regarding this phenomenon that entrepreneurial activities are concentrated in downtown areas within the major metropolitan areas, Hutton (2004) observed the emergence of new economy clusters grounded in technology in the inner cities of metropolitan areas, such as

San Francisco, London, Vancouver, and Singapore, and the rapid expansion of information and communication technologies (ICT) in the 1990s. He investigated these new economy clusters and anticipated that these clusters would play pivotal roles in the change of cities and the urban space economy in the 21st century. Furthermore, he saw the advent of technology-based industries in the center of metropolitan areas as a part of the long-term restructuring of declining manufacturing industries and the development of the new economy. Thus, he noted that the growth of creative and technology-based industries in the inner cities constitutes an essential aspect of the spatial characteristics of the new economy. This notion implied that the new economy clusters in the inner cities were formed through interaction among ICT, culture, and a sense of place embodied by the innovative milieu, representing the density of social networking, the variety of actors, and opportunities for interaction. Examining the spatial distribution of venture capital investments and startups, Florida (2014) also confirmed that high-tech startup activities in the United States moved from the suburbs to the inner cities. He attributed this trend to three factors: first, startups are efficient in dense cities; second, as the center of information technology (IT) industries has shifted from hardware to software, they no longer require a large footprint; and third, a dense labor market and social networking are essential.

This phenomenon of the agglomeration of entrepreneurial activities in dense downtown areas might reflect the mega-trend of changing location preferences for talents and innovative firms. In these inner cities, knowledge spillovers occur in proximity, and the fusion of knowledge from diverse industrial sectors arises (Katz and Wagner, 2014). Firms located in the inner cities aim for "open innovation" where boundaries with surrounding environments become porous and innovation can be easily diffused (Chesbrough, 2003). However, it is also important to recognize that this phenomenon is not common for all metropolitan areas. Kotkin (2014) verified that only six metropolitan areas – San Francisco, Boston, New York, Washington, D.C., Chicago, and Philadelphia – out of 51 metropolitan areas in the United States primarily experienced the growth of population in downtown areas from 2000 to 2010.

Then, would entrepreneurial activities disappear in the outskirts or suburbs within the major metropolitan areas? Florida (2014) believed that entrepreneurial activities will not disappear in suburban areas. Instead, he argued that a new spatial division of labor would emerge, in which small-scale startups would be nurtured in the inner cities and existing companies requiring a large footprint remain in suburban areas. Relatedly, Duvivier *et al.* (2018) investigated the spatial distribution of IT-related new economy employment and its determinants in the three largest metro areas in Canada: Toronto, Vancouver, and Montreal. As a result, they exhibited that IT-related employment was spatially polarized in the inner cities with a high proportion and suburban areas along major transportation corridors in all three metro areas. Specifically, creative industries representing the creative

milieu were highly concentrated in the inner cities, whereas employment in computer manufacturing was mainly located in the suburbs. Therefore, it could be conjectured that suburban areas also remain important with different demands.

Meanwhile, in the context of South Korea, several studies investigated the geographical distribution of entrepreneurial activities within the Seoul metro area. Hwang and Kang (2021) confirmed that venture capital-backed manufacturing and service startups were mainly agglomerated in major business districts and several industrial areas in Seoul. Kwon and Nam (2022) also identified 24 startup clusters within the Seoul metro area at the census tract level. They confirmed that some of them were located in the center of Seoul, whereas the others were placed in the suburbs.

2) Mechanism for the Spatial Distribution of Entrepreneurial Clusters

If so, through which mechanism are entrepreneurial clusters spatially distributed, showing the division of labor in metropolitan areas? Just as several studies briefly mentioned above, while small-scale early-stage or software-related firms tend to be primarily located in the center of cities, mature or manufacturing firms requiring a large footprint are inclined to move to the suburbs (Duvivier *et al.*, 2018; Florida, 2014; Hutton, 2004).

Looking at it more specifically, there are several additional studies that examined the mechanism through life cycle models and agglomeration externalities.[2] To begin with, Duranton and Puga (2001) explained the spatial division of labor in entrepreneurial activities with their "nursery city" model, suggesting that diversified and specialized clusters coexist in the same metro area. They noted that early-stage firms tend to agglomerate in the center of cities and enjoy great benefits from the urban environments involved in industrial diversity. Meanwhile, as products and services mature, firms tend to cluster in suburban areas and gain further advantages through specialization in specific industries.

Audretsch and Feldman (1996) demonstrated that innovative activities tend to spatially cluster along the industry life cycle, using the United States commercial innovation data in manufacturing industries. They observed that during the early stages of the life cycle, there is a strong tendency for innovative activities to cluster due to the crucial role of tacit knowledge. However, they found that as products become highly standardized, innovative activities tend to be dispersed within the same region during the mature stage of their life cycle.

Neffke *et al.* (2011) also investigated the dynamic characteristics of agglomeration externalities according to the industry life cycle with the data of Swedish manufacturing plants. As a result, they exhibited that industries in the initial stage tend to be situated in high-cost and high-diversity environments, whereas mature industries prefer low-cost and specialized locations. It is because industries in their early stages benefit from knowledge diffusion from diverse sources, which is the evidence of Jacobs externalities. On the contrary, mature industries have advantages from knowledge spillovers among related

industries, which is the proof of Marshall–Arrow–Romer (MAR) externalities. Consequently, they posited that industries need different kinds of agglomeration externalities in different phases of their life cycle.

Meanwhile, the extent of agglomeration of software or non–software industries in entrepreneurial clusters can be another criterion to understand the mechanism for the spatial distribution of clusters. In the United States, since the 1990s the software industries within the ICT sector have experienced rapid growth, particularly in major tech centers such as San Francisco, Boston, Seattle, San Diego, Denver, and Austin (Chattergoon and Kerr, 2022). Through this evidence, it can be conjectured that the rapid growth of software industries has caused the changes in the inner cities of tech centers. As software industries generally do not require a large footprint, they are likely to be located in the center of cities (Florida, 2014). By contrast, since non–software industries including manufacturing need ample space for production, they tend to be placed in the suburbs of metropolitan areas (Duvivier *et al.*, 2018).

