Essays on Regional Characteristics and Industrial Performance

By

KIM, Baesung

Dissertation

Submitted to

KDI School of Public Policy and Management

In Partial Fulfillment of the Requirements

For the Degree of

DOCTOR OF PHILOSOPHY

IN DEVELOPMENT POLICY

2020

Essays on Regional Characteristics and Industrial Performance

By

KIM, Baesung

Dissertation

Submitted to

KDI School of Public Policy and Management

In Partial Fulfillment of the Requirements

For the Degree of

DOCTOR OF PHILOSOPHY

IN DEVELOPMENT POLICY

2020

Professor CHO, Man

Essays on Regional Characteristics and Industrial Performance

By

KIM, Baesung

Dissertation

Submitted to

KDI School of Public Policy and Management

In Partial Fulfillment of the Requirements

For the Degree of

DOCTOR OF PHILOSOPHY

IN DEVELOPMENT POLICY

Committee in
charge:

Professor CHO, Man, Supervisor

Professor KIM, Kyung-Hwan

Professor BAEK, Jisun

Professor LEE, Jinsoo

Professor LEE, Jongyearn

Approval as of December, 2020

ACKNOWLEDGEMENTS

This dissertation is dedicated to Daisaku Ikeda, the eternal mentor of my life. I would like to give special thanks to Sunwoo Lee, my wife, who always inspires me, and my family members who support me all the time.

I also would like to express my deep gratitude to my supervisor, Professor Man Cho, and the committee members: Professor Kyung-Hwan Kim, Professor Jisun Baek, Professor Jinsoo Lee, and Professor Jongyearn Lee. Their valuable feedback, patient guidance, and encouragements allow me for finishing the dissertation and academic journey in KDI School.

Lastly, I wish to thank my friends who helped me in the writing of this dissertation.

TABLE OF CONTENTS

Chapter 1. Land use and firm performance

Chapter 2. Effects of regional industrial features on firm performance in digital age

Chapter 3. Differential effects of having parent companies on subsidiaries' total factor productivity by geographic proximity

LIST OF TABLES

Chapter 1. Land use and firm performance

Chapter 2. Effects of regional industrial features on firm performance in digital age

Chapter 3. Differential effects of having parent companies on subsidiaries' total factor productivity by geographic proximity

LIST OF FIGURES

Chapter 1. Land use and firm performance

Chapter 2. Effects of regional industrial features on firm performance in digital age

Chapter 3. Differential effects of having parent companies on subsidiaries' total factor productivity by geographic proximity

Chapter 1

Land use and firm performance

Abstract

This study aims to enhance the understanding how cities contribute to the success of firms. Based on the prior studies on agglomeration economies, this study unbundles the agglomeration economies by land use type. In addition, this study touches on the differential effects of each land use on different types of firms. Land use can influence firms positively through sources of agglomeration economies such as labor market pooling, knowledge spillover, input sharing, and quality human capital. These sources usually affect firms' performance through total factor productivity, cost, and labor quality. Moreover, each land use type has different levels of importance to different types of firms. For instance, specialized industrial areas matter to independent firms, whereas mixed land use can be more important to digital-intensive firms.

These relationships are important from a policy point of view. Each land use is related to policy tools. If policymakers have the whole picture of the relationship, they can take policy measures to change land use, leading to higher performance of firms. Room for further improvement also exists. First, concerning the relationship between each land use and performance of each firm type, most prior studies have interests in the impact of knowledge spillovers on the firms' performance. Second, compared to the traditional firm types, relatively studies on recent types such as digital-intensive firms are dearth. Future studies need to investigate these areas to fill the knowledge gap.

Keywords: land use, firm typology, firm performance, differential effects.

1.1. Introduction

Land is one of the production factors to firms. When firms produce output by consuming labor and capital, they also consume some amount of land. For example, manufacturers need space for factories, and firms that belong to the service sector need space for offices (Metzemakers & Louw, 2005).

Leaving the production factor side, land is also related to business activities. Specifically, dense urban areas are helpful for firms to have greater efficiency in the production process. They make local labor markets thick and enhance the matching between firms and workers. They also attract talented people, results in providing quality human capital. Furthermore, this dense fabric boosts knowledge spillovers among firms and workers. These benefits are known as agglomeration economies.

This paper aims to enhance understanding how cities contribute to the success of firms. Based on the prior studies on agglomeration economies, this study unbundles the agglomeration economies by land use type, which includes residential, industry & business, community services, recreation & leisure, and transport. As Duranton and Puga (2015) mention, land use is fundamentally important. It is about large allocation decisions for firms, thus it affects the labor market and the markets for the products. While firm performance is ultimately driven by individual decisions of workers and companies on how to use resources in the process of value generation, the regional environment conducive to more efficient choices is also important. Land use plays a role in the ways people, firms, industries, and other actors interact and function, which can bring direct and indirect influence on firms' performance (OECD, forthcoming). Furthermore, this unbundling by land use is important from a public policy point of view. Each land use is related to policy tools that governments can handle. If policymakers have an idea of a more accurate relationship between land use and business activities, they can take policy measures to change land use, leading to higher performance of firms.

Followed by the unbundling, this study touches differential effects of each land use, on different types of firms. It is not surprising different types of firms may have a different impact from even the same type of land use. Therefore, it is helpful to advance the understanding of the relationship between land use and business activities.

This paper points out land use has various sources of agglomeration economies, and it includes labor market pooling, knowledge spillover, input sharing, and quality human capital. These sources usually affect firms' performance through total factor productivity, cost, and labor quality. However, concerning the relationship between each land use and performance of each firm type, this study finds most prior studies focus on knowledge spillovers as agglomeration economies sources. In addition, studies on rising types of firms such as digital intensive firms and corporate affiliates are relative dearth. Future studies need to investigate these areas to fill the knowledge gap.