In this context, several studies have also explained the mechanism for South Korea. Hwang and Kang (2021) examined the agglomeration externalities for manufacturing and service startups depending on the growth stage of startups. As a result, they observed that the location of startups was greatly influenced by MAR externalities, especially for manufacturing industry, and MAR externalities became stronger as manufacturing firms mature. In contrast, Jacobs externalities were not significant for both industries. Meanwhile, Kwon and Nam (2022) confirmed the locational characteristics of startup cluster types in the Seoul metro area. They categorized the identified 24 startup clusters into four types based on the components of clusters and startup features. Furthermore, they investigated the locational characteristics of clusters by type, such as industrial specialization through location quotient (LQ). Consequently, they showed that some cluster types tended to be located in the inner cities, normally attracting early–stage startups. On the other hand, other types of clusters were situated on the boundaries of Seoul or in its suburbs, occupied by mature stage and manufacturing firms.

However, there is room to supplement these studies for a more comprehensive understanding on the spatial distribution of entrepreneurial clusters in the Seoul metro area. To begin with, Hwang and Kang (2021) confirmed the spatial distribution of manufacturing and service startups and examined the agglomeration externalities determining their locations. However, since this method was based on specific industries, manufacturing and service, the explanation was limited to these selected industries. In addition, focusing on the clusters, Kwon and Nam (2022) confirmed the components and industrial composition of clusters. However, when they confirmed the industrial composition, they only quantified the degree of industrial specialization of the clusters at Korean Standard Industrial Classification (KSIC)–1 digit level. Considering that the spatial distribution of startup clusters within metro areas are influenced by industrial

diversity as well as specialization, it would be necessary to measure these two factors simultaneously. Moreover, since KSIC-1 digit level is too broad to look into sub-industries, a more detailed industrial classification system would be necessary to be applied. On top of that, this study aims to explore the share of software and non-software industries of entrepreneurial clusters to explain the spatial distribution of clusters in another aspect. Along with this, we will refer to government policies implemented to form clusters. Consequently, these supplementary analyses focused on the industrial composition of clusters are expected to explain more plainly the spatial distribution of entrepreneurial clusters in the Seoul metropolitan area.

3. Data and Methods

1) Data

This study mainly used venture capital data to investigate the spatial distribution of entrepreneurial activities within the Seoul metro area. Venture capital is funding for businesses developing and commercializing technological innovations and ideas (Bollinger *et al.*, 1983). The role of venture capital is to supply funds for the initial growth of startups that have difficulties raising funds through lending institutions or stock markets. Doing so can foster the development of new industries, spreading innovation and contributing to economic growth (Bygrave *et al.*, 2001; Pratt, 1987). Thus, utilizing venture capital data enables us to measure entrepreneurial activities, reflecting the concept of Schumpeterian entrepreneurship. With these data, we can focus on firms with high-growth potential in cutting-edge industries such as artificial intelligence, robotics, and biotechnology (Adler *et al.*, 2019).

Meanwhile, Schumpeter defined entrepreneurship as a capacity to reform the way of production through new technological possibilities for new commodities and processes (Schumpeter, 1942: 132). This can be seen as a process of recognizing and utilizing the entrepreneurial opportunities (Shane and Venkataraman, 2000). This study intends to borrow this definition. The concept of entrepreneurship generally emphasizes the activities creating "novelty" and encompasses all things related to innovation, not restricted to merely startups or entrepreneurs (Koo, 2022). Several studies have defined entrepreneurship as formation of a firm and made startups the main subjects of research (Kim *et al.*, 2017). However, there exists criticism that newly established firms are only a part of entrepreneurship (Shane, 2012).

To date, venture capital data have been commonly utilized in economics and management studies to understand the attributes of high-tech industries (Lerner, 1995; Mason, 2007). In contrast, most previous studies in the geography of innovation and entrepreneurship have primarily relied on data such as patents, R&D funding, and newly established firms (Adler *et al.*, 2019). Only a few geographical studies have used venture capital data, but studies utilizing venture capital data have been increased in

recent years (Adler *et al.*, 2019; Hwang and Kang, 2021; Kerr and Robert-Nicoud, 2020; Kwon and Nam, 2022). Venture capital investment data are limited in that they merely represent the inputs of entrepreneurial activities and do not guarantee concrete output. Nevertheless, such data can contribute to the literature concerning the geography of entrepreneurship by reflecting the dynamic characteristics of entrepreneurship, such as opportunity perception and risk orientation (Capello and Lenzi 2016; Glaeser and Kerr 2009).

Thus, this study used "The VC Korean Startup Investment Database" to gain venture capital data invested in South Korea (The VC, n.d.). The database provides detailed information on the name of firm, the amount of investment, the stage of investment, the address of firm, the industrial sector of investment, the type of business, and the type of product and service, which were all collected to construct a dataset for analyses. As the database prevents individuals from downloading data, we collected them one by one. Regarding the industrial sector of investment, we followed the classification of The VC database[3] instead of the KSIC. Moreover, the amount of investment was filtered based on approximately 0.9 million United States dollar (USD) (one billion Korean won, as of 2021), ranging from pre-A to series A~G, pre-IPO, and post-IPO stages. We excluded the seed stage, government grants, and investment cases below approximately 0.9 million USD because these stages are still in states where ideas have not been validated in the market and have not yet passed through the so-called "death valley."[4] This study investigates the spatial distribution of proven entrepreneurial capabilities; thus, the analyses were conducted only for investment cases whose market viabilities had been verified. Through this process, we could filter out 45.5% of venture capital investment cases carried out in 2021 in South Korea. Considering that only 39.7% of venture capital-backed firms failed in the United States from 1981 to 2005 (Puri and Zarutske, 2012), this filtering could be reasonable. Meanwhile, target investment firms included not only startups within seven years since establishment, but also small and medium-sized and subsidiary firms invested by conglomerates that had been in operation for more than seven years. The subject of research was not limited to startups alone because entrepreneurship is not determined by the age of firms. Based on these criteria, venture capital data invested in South Korea in 2021 (when venture capital was invested the most) were collected. The dataset was constructed with 955 investment cases for 871 firms.

In addition to this, the spatial data for boundary shapefiles at the census output area (jipgyegu)[5] level (based on 2021) were obtained from the Statistical Geographic Information Service of Statistics Korea to confirm the geographical distribution of entrepreneurship within the Seoul metro area. The lease price data for office space were collected from the RealtyPlanet Office Lease Price Database (RealtyPlanet Office, n.d.).

Meanwhile, to compare the degree of concentration of venture capital investments by municipality (si-gun-gu) across South Korea, we also utilized granted patents data from

Intellectual Property Rights Statistics of the Korean Intellectual Property Office for 2021 and employment data from the Economic Census of Statistics Korea for 2020 (Table 1). The result showed that venture capital investments were highly concentrated in specific municipality, compared to granted patents and total employment. Especially, Gangnam-gu was the most concentrated municipality for entrepreneurial activities and followed by Seongnam-si. The top 15 out of 229 municipalities accounted for 88.5% of venture capital investments and the Seoul metro area for 91.3%.

2) Confirming the Geographical Concentration and Distribution of Entrepreneurial Activities

In this study, we first identified the geographical concentration and distribution of entrepreneurial activities at the micro-geographic level of census output area (jipgyegu), limiting the spatial scope to the Seoul metro area. For this analysis, we used venture capital data of 806 investment cases in 2021 for 728 firms located within the Seoul metro area. As for the method, we conducted the hotspot analysis based on venture capital-backed firms using the Getis- Ord Gi* statistics with

Table 1. Leading municipalities for entrepreneurial activities in South Korea

City/District (Si-Gu)	Region (Si-Do)	Venture capital investment	Granted patents	Total employment
Gangnam-gu	Seoul-si	46.1%	3.3%	3.4%
Seongnam-si	Gyeonggi-do	11.6%	4.1%	2.1%
Seocho-gu	Seoul-si	5.1%	2.6%	2.0%
Yongsan-gu	Seoul-si	4.3%	0.8%	0.6%
Jongno-gu	Seoul-si	4.1%	1.4%	1.1%
Songpa-gu	Seoul-si	3.0%	1.4%	1.7%
Yuseong-gu	Daejeon-si	2.6%	4.7%	0.8%
Yeongdeungpo-gu	Seoul-si	2.4%	6.5%	1.8%
Mapo-gu	Seoul-si	2.0%	0.8%	1.1%
Seongdong-gu	Seoul-si	1.8%	1.0%	0.8%
Suwon-si	Gyeonggi-do	1.5%	6.7%	1.9%
Guro-gu	Seoul-si	1.4%	0.8%	1.0%
Geumcheon-gu	Seoul-si	1.1%	1.1%	1.1%
Daedeok-gu	Daejeon-si	0.8%	0.6%	0.4%
Dongjak-gu	Seoul-si	0.7%	0.5%	0.4%
Top 15 districts/cities		88.5%	36.3%	20.2%
City of Seoul		75.0%	28.8%	23.7%
Seoul Metro Area		91.3%	63.7%	52.2%
Non-Seoul Metro Area		8.7%	36.3%	47.8%

Notes: This table lists the top 15 cities and districts based on the amount of venture capital investments in descending order.
Source: The VC (2021); Korean Intellectual Property Office (2021); Statistics Korea (2020).

the ArcGIS Pro 2.9 program. For hotspot analysis, we used the Fixed distance band method.

Meanwhile, a spatial weights matrix, conceptualizing spatial relationships, should be set up before analyzing the spatial clustering patterns. Specifically, the distance where entrepreneurial activities affect each other, the radius where knowledge spillovers occur, needs to be defined. Arzaghi and Henderson (2008) found that the spatial range of knowledge diffusion among advertising agencies in Manhattan, New York, extends to a maximum of 500~750m. In this study, referring to their findings, we analyzed the optimal distance at which the spatial autocorrelation value was maximized. As a result, we observed that the z-score is maximized at the 650m point (Figure 1). Thus, we selected 650m as the optimal distance for knowledge spillovers. With this chosen distance, we generated a spatial weights matrix.

Finally, we conducted the hotspot analysis with the generated spatial weights matrix. The Getis-Ord Gi* analysis provides the values of Gi* (z-score) and significance level (p-value). The intensity of clustering is determined using

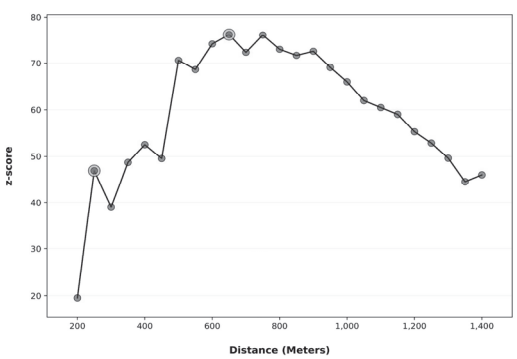


Figure 1. Spatial autocorrelation by distance

Notes: The Euclidean distance method and row standardization were applied.

z-scores based on the significance level. Thus, we set the significance level at 90% and extracted the z-scores. Consequently, we identified the spatial distribution of entrepreneurial clusters within the Seoul metro area using these values through GIS program. To divide the data values into classes for visualization, the natural breaks method was used. Furthermore, we arranged the characteristics of the clusters, including the number of venture capital-financed firms, the amount of venture capital investments, the average lease price for office space, and the average years of operation of firms within the clusters.

3) Analyzing the Industrial Composition of Entrepreneurial Clusters

Subsequently, we investigated the industrial composition of the entrepreneurial clusters identified above to better understand the spatial distribution of the clusters. To begin with, we measured the industrial diversity and specialization indices of the entrepreneurial clusters to reveal whether such clusters are diversified with various industrial sectors or specialized in specific industries. In measuring these indices, we utilized the boundaries of the clusters generated through hotspot analysis instead of administrative boundaries that could arbitrarily separate the clusters.

Looking into the methods used to derive these indices individually, first, we utilized the inverse Herfindahl-Hirschman Index (HHI) to measure the diversity index (Chea and Shin, 2015). As the HHI values decrease when diversity increases, we used the values of the reciprocal of HHI for

a more intuitive interpretation. The equation for calculating the inverse HHI is as follows:

$$Inverse\ HHI = \frac{1}{\sum_{j=1}^{n}\left(\frac{F_{ij}}{F_i}\right)^2}, \quad (1)$$

where F represents the number of firms financed by venture capital, i is a cluster, j represents an industrial sector, and n denotes the total count of industrial sectors. The range of this index is from 1 to ∞. The higher the value of the index, the greater the diversity.

Second, we measured the specialization index through the number of firms financed by venture capital in a particular industrial sector. The specialization of industry has been primarily quantified through LQ in many literature (Beaudry and Schiffauerova, 2009: 322). However, since LQ measures the relative concentration of a specific industry in a region compared to the overall region, care is needed when interpreting the results. On the other hand, the number of firms can be a good index for measuring localization externalities (Beaudry and Schiffauerova, 2009: 322; Neffke *et al.*, 2011: 57) as it explains the firm- external economies of scale (Henderson, 2003). Thus, we calculated the specialization index through the Number-of-Firms Index (NFI), which is derived as follows:

$$NFI = \max_{j \in J} F_{ij}, \quad (2)$$

where F represents the number of firms financed by venture capital, i is a cluster, j represents an industrial sector, and J denotes the entire industrial sector. The range of this index is from 1 to ∞. The higher the value of the index, the greater the specialization. However, since this index does not provide any information regarding the share of the industrial sector within a cluster, it is difficult to compare the relative sizes of the indices between clusters. Therefore, we also measured the shares of the industrial sectors at the same time.