This paper is organized as follows. The next two sections provide a literature review on land use and firm types. Section 1.4 presents sources of agglomeration economies and its unbundling by land use. Section 1.5 explains the interplay between land use and firm types. Finally, in Section 1.6 and 1.7, I summarize earlier sections and draw conclusions.

1.2. Land use

How land is used is closely associated with individual well-being and firm performance. Land use contains many factors that affect firm performance. For example, it determines the commuting time, economic interactions in a city, and quality of amenities (OECD, 2017c).

As land use is determined by physical forms, it would be helpful to take a look at what are the primary elements of urban formation. According to Levy (1999), the primary elements are plot, street, constructed space, and open space. Open space means spaces excluding streets, for example, squares and gardens. Different combinations and relationships among the primary elements can make different urban formation. The primary elements can be divided into detailed forms. For example, James and Bound (2009) use the term of urban morphology types (UMTs), which are detailed forms or usage patterns of lands. It includes dwellings, offices, schools, and roads, and so on. UMTs have the idea that each UMT has peculiar land use characterized by physical characteristics and human activities that happen in them. UMT's categories can be building blocks to form distinct urban morphology or urban formation (James & Bound, 2009). Based on Gill et al. (2008) and James and Bound (2009), Table 1.1 shows 5 primary land use types and 11 detailed urban morphology types.

Table 1.1. Land use and related urban morphology types

Primary Land Use	Detailed Urban Morphology Types
Residential	Dwellings
Industry and business	Offices; Manufacturing; Retails
Community services	Schools and universities; Other community services (hospitals, etc.)
Recreation and leisure	Open spaces; Amusements and sports facilities
Transport	Roads; Rails; Car parks

Source: Gill et al. (2008) and James and Bound (2009)

1.3. Typology of firms

Being located in a city has an impact on firms' performance, but one caveat is the impact of being located in a city that would not be uniform across firms. The same urban environment may give different impacts on firms, depending on firms' characteristics. Therefore, it is required to consider firms' features to understand the impact of urban settings.

It is well-known that business entities have a heterogeneous landscape. Put differently, many different types of firms exist, and accordingly, there are a variety of ways to classify them. It includes size, age, location, level of innovation, and degree of digitalization, and so on, and they are divided into either external characteristics or internal ones. As some typologies give us the insight to understand the relationship between land use and firms, they are presented here. Section 1.5 investigates the detailed interplay between land use and firms' types.

1.3.1. Typologies based on external characteristics

1.3.1.1. Large firms vs Small and medium-sized enterprises (SMEs)

Although it is clear large firms have greater sizes than SMEs, one challenge for this typology is that the definition of SMEs varies across countries. OECD (2005; 2019d) defines SMEs as firms with less than a certain number of employees. Even if the numbers are different across countries, the commonly used limit is 250 employees. In some cases, financial capability is also considered to define SMEs. The European Union (EU) uses the number of employees and revenue to define SMEs. For example, a firm is eligible to be SME if the number of employees is smaller than 250, and the annual revenue is less than fifty million euros (OECD, 2005).

Korea focuses on the revenue to determine whether a firm is a large firm or an SME. The Korean government provides a detailed guideline to define SMEs. To be eligible as SMEs, they should be independent firms and the average revenues for the past three years should be less than certain limits, which are different by industry sectors and divisions (see Appendix 1.1).

1.3.1.2. Independent firms vs Corporate affiliates (subsidiaries)

Firms are split into either independent ones or subsidiaries depending on the level of independence to parent organizations. If a firm has the autonomy of managing the firm and does not have a parent company, it is an independent firm. In contrast, a firm hands over some of the autonomy to its parent company, it is called a corporate affiliate or a subsidiary.

Bradley et al. (2011) mention that organizational independence is closely related to the autonomy a firm decides on allocating its resources. They explain the advantages and disadvantages of turning over the autonomy to the parent companies. In terms of the advantages, a firm can take advantage of the resources and the network of the parent company, and the parent company can protect the corporate affiliate from threats outside. On the other hand, a corporate affiliate can control its resource less than an independent firm, which means it does not have enough discretion to react to the market situation.

Two kinds of advantages from a parent company are usually mentioned in the prior studies. The first one is easing of access to production factors such as labor and capital. Park and Jung (2011) explain a business group can create a kind of internal capital market to support each other. Those who are in trouble to finance from outside due to asymmetric information, the parent company can invest in its subsidiary instead of outside the capital market. Cho (2016) argues that the vertical structure allows the subsidiary for enjoying higher leverage. The second one is knowledge sharing. Wang et al. (2004) empathize that parent-subsidiary structure allows easily to share a variety of knowledge from technical one (e.g., manufacturing-related knowledge) to managerial one (e.g., sales skills, HRM skills, and business strategy), which are more difficult to learn from competitors or strategic alliance.

1.3.1.3. Young vs Old firms

It is not surprising that there is no concrete definition for young firms. However, some prior studies tell young firms from old ones by articulating operational definitions, since they may have different characteristics in terms of ownership, business sectors, and potential job creation capacity, and so on. For example, Pickernell et al. (2013) from the UK survey data in 2008 find that young firms tend to have younger owners, and belong more to basic service sectors, and have fewer employees. In addition, they export less of their total production on average and also have a higher share from e-commerce in their total turnovers. In terms of the definition of young firms, some studies define firms with the age of 1-4 years (Berger & Udell, 1998; Robb, 2002; Pickernell et al., 2013), and others do with 1-5 years (Criscuolo et al., 2014).