Next, we confirmed the share of software and non-software industries by investigating the types of products or services of each firm located within the entrepreneurial clusters. If the types of products or services are intangible mobile apps, websites, API or contents, we classified them into software industries. In contrast, if those are tangible materials, products, hardware or spaces, we classified them into non-software industries. Through this process, we measured the share of software and non-software industries of each cluster.

Furthermore, to understand the spatial distribution of entrepreneurial clusters more thoroughly, it would be beneficial to confirm the government policies implemented to form the clusters. Accordingly, we investigated government policies related to the formation of the clusters identified above.

4. The Geography of Entrepreneurship in Seoul Metropolitan Area

1) Spatial Concentration and Distribution of Entrepreneurial Activities

To understand the geography of entrepreneurship in the Seoul metropolitan area, we start with our

findings regarding the spatial concentration and distribution of entrepreneurial activities at the micro-geographic level of census output areas. We identified 14 major entrepreneurial clusters within the Seoul metro area through hotspot analysis (Figure 2). A high z-score represents a strong clustering intensity of venture capital-backed firms. We confirmed the spatial range and agglomeration intensity of the clusters through this analysis. Among the 14 clusters, (1) Teheran Valley, (2) Pangyo Techno Valley, (5) Yeouido Financial District, and (8) Munjeong Business Valley showed the highest density of firms financed by venture capital. Furthermore, we measured the scale of the 14 entrepreneurial clusters through the number of venture capital-backed firms located within the clusters and the amount of venture capital funding. In addition,

Figure 2. Spatial distribution of entrepreneurial clusters in the Seoul metropolitan area

Notes: The names of clusters according to the numbers are as follows: (1) Teheran Valley, (2) Pangyo Techno Valley, (3) Seongsu Valley, (4) G-Valley, (5) Yeouido Financial District, (6) Honghap Valley, (7) Central Business District, (8) Munjeong Business Valley, (9) Gwanak S-Valley, (10) Gwanggyo Techno Valley, (11) Digital Media City, (12) Songdo International City, (13) Seongnam High-tech Valley, and (14) M-Valley.

we compiled the average years of operation of firms within the clusters and average lease prices for office space within the clusters (Table 2).

As expected, (1) Teheran Valley, which spans Gangnam-gu and Seocho-gu of Seoul, was the largest entrepreneurial cluster in the Seoul metro area, accounting for 37.7% of venture capital-financed firms and 54.4% of venture capital investments. Teheran Valley, one of the three city centers[6] in Seoul, has been well known as the busiest business district in Seoul since IT firms started to gather in the late 1990s. Following that, (2) Pangyo Techno Valley (TV) in Seongnam-si was the second largest entrepreneurial cluster in the suburbs of Seoul. Many leading South Korean scaled-up IT companies have been headquartered in this cluster.

In addition, several medium-sized clusters of various types were observed in Seoul. One type was clusters located in former industrial areas such as (3) Seongsu Valley in Seongdong-gu and (4) G-Valley (Seoul Digital Industry Complex) in Guro-gu and Geumcheon-gu. Seongsu Valley, one of the twelve local centers in Seoul, has been transformed into trendy spaces sought after by the youth and startups since around 2011. Meanwhile, G-Valley, one of the seven subcenters in Seoul, has evolved into advanced industrial parks since the 2000s by the government.

Another type was clusters formed in city

Table 2. Leading entrepreneurial clusters in the Seoul metropolitan area

	Cluster	Number of Firms		Venture Capital Investment (Mn. won)		Avg. Years of Operation	Avg. Lease Price (won/m^2)
1	Teheran Valley	274	(37.7%)	90,577	(54.4%)	5.3	25,253
2	Pangyo TV	47	(6.5%)	17,222	(10.3%)	4.5	22,807
3	Seongsu Valley	37	(5.1%)	2,770	(1.7%)	5.3	16,903
4	G-Valley	36	(5.0%)	3,419	(2.1%)	6.5	12,637
5	Yeouido FD	30	(4.1%)	3,622	(2.2%)	5.2	19,695
6	Honghap Valley	26	(3.6%)	1,786	(1.1%)	4.6	21,246
7	CBD	24	(3.3%)	7,069	(4.2%)	5.4	25,706
8	Munjeong BV	21	(2.9%)	4,194	(2.5%)	6.2	14,709
9	Gwanak S-Valley	14	(1.9%)	1,063	(0.6%)	3.8	14,223
10	Gwanggyo TV	11	(1.5%)	1,067	(0.6%)	3.9	8,485
11	DMC	10	(1.4%)	1,008	(0.6%)	7.3	12,046
12	Songdo IC	10	(1.4%)	850	(0.5%)	6.3	17,656
13	Seongnam HV	9	(1.2%)	1,700	(1.0%)	8.7	7,033
14	M-Valley	7	(1.0%)	653	(0.4%)	3.3	13,265
	The Rest	171	(23.5%)	29,519	(17.7%)		
	Mean					5.5	16,548
	Sum	727	(100.0%)	166,517	(100.0%)		

Notes: This table lists the entrepreneurial clusters based on the number of firms in descending order. The number of firms and the amount of venture capital investments are summed up for firms located within clusters, as shown in Figure 2. The average years of operation are as of 2021, and the average lease prices are as of June 2024. Source: The VC; RealtyPlanet Office.

centers, like (5) Yeouido Financial District (FD) in Yeongdeungpo-gu and (7) CBD around Jongno-gu and Jung-gu. Yeouido FD has been specialized in the finance sector since the mid-1990s. Meanwhile, CBD houses many headquarters of leading South Korean conglomerates as well as public institutions.

The other type was newly emerging clusters such as (6) Honghap (Hongdae and Hapjeong) Valley in Mapo-gu and (8) Munjeong Business Valley (BV) in Songpa-gu. Honghap Valley, one of the local centers in Seoul, is located in a downtown area famous for its trendy and hip culture. In contrast, Munjeong BV, as a local center, is a newly developed business district by the government in the vicinity of Teheran Valley with relatively affordable lease prices.