1.3.2. Typologies based on internal characteristics

1.3.2.1 High digital intensive vs low intensive firms

OECD (2019c) proposes a taxonomy of industry sectors regarding the degree to which they are digitalized. It classifies industries into a low, medium-low, medium-high, and high digital intensity industry. This taxonomy captures several aspects of digitalization such as technological components, human capital, and market transaction channel such as e-commerce. Furthermore, OECD calculates the overall ranking of digitalization levels across industries based on data from 12 OECD countries. As firm-level typology on digital intensity does not exist, this industry-level typology can be used as a proxy to estimate the degree of a firm's digital intensity.

Table 1.2. Industry Taxonomy by digital intensity, overall ranking (based on data 2013-2015)

Industry denomination (ISIC Rev. 4)	Digital intensity	Industry denomination (ISIC Rev. 4)	Digital intensity
Agriculture, forestry, fishing	Low	Wholesale and retail trade, repair	Mid-high
Mining and quarrying	Low	Transportation and storage	Low
Food products, beverages, and tobacco	Low	Accommodation and food service activities	Low
Textiles, wearing apparel, leather	Mid-low	Publishing, audio-visual, and broadcasting	Mid-high
Wood and paper products, and printing	Mid-high	Telecommunications	High
Coke and refined petroleum products	Mid-low	IT and other information services	High
Chemicals and chemical products	Mid-low	Finance and insurance	High
Pharmaceutical products	Mid-low	Real estate	Low
Rubber and plastics products	Mid-low	Legal and accounting activities, etc.	High
Basic metals and fabricated metal products	Mid-low	Scientific research and development	High
Computer, electronic and optical products	Mid-high	Advertising and market research etc	High
Electrical equipment	Mid-high	Administrative and support service activities	High
Machinery and equipment n.e.c.	Mid-high	Public administration and defence	Mid-high
Transport equipment	High	Education	Mid-low
Furniture; other manufacturing, etc	Mid-high	Human health activities	Mid-low
Electricity, gas, steam, and air cond.	Low	Residential care and social work activities	Mid-low
Water supply; sewerage, waste management	Low	Arts, entertainment, and recreation	Mid-high
Construction	Low	Other service activities	High

Note: see appendix 1.2 for more details.
Source: OECD (2019b). Measuring the Digital Transformation: A Roadmap for the Future

1.3.2.2 High R&D intensive vs low intensive firms

OECD proposes new industry typology in terms of R&D intensity (Galindo-Rueda & Verger, 2016). As renewing the previous one based on technology intensity, OECD expands the classification scopes; the previous taxonomy covered only the manufacturing industry, the new one, however, does both manufacturing and non-manufacturing industries. R&D intensity has five groups from low to high. One caveat is the term is changed from "technology intensity" to "R&D intensity", due to the concern of inappropriate use of the term "technology intensity". Nevertheless, the former is substantially consistent with the latter (Galindo-Rueda & Verger, 2016). Therefore, it is acceptable to use the new taxonomy as a proxy for technology intensity by industry.

R&D intensity is associated with the absorptive capacity of a firm. Cohen and Levinthal (1990) introduce the concept of absorptive capacity. It is an organizational capability that allows firms to identify valuable knowledge and to commercialize. They suggest a firm's capability to utilize knowledge from outside is developed from a spin-off of its R&D. Thus, they argue, R&D enhances the firm's absorptive capacity.

Table 1.3. R&D intensity by industry (ISIC ver4)

Intensity	Manufacturing	Non-manufacturing
High	Pharmaceuticals Computer, electronic and optical products	Scientific research and development
Medium -high	Motor vehicles, trailers, and semi-trailers Machinery and equipment Chemicals and chemical products etc	Publishing activities IT and other information services
Medium	Rubber and plastic products Basic metals Repair and installation of machinery etc	-
Medium -low	Textiles, leather, and related products Coke and refined petroleum products Wood and products of wood and cork etc	Professional, scientific, technical activities Telecommunications Mining and quarrying
Low	-	Financial and insurance activities Wholesale and retail trade Accommodation and food service etc

Note: See Appendix 1.3 for details.
Source: Galindo-Rueda & Verger (2016).

1.3.2.3. Born-Global vs Gradualist firms

Since the early 1970s, many studies have explained the internationalization process of firms with the angle of gradual approach (Johanson & Vahlne, 1977). The approach delineates the process as firms are equipped with more knowledge about global markets during operating their businesses, and then they commit more to foreign markets (Gankema et al., 2000). In contrast, some firms try to make them internationalized rapidly, in some cases from the foundation of the firms, than the gradualist model expects (Oviatt & McDougall, 2005). It describes that some firms, focusing on knowledge-intensive ones, tend to have a rapid internationalization that jumps over some stages. Specifically, firms called ‘Born-Global’ are internationally oriented, and they reach some level of internationalization right after their inception or within a relatively short period (Bell et al., 2003). Table 1.4 presents the different patterns between Born-Global and gradualist firms. In addition, table 1.5 summarizes the firm typologies above-mentioned.

Table 1.4. Different patterns between Born-Global and Gradualists

Category	Born-Global	Gradualist
Managerial vision	Global from founding	Global markets are considered gradually after securing a substantial share in the local market
Global market knowledge	High from the founding because of superior internationalization knowledge from previous experience	Slowly accumulating local and international market knowledge
Value creation sources	Greater value creation by quality differentiation, leading-edge technology products, innovation	Less innovative, limited value creation ability

Source: Kalinic and Forza (2012)

Table 1.5. Summary of firm typologies

Characteristics	Types	Perspective	Author(s)
External	Large SME	Size	OECD (2005) OECD (2019d)
External	Independent Corporate affiliates	ownership structure	Bradley et al. (2011)
External	Young Old	Age	Berger and Udell (1998); Robb (2002); Criscuolo, Gal, and Menon (2014)
Internal	Low Medium-low Medium-high High	Digital intensity	OECD (2019c)
Internal	Low Medium-low Medium Medium-high High	R&D intensity (absorptive capacity)	Galindo-Rueda and Verger (2016) Cohen and Levinthal (1990)
Internal	Born global Gradualist	Internalization	Kalinic and Forza (2012)

Source: Author's elaboration

1.4. How can cities support firms?

Cities provide a conducive business environment, given the fact that firms are concentrated in cities. In this regard, Rosenthal and Strange (2004) mention proximity is advantageous. When people and firms locate spatially close, they may have more interactions, which can enhance firms' performance. Moreover, cities can allow firms to access to the skilled labor force, efficient business services, and knowledge (Giner et al., 2017). These positive benefits are known as agglomeration economies.

A plethora of studies (e.g., Jaffee et al., 1993; Holmes, 1999; Moretti, 2000; Glaeser et al., 2001; Rosenthal & Strange, 2001; Henderson, 2003; Duranton & Puga, 2015) have investigated the sources of agglomeration economies. They include improved matching between firms and workers, knowledge spillovers, quality human capital, and input sharing. Moreover, they estimated the impact and revealed the benefits of agglomeration are substantial (Andersson et al., 2007).

The profit function is helpful to make the linkage between the sources and the benefits firms get clear, as the profit function includes many aspects of the firms' activities such as production and cost. Consider a typical profit function below.

$$\mathbf{\Pi_i = p_i \cdot [A_i \cdot f(L_i, K_i)] - c(L_i, K_i)}$$

where Π is the profit of firm i, p is output price, A is total factor productivity (TFP), L is labor input, K is capital input, f is production function, and c is the cost function.

The sources of agglomeration economies have positive effects on total factor productivity, quality of labor, and cost. The sections below explain benefits from each source of agglomeration economies. In addition, the linkages between the benefits and the sources are unbundled by land use type.

1.4.1 Sources of agglomeration economies

The sources of agglomeration economies include labor market pooling, knowledge spillovers, urban culture, human capital, input sharing, infrastructure, and home market effects. First, the labor market pooling, knowledge spillovers, and urban culture have a positive impact on the total factor productivity (TFP) of firms. Second, quality human capital improves the quality of labor. Third, input sharing decreases the input costs. Finally, infrastructure and home market effects boost agglomeration economies.

1.4.1.1. Labor market pooling

Cities allow for greater matches between firms and employees, and it can improve the total factor productivity of firms by lowering search friction in the labor market and by improving complementarity in production (Andersson et al., 2007). Rosenthal and Strange (2001) show that labor market pooling can explain the large portion of the spatial concentration of firms. Baumgartner (1988) also shows that the labor division is finer in cities, which means cities provide a more efficient labor market.

Put differently, the urban environment makes the match between a firm's labor demand and a worker's skill set easier. There are two theoretical explanations for labor market pooling. One is large cities are better for the matching. That is because large cities can offer various job opportunities and also have various types of job seekers. It gives a higher probability to match between workers and firms. The other is cities with industrial concentrations are better for the matching. In some cases, workers have firm-specific skills, and firms also require hiring people who have particular skill sets, which are customized to the firms. Under this situation, if the workers need other jobs, and the firm needs another worker. These needs can be easier to meet in an area where the industry is concentrated. Thus, the worker and firm-specific risk can be reduced in large cities (Rosenthal & Strange, 2004).

1.4.1.2. Knowledge spillovers

Knowledge matters for firm performance. As knowledge is directly associated with R&D and innovation in businesses, accumulating more and better knowledge has a substantial effect on performance. Aligned with it, knowledge spillovers is also an important source to enhance performance. Geographical proximity is important for exchanging knowledge and cross-fertilization of ideas (OECD, forthcoming). In addition, Jaffe, Trajtenberg, and Henderson (1993) provide compelling evidence that the impact of knowledge spillovers reduces with spatial distance. Audretsch and Feldman (1996) also confirm that knowledge-intensive industries have more spatially concentrated, consistent with the presence of knowledge spillovers.

Glaeser et al. (1992) explain different mechanisms of knowledge spillovers which are argued by Marshall-Arrow-Romer (Marshall, 1890; Arrow, 1962; Romer, 1986) and Jacobs (1969). First, Marshall-Arrow-Romer (MAR) focuses on within-industry transmissions of knowledge. Primarily, one firm's knowledge can help other firms' business activities when they are similar; in this regard, regionally specialized industrial characteristics are efficient for knowledge spillovers. On the other hand, Jacobs argued that the main knowledge spillovers in cities occurs across different industries by allowing more interchange of different ideas. In this sense, diversified regional industrial settings are helpful for knowledge spillovers.

1.4.1.3. Urban culture

Open and tolerant culture often plays a critical role in firm performance. Florida and Gates (2001) find that cities with people who have artistic jobs innovate more than less creative cities. Similarly, Qian et al. (2013) find that tolerant culture (measured by the share of households with homosexual unmarried partners, etc.) is positively related to the share of innovative start-ups in the US.

Accepting business failure is another example of open urban culture. For example, Feld (2012) finds in the study for start-ups communities in the United States that the success of newly set-up firms is partially related to the lack of stigma on business failure. Failed businessmen work for the business community again by taking some positions such as advisors.