Furthermore, multiple small-sized and newly formed entrepreneurial clusters were also found near the boundaries of Seoul or in its suburbs. First, the clusters placed near the boundaries were (9) Gwanak S-Valley (SV) in Gwanak-gu, (11) Digital Media City (DMC) in Mapo-gu, and (14) M-Valley in Gangseo-gu. Gwanak SV, as a local center, is located around Seoul National University, one of the prestigious universities in South Korea. DMC, one of the seven subcenters, is a cluster where major broadcasting stations have been headquartered since around 2013. As another subcenter of Seoul, M-Valley is home to many R&D centers of major South Korean companies.

Next, the clusters positioned in the suburbs of Seoul were (10) Gwanggyo Techno Valley (TV) and (13) Seongnam High-tech Valley (HV) in Suwon-si alongside (12) Songdo International City (IC) in Incheon Metropolitan City. Gwanggyo TV is a cluster specialized in Nano technology (NT) and bio technology (BT). Songdo IC is well known as a biotech-specialized cluster. Lastly, Seongnam HV has been the first general industrial complex of South Korea nearby Seoul.

Meanwhile, when comparing the average years of operation of firms and average lease prices for office space within identified entrepreneurial clusters, we could discern several characteristics of these clusters. First, the clusters whose average years of operation were below the mean, such as (2) Pangyo TV, (6) Honghap Valley, (9) Gwanak SV, (10) Gwanggyo TV, and (14) M-Valley, were agglomerated with early startups. These clusters are conjectured to not be largely affected by lease prices, as they have been home to several incubators and accelerators. Second, the clusters whose average years of operation were similar to the mean, such as (1) Teheran Valley, (3) Seongsu Valley, (5) Yeouido FD, (7) CBD, were mostly placed in the city centers. Despite high lease prices, firms in the growth stage within these clusters are expected to be agglomerated in city centers to benefit from the innovative milieu. Third, the clusters whose average years of operation were above the mean, such as (4) G-Valley, (8) Munjeong BV, (11) DMC, (12) Songdo IC, and (13) Seongnam HV, were primarily located near the border of Seoul or in its suburbs. These clusters were characterized by ample office space and affordable lease prices compared to city centers. Through these results, we could confirm that firms tend to relocate from city centers to the edge or suburbs as they grow.

2) Industrial Composition of Entrepreneurial Clusters

Referring to the previous findings, we subsequently study the industrial composition of the entrepreneurial clusters to understand the spatial distribution of the clusters within the Seoul metro area. To begin with, we derived the industrial diversity and specialization indices of the 14 entrepreneurial clusters and utilized these indices to determine whether each cluster is diversified across multiple industries or specialized in particular ones (Table 3). According to the results, (1) Teheran Valley exhibited the highest diversity index (16.7), followed by (3) Seongsu Valley (13.0), which is adjacent to Teheran Valley. Regarding the specialization index, according to the NFI index, (1) Teheran Valley exhibited the highest specialization index in the bio/medical sector (37). However, this index has a limitation in that it does not consider the share of the specialized industrial sectors in each cluster. While Teheran Valley has the highest NFI index in the bio/medical sector, its share is only 13.5%. Therefore, it would be difficult to say that Teheran Valley is specialized in the bio/medical sector. Accordingly, to accurately confirm the specialization index of entrepreneurial clusters, it is necessary to consider the share of the specialized industrial sector identified through NFI index. Consequently, based on the share index, (10) Gwanggyo TV showed the highest specialization index in the bio/medical sector (72.7, NFI: 8), followed by (8) Munjeong BV in the bio/medical sector (61.9, NFI: 13) and (5) Yeouido FD in the finance sector (60.0, NFI: 18).

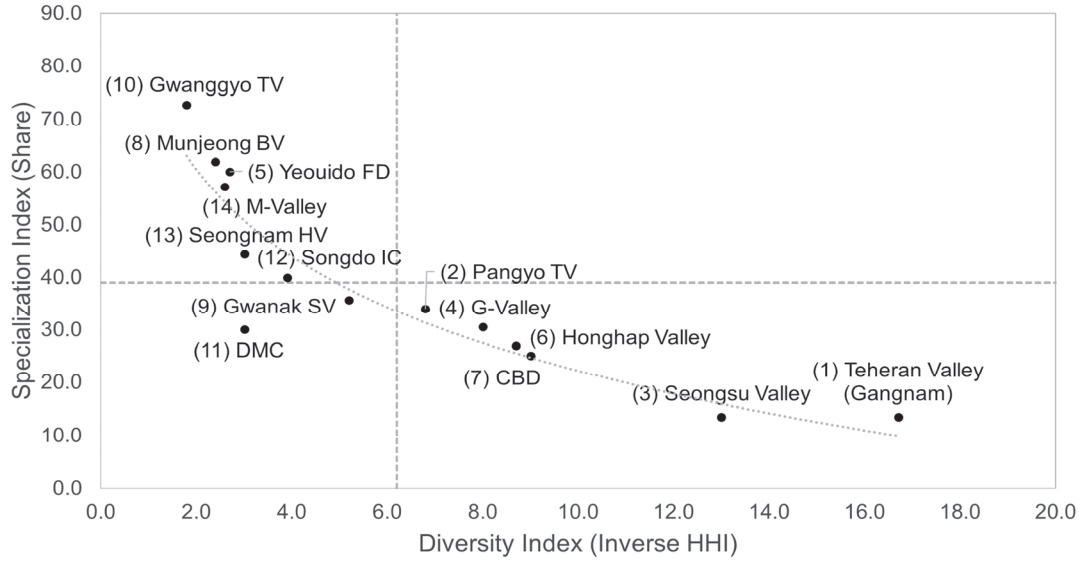
Table 3. Industrial composition of entrepreneurial clusters