1.4.1.4. High quality of human capital

Many prior studies have investigated the association between human capital and economic performance in firms. One example is Shinada (2011). He argues the quality of labor (e.g., level of skill) increases the productivity of firms. Local conditions such as job opportunities and the quality of life can determine to some degree the human capital composition of a city (OECD, forthcoming). In this regard, the urban environment can attract better human capital since it provides better job and consumption opportunities. Shapiro (2006) also finds that highly educated people tend to concentrate in urban areas.

Glaeser et al. (2001) explain three ways that how large cities can make consumption opportunities better. First, some goods and services are available only in large urban areas. One example is opera houses. Second, large cities may provide public facilities that would not be possible in smaller areas. Specialized schools can be a good example. Third, urban density facilitates social interaction. These better consumption opportunities are helpful to attract educated and creative people to cities.

1.4.1.5. Input sharing

Marshall (1920) argues that the geographical concentration of firms in a given area enables firms to share input suppliers, and the input sharing can allow input suppliers to enjoy internal increasing returns to scale in their production process. Spatially concentrated firms can outsource their demands of input to producers who can attain a more efficient scale of production. As a result, downstream firms can procure inputs at a lower price than isolated ones (Rosenthal & Strange, 2004).

1.4.1.6. Infrastructure

Physical infrastructure is another determinant of agglomeration economies. Infrastructure helps firms having cost-efficient access to necessary resources. Quality infrastructure is also crucial for firms' entry to markets. In addition, it is known that transport infrastructure can enhance the impact of agglomeration economy, as it allows better matching and sharing inputs and knowledge among economic agents (Auckland Council, 2017). In addition, good transport infrastructure boost firms' performance by reducing travel cost, attracting more firms, which imply greater home market, and increasing labor productivity.

Digital infrastructure is important to diffuse digital innovation across firms. In addition, it can contribute to higher productivity of firms (Haller & Siedschlag, 2011). Research comparing UK firms with low-speed internet connection to ones with high-speed internet connection shows that high-speed connection is positively associated with firms' productivity. A recent OECD study presents evidence that adopting high-speed internet can substantially increase productivity. Accessing high-speed networks allows firms connecting to suppliers and customers, accessing real-time information, responding to market timely. In addition, digital network (e.g. cloud computing) enables firms to develop digital capacity, not spending much on purchasing and maintaining digital equipment (OECD, 2019d).

1.4.1.7. Home market effects

Large cities can enjoy home market effects that can increase local market size. Home market effects mean the demand concentration can encourage agglomeration and economies in consumption. For instance, urban agglomeration brings people and large factories in a given place. If there is benefit to transportation costs when other firms locate in the same place, they would move there, and then it creates a larger market. The point is that the interaction between the agglomeration economy from the production side and the benefit of transportation costs lead to reinforcing agglomeration effect, and it expands home market demand (Rosenthal & Strange, 2004). Table 1.6 summarizes the sources and benefits.

Table 1.6. Summary of the sources and benefits of agglomeration economies

Sources	Benefits	Details	Authors
Labor market pooling	TFP	It improves complementarity in production. Diversity enhances the employer-employee match. Industrial concentration expedites labor force flow across firms under the presence of firm-worker skill-set linkage.	Diamond & Simon (1990) Rosenthal & Strange (2001) Andersson et al (2007)
Knowledge spillovers		Geographical proximity facilitates knowledge exchange. More patent citations are found in the same metro regions. Average education level in a city increases wage.	Jaffee et al (1993) Audretsch & Feldman (1996) Moretti (2000)
Urban culture		Cities with creative people innovate more. Open and tolerant culture can enhance firm performance.	Florida & Gates (2001) Qian et al. (2013)
human capital	Labor quality	Quality of labor increases the productivity of firms. Better job and consumption opportunities attract quality human capital.	Shinada (2011) Glaeser et al (2001) Waldfogel (2003)

Input sharing	Cost	It allows firms to enjoy internal increasing returns to scale. It decreases procurement costs for downstream firms.	Holmes (1999) Rosenthal & Strange (2004)
(Digital) Infrastructure	Overall	It enhances the impact of urban agglomeration. It reduces travel costs and attracts more firms.	Haller & Siedschlag (2011) OECD (2019d)
Home market effects		Interaction between agglomeration economy and transport costs leads to reinforcing agglomeration.	Davis & Weinstein (1999) Rosenthal & Strange (2004)

Source: Author's elaboration based on Rosenthal and Strange (2004)

1.4.2. Unbundling the benefits and the sources by land use

Jacobs (1961) recognized that the physical structure and urban form wield considerable effect on human activities and firms' performance. Although overall cities can support firms' performance, cities have very heterogeneous in terms of their fabrics. In other words, each area or spot in a given city may have a different impact or different sources of agglomeration economies. Thus, this section surveys existing studies to unbundle the sources and benefits of agglomeration economies by land use.

1.4.2.1. Residential area

Intuitively, some people may think the residential area has no relationship with the firms' economic performance. However, it has. Residential areas are related to firms' production through the housing market. Put differently, it is important to think about the effect of insufficient housing stock per capita on productivity. Insufficient housing stock may induce more difficulties for having proper housing, leading to decreased labor mobility. This restricted mobility of the labor force affects negatively the efficient allocation of labor across firms and industries. In other words, it may constrain the ability of workers to find jobs with better skill-match. Hacker (1999) analyzes Polish data which is aggregated at the regional level and find that greater residential crowding in a region induces lower labor productivity in that region. Hsieh and Moretti (2017) also find similar results. They evaluate the degree of spatial misallocation of the labor force across cities in the United States and estimate its total costs. One of the reasons for misallocation is that highly productive cities such as New York take strict restrictions on housing supply, leading to limit workers to access these cities. They find that these restrictions decreased aggregated growth by higher than 50% from 1964 to 2009 in the US.