Cluster		Diversity Index	Specialization Index			Software		Non-software	
		Inverse HHI	NFI	Share	Sector	Number of Firms (Share)			
1	Teheran Valley	16.7	37	13.5%	Bio/Medical	224	(82%)	50	(18%)
2	Pangyo TV	6.8	16	34.0%	Bio/Medical	25	(53%)	22	(47%)
3	Seongsu Valley	13.0	5	13.5%	Enterprise	27	(73%)	10	(27%)
4	G-Valley	8.0	11	30.6%	Bio/Medical	19	(53%)	17	(47%)
5	Yeouido FD	2.7	18	60.0%	Finance	29	(97%)	1	(3%)
6	Honghap Valley	8.7	7	26.9%	Contents	19	(73%)	7	(27%)
7	CBD	9.0	6	25.0%	Travel	22	(92%)	2	(8%)
8	Munjeong BV	2.4	13	61.9%	Bio/Medical	4	(19%)	17	(81%)
9	Gwanak SV	5.2	5	35.7%	Bio/Medical	10	(71%)	4	(29%)
10	Gwanggyo TV	1.8	8	72.7%	Bio/Medical	1	(9%)	10	(91%)
11	DMC	3.0	3	30.0%	Contents	7	(70%)	3	(30%)
12	Songdo IC	3.9	4	40.0%	Bio/Medical	3	(30%)	7	(70%)
13	Seongnam HV	3.0	4	44.4%	Food	2	(22%)	7	(78%)
14	M-Valley	2.6	4	57.1%	Bio/Medical	3	(43%)	4	(57%)
	Mean	6.2	10.1	39.0%					

Notes: The specialized industrial sector is selected for the sector with the highest NFI index in each cluster. Source: The VC.

Furthermore, we confirmed the relationship between diversity and specialization indices of 14 entrepreneurial clusters through a scatter plot (Figure 3). The results revealed an inverse relationship between the two indices. It is natural for a cluster to exhibit low industrial specialization when there is high industrial diversity, and vice versa. Subsequently, we categorized the clusters into two main types using the mean values of the two indices. The first type was "diversified clusters," such as (1) Teheran Valley, (3) Seongsu Valley, (7) CBD, (6) Honghap Valley, (4) G-Valley, and (2) Pangyo TV (the fourth quadrant). This type consisted of clusters where diversity indices were above the mean, but specialization indices below the mean. These clusters showed the tendency to be located in the center of Seoul. Meanwhile, the second type was "specialized clusters," such as (10) Gwanggyo TV, (8) Munjeong BV, (5) Yeouido FD, (14) M-Valley, (13) Seongnam HV, and (12) Songdo IC (the second quadrant). This type was composed of the clusters where their specialization indices were above the mean, but diversity indices below the mean. These clusters, except (5) Yeouido FD, were mostly situated near the boundaries of Seoul or in its suburbs, and specialized in bio/medical or food sectors.

Next, we confirmed the industrial composition of the entrepreneurial clusters by classifying firms within the clusters into software and non-software industries (Table 3). We visualized the share relationship between software and non-software industries through a graph, and grouped the clusters with similar shares of software industries into four categories (Figure 4). In descending order based on the share of software industries, the first group of clusters, with an 80-100% share of software industries, was located in the three city centers of Seoul: (5) Yeouido FD, (7) CBD, and (1) Teheran Valley.



Notes: The vertical and horizontal dotted lines represent the mean values of clusters.

Figure 3. Categorization of entrepreneurial clusters by diversity and specialization indices

These clusters exhibited the highest average lease prices for office space. The second group of clusters, where software industries occupied 60-80% of the share, was primarily placed in local centers near city centers of Seoul: (3) Seongsu Valley, (6) Honghap Valley, (9) Gwanak S-Valley, and (11) DMC. These clusters are also well-known for their cultural amenities. The third group of clusters, with a 40-60% share of software industries, was situated in subcenters on the border of Seoul or in its suburbs: (2) Pangyo TV, (4) G-Valley, and (14) M-Valley. These clusters are characterized by knowledge industry centers constructed to attract manufacturing, knowledge, and IT industries. Lastly, the fourth group of clusters, where the share of software industries was below 40%, was mainly located in the suburbs of Seoul: (12) Songdo IC, (13) Seongnam HV, and (10) Gwanggyo TV, except (8) Munjeong BV. These clusters were mostly specialized in the bio/ medical sector. Through these results, we could observe that the clusters closer to the city centers tend to have a higher share of software industries.

Meanwhile, we also found several spatial characteristics of software and non-software industries by industrial sector (Table 4). First, firms in software-oriented industrial sectors, such as contents, finance, enterprise, and education, tend to be located in the center of Seoul, especially Teheran Valley. The contents sector is a typical example of this type of industrial sectors. Second, firms in non-software-oriented industrial sectors such as bio/medical showed the tendency to be placed on the boundaries of Seoul or in its suburbs. However, we also observed that software firms in this sector were strongly agglomerated in Teheran Valley. This confirmed that while the bio/medical sector primarily consists of non-software firms located outer Seoul, its

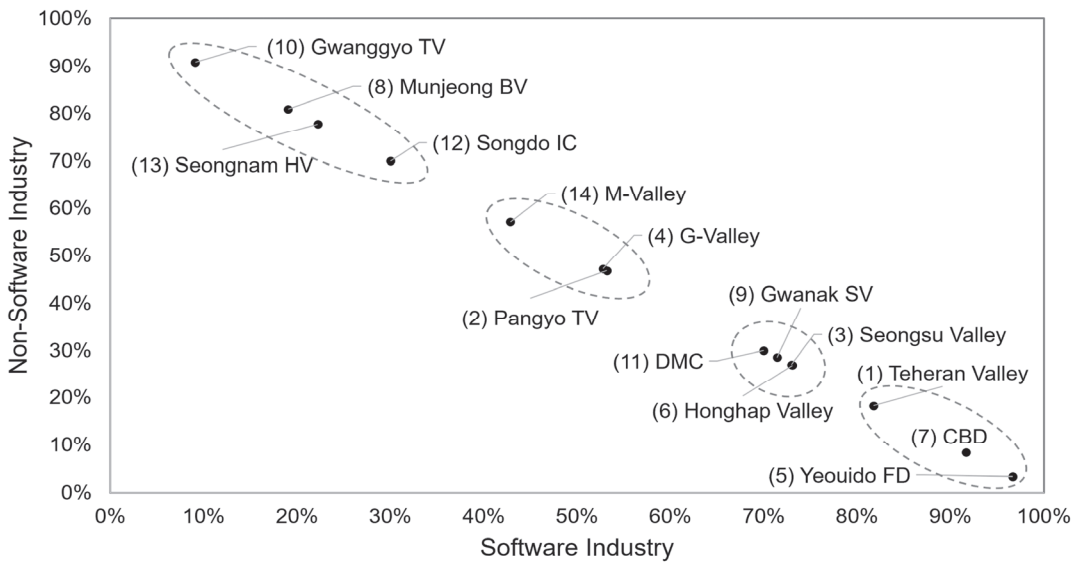


Figure 4. Share of software and non-software industries of entrepreneurial clusters