1.4.2.2. Industry and business area

Industry and business areas are directly related to job creation. Hanushek and Quigley (1990) analyze the effect of land use regulation on business growth. Specifically, they investigate the case of San Francisco in 1986. A regulation, called Proposition M, set up an annual limit on a new provision of office spaces, which is 950,000 square feet per year. They argue this restrictive regulation on commercial land use reduces jobs. They compare the number of employment if the economy grows under this regulation with estimations without this regulation. They show the projections of differences in employment growth over the first 10 years, and the projections indicate this regulation on commercial land use is negatively associated with employment, by lowering growth in office employment by approximately one percent per year.

With regard to knowledge spillovers and inter-firm cooperation, geographic proximity in industrial areas can enhance trust, improve cooperation, and expedite knowledge spillovers (Prashantham, 2004). As above-mentioned, Marshall-Arrow-Romer (MAR) emphasizes the mechanisms from regional industrial specialization. They argue the specialized industrial setting can enhance knowledge spillovers among firms by making within-industry transmissions of knowledge easier.

1.4.2.3. Community services (universities and training facilities)

Universities and educational institutions can contribute to the productivity and innovation of firms by diffusing knowledge and training local employees. First, in terms of knowledge diffusion perspective, Cohen, Nelson, and Walsh (2002) and Laursen and Salter (2004) find universities and research labs considerably increase knowledge-intensity and diffuse technologies in the host areas, leading local firms to more innovations. The cooperation between firms and academia includes the sharing of research equipment. It enables firms that cannot equip with in-house research facilities to utilize cutting-edge research equipment, techniques, and manpower from academia such as universities and research organizations, resulting in improving their technological capacity (OECD, 2019d).

Second, for the view of the training, OECD (forthcoming) argues that these facilities can contribute to an array of productivity-enhancing activities via training. Firms' benefits from upskilling their workforce can be substantial. An improved workforce can help to catch up with the productivity gap with market leaders and make better positioning in global value chains by identifying their niche in the value chains. Moreover, skilled employees are critical for firms to manage organizational changes to cope with new challenges from outside (OECD, 2019d).

1.4.2.4. Recreation and leisure

Recreation and leisure facilities can contribute to firms' performance through two channels. One is good recreation and leisure service can attract talented people to the host areas, which means firms can access easier to potential workers. The other is workers can increase their labor productivity by participating in recreational and leisure activity. First, Florida (2002) and Glaeser, Kolko, and Saiz (2001) find that cultural amenities and green space can improve the level of local attractiveness to workers. Not only that, but they can also enhance firm performance (Sleutjes, Van Oort, and Schutjens, 2012).

In Australia, research estimates local sports facilities can bring about the value of $6.3 billion worth of economic benefit annually. It also has improved the labor productivity of people who are physically active by using those facilities. By taking part in sport and leisure activities, people can be healthier and enhance cognitive ability. As a result, the economy is more productive. This benefit can be attained through various channels such as lower absenteeism, higher labor productivity, and better human capital (KPMG, 2018).

1.4.2.5. Transport

Transport infrastructure is one of the main contributors to agglomeration economies. In the case of the West Coast Expressway in Korea, for example, greater accessibility by the newly constructed West

Coast Expressway brings about a substantial effect on the location decision of new manufacturing firms. These firms tend to select a location near the interchange of the Expressway. The Expressway shows several positive impacts on new entrants, employment, and productivity (OECD, 2019d).

As motorized transport and non-motorized transport have different characteristics, here, the effects on a firm's performance are explored respectively. For motorized transport, there are empirical pieces of evidence that better transport enhances firms' performance by reducing travel costs. For instance, Bernard, Moxnes, and Saito (2019) find that the opening of a high-speed rail in Japan has increased the performance of local firms. The positive effect of transport on productivity is found by Banerjee, Duflo, and Qian (2012) for China and by Ahlfeldt and Feddersen (2018) for Germany (OECD, forthcoming). Gibbons et al. (2019) provide another empirical evidence by exploring the impact of transport improvements on employment and productivity in the UK for the period 1997–2008. They assess exposure to road improvements or accessibility. They find the improved roads increase both ward-level employment and the number of firms. However, they find no employment effects at the establishment level, suggesting the local employment changes are induced from firm entry and exit.

The result from Gibbons et al. (2019), especially for accessibility improvements that may attract firms, can be related to the home market effect. Good transport infrastructure can make local market demand greater by making more firms located in the host areas. With regard to knowledge spillovers, Parent and LeSage (2008) find transport network linkages and geographical proximity are positively related to knowledge spillovers by analyzing patents data in Europe.

For non-motorized transport, especially for well-connected streets, urban areas can enjoy higher productivity because of optimized commuting and other services. Improved street connectivity reduces traffic congestion and improves walkability. As street connectivity increases, travel time decreases, and route options increase, allowing more efficient journeys from origins to destinations. Efficient transport can increase labor productivity by lowering commuting times (UN-Habitat, 2013).

1.4.2.6. Mixed land use

Mixed land use is not a single urban spatial element, rather it is a combination of some spatial elements. However, mixed land use has been a hot topic on the relationship between land use and firm performance. Thus, it is also explored in this section. Mixed land use means various land uses such as residential, commercial, and industrial are located in an integrated way, and then it increases neighborhood amenity and supports sustainable transport, encouraging walking and cycling. In that sense, mixed land use increases the economic vigor by encouraging more people to stay in streets and public spaces (Healthy Spaces & Places, 2009). Mixed land use that encourages social interactions tends to be more economically active. Characteristics such as moderate density are related to the enhancement of economic dynamism of neighborhoods. One of the main reasons is frequent face-to-face interactions, which allow enhanced social networks, knowledge spillovers, and innovation (Bereitschaft, 2019).

Mixed land use is related to a firm's performance in two distinct ways; one is through innovation, specifically knowledge spillovers, and the other is through human capital. First, mixed land use can enhance innovation by facilitating knowledge spillovers. Santamaria-Varas and Martinez-Diez (2015) argue that innovation spreads through mixed land use fabrics. In other words, mixed-used morphological conditions represented by compactness, good accessibility, diverse amenities are conducive to innovation by expediting social interaction and the exchange of ideas. Therefore, the co-location of educational and research organizations, start-ups and street vendors, well-connected walkable streets, bike-sharing, well-connected public transport are important factors that influence the proliferation of innovation.

Considering exchanges of ideas and knowledge that happens more in face-to-face interaction, it needs to check the relationship between connectivity and performance. Auckland Council (2017) find there is a positive relationship between walking effective job density, which means the number of jobs within walking distance, and labor productivity within the Auckland city center, New Zealand. In other words, more walkable locations tend to have higher performance. They explain that one of the reasons is better sidewalks connectivity increases the impact of urban agglomeration, thus walkability is positively associated with economic performance.

Second, mixed land use is conducive to attract high skilled and innovative workforce. Mixed land use usually tends to have more walkable and high-amenity space, and they play a key role to attract and retain highly-skilled, innovative people (Zenker, 2009; Borén & Young, 2013). Florida (2012) also argues that high-skilled and creative people prefer to be in cities having vibrant street life and various cultural facilities. Katz and Wagner (2014) state a rising number of talented people tend to locate together in compact and amenity-rich places. Table 1.7 summarizes the effects of urban spatial elements on the firms' economic performance and innovation.

Table 1.7. Summary of the sources and benefits of agglomeration economies by land use

Land use	Sources	Benefits	Details	Authors
Residential	Labor market pooling	TFP	Sufficient housing stock facilitates efficient labor allocations and matching. Greater residential crowding induces lower labor productivity.	Hacker (1999) Hsieh & Moretti (2017)
Industry & Business	Labor market pooling	TFP	It provides more job creation opportunities and attracts skilled labors. Restrictive regulations on commercial land use reduce jobs.	Hanushek & Quigley (1990)
	Knowledge spillover	TFP	Specialized industrial areas enhance knowledge spillover and cooperation among firms.	Marshall (1890) Romer (1986) Prashantham (2004)
	Input sharing	Cost	It allows firms for sharing input suppliers to reduce the cost.	Holmes (1999)
Community services	Knowledge spillover	TFP	Universities expedite knowledge exchanges and technology diffusion.	Nelson & Walsh (2002) Laursen & Salter (2004)
	Human capital	Labor quality	It improves human capital by providing training.	OECD (2019d)
Recreation and Leisure	Labor market pooling	TFP	It improves amenity and better consumption opportunities attract more potential workers.	Florida (2002) Glaeser et al. (2001)
	Human capital	Labor quality	It improves labor productivity.	KPMG (2018)
Transport	Labor market pooling	TFP	It makes matching easier.	Gibbons et al. (2019)
	Knowledge spillover	TFP	It expedites knowledge exchanges.	Parent & LeSage (2008)
	Input sharing	Cost	Travel cost decrease makes it easier to share suppliers.	Gibbons et al. (2019)
	Human capital	Labor quality	It increases labor productivity by optimizing commuting time.	UN-Habitat (2013)
Mixed Land use	Knowledge spillover	TFP	Walkability increased knowledge exchanges. More walkable locations tend to have higher performance in New Zealand.	Santamaria-Varas & Martinez-Diez (2015) Auckland Council (2017)

	Labor market pooling	TFP	Walkability and amenities attract creative and skilled labors.	Florida (2012) Katz & Wagner (2014)

Source: Author's elaboration

1.5. Interplay between land use and firm types

Doing businesses in cities has an impact on firms' performance. Cities can make firms access to the skilled labor force, intermediary inputs, business services, and knowledge easier because of proximity, leading to higher productivity and better economic performance (Giner et al., 2017).

There are many theoretic and empirical pieces of evidence on how cities support firms' businesses. For example, Glaeser (2011) finds that firms can improve their capacity for innovation by being in cities, and the agglomerations effect can make it happen. Many empirical studies have found positive effects of locating in cities on firms' performance. For instance, firms may be attracted to dense, more walkable urban areas to enjoy agglomeration economies (Foord, 2013). Łuczka and Przepióra (2012) also find that abundant labor force, infrastructure, and business services are helpful to business entities. Finally, Houston and Reuschke (2017) find that cities provide benefits to small firms for revenue growth, in contrast to less dense areas such as villages.

One caveat is the impact of being located in cities that would not be uniform across firms. At the same time, it is hardly possible to present a generalized difference in terms of the impact of land use on firms by firm types. However, it is worth trying, as firms in different types would have a different impact from the urban settings. Thus, this paper explores the interplay between land use and firm types to have insight into how to take advantage of land use to boost the performance of firms.