Table 4. Characteristics of software and non-software industries by sector

Industrial Sector / Cluster		Software-oriented		Hybrid-oriented		Non-software-oriented	
		Contents		Food		Bio/medical	
		Software	Non-software	Software	Non-software	Software	Non-software
1	Teheran Valley	26	0	10	6	20	17
2	Pangyo TV	3	0	2	0	0	16
3	Seongsu Valley	3	1	2	1	0	4
4	G-Valley	3	0	1	1	3	8
5	Yeouido FD	2	0	0	1	1	0
6	Honghap Valley	6	1	0	2	0	0
7	CBD	0	0	0	0	0	1
8	Munjeong BV	0	0	1	0	0	13
9	Gwanak SV	1	0	0	0	1	4
10	Gwanggyo TV	0	0	0	1	1	7
11	DMC	3	0	0	0	1	1
12	Songdo IC	0	0	0	0	1	3
13	Seongnam HV	0	0	2	2	0	3
14	M-Valley	1	0	0	0	0	4
	Sum	48	2	18	14	28	81

Notes: The numbers in this table denote the number of firms.

software firms can be situated in the city center. Lastly, firms in hybrid-oriented (both software and non-software) industrial sectors, such as food and motor vehicle, tend to be placed in both city center and suburbs of Seoul, regardless of whether they were software or non-software firms. These spatial characteristics exhibit that even within the same industrial sector, software and non-software industries can affect entrepreneurial clusters in different ways.

3) Government Policies for the Formation of Entrepreneurial Clusters

In the previous section, we investigated the industrial composition of the entrepreneurial clusters to understand the spatial distribution of the clusters within the Seoul metro area. However, these results on the industrial composition of the clusters are attributable to not only geographical factors between city centers and suburbs, but also government policies related to the formation of clusters. Therefore, to better understand the industrial composition of the clusters, it is necessary to examine government policies.

The backgrounds of the entrepreneurial clusters in the Seoul metro area vary. However, they can be categorized into several types (Table 5). The first type consists of the clusters formed spontaneously, such as (1) Teheran Valley, (7) CBD, and (6) Honghap Valley. Looking at each of these, Teheran Valley began to be developed by the government in the 1970s. However, its entrepreneurial milieu today is not the result of

Table 5. Background of formation for entrepreneurial clusters

Type		Cluster	Industry Restriction	Formation Period
Spontaneous Formation		(1) Teheran Valley	-	Late-1990s
		(6) Honghap Valley		Early-2010s
		(7) CBD		Mid-2010s
Govt. Policy	Industry Transition	(4) G-Valley	IT Mfg., SW	Early-2000s
		(3) Seongsu Valley	IT, R&D, Media	Early-2010s
		(13) Seongnam HV	Mfg., BT	Early-2020s
	Large-scale Complex Development	(5) Yeouido FD	Finance	Mid-1990s
		(10) Gwanggyo TV	NT, BT	Late-2000s
		(2) Pangyo TV	IT, BT, CT	Early-2010s
		(11) DMC	Media & Ent., SW	Early-2010s
		(12) Songdo IC	IT, BT, R&D	Early-2010s
		(14) M-Valley	IT, BT, NT	Late-2010s
		(8) Munjeong BV	IT, BT, ET	Late-2010s
	University	(9) Gwanak S-Valley	-	Late-2010s

Notes: Mfg. is an abbreviation for manufacturing, and Ent. for entertainment.

policies, but rather of spontaneous formation (Rhee, 2019). While CBD has also been formed since the 1960s, its entrepreneurial ecosystem started to be spontaneously formed in the 2010s. In addition, Honghap Valley has been a startup cluster based on cultural contents industries without government supports since the early 2010s (Min, 2020). We could confirm that these clusters were all located in the center of Seoul, that the government did not have to make policies to form these clusters.

The second type was composed of the clusters that went through industrial transition by government policies, such as (3) Seongsu Valley, (4) G-Valley, and (13) Seongnam HV. Seongsu Valley was originally an industrial area in Seoul, but designated as an "IT industry development promotion district" in 2010 to foster it as a high-tech industrial cluster specialized in IT, R&D, and media. G-Valley was also an industrial area, but has been specialized in IT manufacturing and software development since the 2000s by policies. However, the government minimized its industry restrictions to promote various industries to be fused. Lastly, while Seongnam HV has accommodated a wide range of manufacturing firms, the local government announced in 2021 plans to transform this general industrial complex into a specialized hub for BT and smart factories. These clusters were characterized that they were all located in industrial areas in the past, but have transitioned into clusters based on advanced industries including manufacturing.

The third type was comprised of clusters developed as large-scale complexes, such as (5) Yeouido FD, (2) Pangyo TV, (10) Gwanggyo TV, (11) DMC, (12) Songdo IC, (14) M-Valley, and (8) Munjeong BV. Yeouido FD was developed as a specialized financial district after "the Act on the Development of Financial Centers" was enacted

in 2007. Pangyo TV was planned to be based on IT, BT, and Culture Technology (CT) industries by the government to reinforce the self-sufficiency of the new town. Its construction started in 2006, and companies began moving into in 2012. Gwanggyo TV, specialized in NT and BT, was also constructed by the government to foster the self-sufficiency of the new town during the period of 2004 to 2008. Meanwhile, DMC was planned to be based on IT software as well as media & entertainment industries by the government in 2000. Songdo IC, as the first Free Economic Zone of South Korea, aimed to be an international city based on international business, IT, BT, and R&D. It started to develop in 2005, and several buildings were completed around 2013. M-Valley was designated as an urban development district in 2007 by the government, and specialized in IT, BT, and NT. Several R&D centers began relocating in 2017. Lastly, Munjeong BV was planned to attract new growth industries, such as IT, BT, and Environment Technology (ET). Firms began relocating to this cluster from 2017. In sum, this type of clusters exhibited the tendency to be specialized in the designated industries by the government.

The last type was a cluster formed to boost startups around university campus such as (9) Gwanak SV. It began to be formed by the government in 2018, and aimed to attract and foster tech-based startups by creating a startup ecosystem.

Through these results, we could confirm how government policies as well as geographical factors have affected the industrial composition of the clusters. Especially in cases of large-scale complex development, we found that policies have significantly influenced industrial specialization. Additionally, we observed that geographic limitations could be overcome through government policies. It is generally difficult for manufacturing firms to locate near city centers due to land use regulations. However, although (8) Munjeong BV is adjacent to the city center, its share of non-software industries was high since it was allowed to attract particular types of manufacturing industries through district units plan. Likewise, the share of software industries of (11) DMC situated on the boundaries of Seoul appeared high as this cluster was planned to attract media, entertainment, and software industries.

5. Discussion and Conclusions

We have investigated the geography of entrepreneurship in the Seoul metropolitan area so far. To begin with, we confirmed the spatial concentration and distribution of entrepreneurial activities in the Seoul metro area at the micro-geographic level. Through this analysis, we identified 14 entrepreneurial clusters within the Seoul metro area, and confirmed that entrepreneurial activities are highly agglomerated in specific clusters, showing the spatial division of labor.

Furthermore, we looked into the industrial composition of the entrepreneurial clusters to better understand the spatial distribution of clusters alongside government policies related to the formation of clusters. Accordingly, we first

measured the diversity and specialization indices of the entrepreneurial clusters. As a result, we observed that the diversified clusters tend to be primarily dispersed in the center of Seoul, and the specialized clusters were located in both city center and suburbs of Seoul. These results demonstrated that both diversified and specialized clusters coexist in the Seoul metro area (Duranton and Puga, 2001). Subsequently, we analyzed the share of software and non-software industries of the clusters, and found the tendency that the closer clusters were to city centers, the higher the share of software industries. Meanwhile, we also observed that in addition to geographical factors, government policies related to the formation of the clusters can affect the industrial composition of clusters.

From these findings, we could derive several points of discussion. Starting with the clusters located in the center of Seoul, these clusters generally not only exhibited a high level of industrial diversity with a significant share of software industries, but also some of them were spontaneously formed clusters. These characteristics of the clusters placed in the center are owing to high networking density, rich cultural amenities, and accessible public transit (Florida, 2014; Katz and Wagner, 2014). These factors contribute to form the innovative milieu as a sense of place, and promote open innovation (Chesbrough, 2003; Hutton, 2004). In addition, software industries are more likely to be located in the center of Seoul because they do not require a large footprint and have less regulations.

Meanwhile, the clusters situated on the border of Seoul or its suburbs showed high industrial specialization and a significant presence of non-software industries. Most of these clusters were formed by government policies, and tended to be specialized in designated industries. In addition, due to space constraints and land use regulations, non-software industries including manufacturing were inclined to be located on the border or in the suburbs, where ample space is available and regulatory restrictions are minimal (Duvivier *et al.*, 2018; Florida, 2014).

However, there exist several exceptions. (5) Yeouido FD was a specialized cluster placed in one of the city centers, and (8) Munjeong BV was adjacent to the city center in spite of a high share of non-software industries. Conversely, (11) DMC showed a high share of software industries despite being situated on the boundaries of Seoul. All these exceptions resulted from government policy interventions. Various outcomes deviating from the general trend may arise according to the strategic plans of the government through methods such as district units plan.

These results suggest several policy implications. First, when formulating policies to support the entrepreneurial clusters in the center of Seoul, it would be beneficial to ease industry restrictions to promote industrial diversity. Moreover, fostering an innovative milieu would require boosting networking density, cultural amenities, and accessibility to public transit. Second, when crafting policies to bolster or establish clusters specializing in specific industries on the boundaries of Seoul or in its suburbs, prioritizing environments conducive to scale-ups rather than start-ups would be advantageous. In addition, focusing on attracting non-software industries than software might

enhance the effectiveness of the policies. Third, nonetheless, if necessary, it would also be possible to establish clusters focused on non-software industries near city centers, or software industries on the border of Seoul through policies such as industry restriction and district units plans.

This study has several limitations. First, when analyzing the industrial composition of the entrepreneurial clusters, we did not include the firms that received venture captial investments below 0.9 million USD in the seed and government grants stages. Due to this filtering, the indices might not show the accurate industrial composition of the clusters and may instead reflect venture capital preferences. Thus, when interpreting them, it is necessary to recognize that these are the results of innovative and proven firms. Second, this study only used venture capital data invested in 2021, which could distort the general trend. Future research could utilize multi-year data to confirm a more general pattern. Lastly, this study did not empirically examine the life cycle model to explain the mechanism for the spatial distribution of entrepreneurial clusters. Thus, this analysis is deferred to future research.

Acknowledgement

This work was supported by the Institute for Sustainable Development (ISD), Seoul National University.

Notes

1) According to Startup Genome (2022), annually announcing the global startup ecosystem ranking, Seoul ranked 10th in 2022. The main reason was the active funding support policies of the South Korean government for entrepreneurship.

2) Life cycle models can be applied to not only life sciences, but also industries and products. Moreover, individual firms within an industry can be in various stages of life cycle according to their entry time into the industry (Inc., 2021). These life cycle models have common grounds in some respects as industries or firms grow and decline.

3) The VC database classified venture capital investments into 43 industrial sectors as follows:

KSIC-1	The VC
A	Agriculture, Fishing
C	Electronics, Semiconductor, 3D printing, Display, VR/AR, Motor vehicle, Aircraft, Munitions
D	Environment/Energy
E	
F	Construction
G	Shopping, Fasion, Beauty, Living, Home, Babies, Motorcycles, Bicycles
H	Logistics, Water transport
I	Food, Travel
J	Contents, Broadcasting, Telecommunications, Game, Blockchain, Security
K	Finance
L	Real estate
M	Bio/medical, Chemistry, Marketing, Enterprise (Accounting, HR, Law), Pet
P	Education
Q	Healthcare
R	Entertainment, Sport
S	Event, Volunteer

4) The term “death valley” is commonly used among venture capitalists and represents the period in which a startup operates its business without generating any revenue, relying on its initial investment. Overcoming the death valley means that a startup generates revenue and becomes self-sustainable (Fernando, 2022).

5) A census output area (jipgyegu) is a minimum space unit that can be utilized with census data in South Korea. It can provide a realistic spatial distribution, reflecting local characteristics, such as population size (minimum 300, optimal 500, maximum 1,000

individuals), socio-economic homogeneity (land value, housing type), and shape (Hwang and Kang, 2021).

6) This study explains the location of entrepreneurial clusters, following the urban spatial structure of Seoul suggested in the "2040 Seoul Plan" (Seoul Metropolitan City, 2023). This plan presents the urban spatial structure of Seoul as a system with three city centers, seven subcenters, and twelve local centers. Meanwhile, we define the clusters located outside Seoul, Gyeonggi-do and Incheon Metro City, as the suburbs.

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최초투고일 2024년 04월 01일
수 정 일 2024년 06월 11일
최종접수일 2024년 06월 24일