1.5.1. Large firms vs SMEs

1.5.1.1. Key difference

Large firms may be able to shape their external environment easier than SMEs. In addition, national or international business networks are crucial for large firms, as their business scope is usually beyond a region where they are located. On the other hand, cities can create a more beneficial influence on SMEs, as small businesses are more dependent on external local business environment than large firms (O'Farrell & Hitchens, 1988). SMEs often have less available resources, fewer R&D activities, and more uncertainties in their market and these issues could be resolved through interacting their networks around them. Given that the interactions are often informal, the areas or cities where they are located could be important supporting space (Tödtling & Kaufmann, 2001). In this vein, compared to large firms, SMEs tend to have a greater degree of regional integration and higher linkages with local economic agents (Crone & Watts, 2000). Houston and Reuschke (2017) also stand on the same ground, arguing that SMEs can benefit more than large firms from urban agglomeration (Romero & Santos, 2007).

One possible exception is technology-intensive SMEs. They are small firms, but they tend to focus on export their product. Thus, the international network could be more important than regional settings (Tödtling & Kaufmann, 2001).

1.5.1.2. Industry and business area

Westhead and Batstone (1998) argue SMEs have a higher willingness to pay for an industrial area such as industrial clusters. They suggest that SMEs tend to enjoy higher productivity per unit of land, thus they can afford premium industrial area to access to other firms and research institutes in a given area.

1.5.1.3. Community services (universities and training facilities)

SMEs largely invest in R&D less than large firms. Tödtling and Kaufmann (2001) find around 13% of SMEs in Upper Austria are engaged in R&D, whereas more than 30% of large firms do in the same region. In this context, there are some pieces of evidence whose proximity to universities tends to help innovative efforts by SMEs, as it is known that SMEs usually have insufficient in-house research capacity (Acs et al., 2006). Tödtling and Kaufmann (2001) also argue SMEs depend on tacit knowledge, and benefit from the knowledge of the local network. Thus, they heavily count on knowledge resources in areas where they are located.

Specifically, research-oriented universities can bring global knowledge to their host regions by taking in cutting-edge global research and sharing them with businesses located closely, which are usually hard to take advantage of global knowledge creation by themselves (Fritsch & Schwirten, 1999).

1.5.1.4. Transport

Almost all SMEs are dependent on good infrastructure, in terms of accessibility. Investments in relevant infrastructures, such as public transport, are important to foster SMEs (ESPON, 2018). Especially for micro-businesses, including home-based firms in residential areas with quality transport infrastructure tend to show greater revenue growth and turn into employers than those in commercial areas. Accessibility is central to how micro-businesses value urban environments (Houston & Reuschke, 2016).

1.5.1.5. Mixed land use

SMEs can benefit from mixed land use in the same vein. Here are some studies, especially for SMEs. Start-ups and other small businesses are attracted to walkable urban areas to take benefits from agglomeration, as spatial proximity allows them to more easily share workers, suppliers, and ideas (Foord, 2013). Yigitcanlar and Dur (2013) also argue that newly established SMEs prefer to be in more walkable places because good access to amenities and public transport can be charmed to attract and retain the talented workforce.

Another study finds neighborhoods equipped with various building types and ages have more start-ups per unit area. Multi-story and historic buildings and pedestrian-friendly districts, and a mix of small and large commercial spaces are helpful to a start-up business, as this type of various building stock can serve as good habitat for local businesses (ILSR, 2014).

1.5.2. Independent firms vs Corporate affiliates

1.5.2.1. Key difference

Relatively, an independent firm may be engaged more in local environments, as they may need to seek market resources in their immediate environment. Miller (1990) argues independent firms tend to be more integrated into regions where they are located. For example, independent firms are likely to procure more from local firms and sell more in the local area. On the other hand, corporate affiliates or subsidiaries seem that urban settings may play a relatively less role, as they can take advantage of the parent company’s internal networks and resources. In more detail, two advantages from a parent company are explained in the earlier section. One is easing of access to production factors such as labor and capital. The other is knowledge sharing. As the former is less related to land use, the knowledge sharing perspective could be a more distinct difference between them.

1.5.2.2. Industry and business area

Bosma et al. (2008) find industry-wise specialized regions are helpful for independent firms. They find that independent ones can benefit from inter-industry knowledge spillovers. One of the main reasons is knowledge spillovers from other firms are less crucial for subsidiaries because knowledge can be transmitted from their parent companies (Bosma et al., 2008).

Westhead and Batstone (1998) take the example of science parks to explain why independent firms consider industrial areas an important factor for their businesses. As independent firms do not have protection from a parent company, they reveal themselves more to uncertainty. As a mechanism for dealing with uncertainty, communication channels provided by science parks are important. For example, science park managers and university-industry liaison officers can help the independent firms find contact information from other firms and research institutions. In addition, science parks can provide technical advice and marketing services to science park firms. Independent firms tend to have less developed communication channels than subsidiaries. Thus, these channels are helpful to counteract to uncertainty. Furthermore, learning opportunities from similar firms and socializing opportunities via informal relationships also can be a good asset to independent firms.

1.5.2.3. Community services (universities and training facilities)

Independent firms do not have technical support and knowledge sharing from their parent company, thus access to knowledge is more critical than subsidiaries. By being located close to universities and research institutes, independent firms can reduce R&D costs, as geographic proximity facilitates knowledge spillovers and knowledge transfer from research institutes can be promoted by frequent informal contacts. In addition, by taking advantage of knowledge and resources from adjacent universities and research institutes, firms can exploit opportunities to make their knowledge and technologies commercialized (Westhead & Batstone, 1998).

1.5.3. Young vs Old firms

1.5.3.1. Key difference

Land use aspects related to a network could make a distinct difference between them. As time goes by, firms obtain more quality experience and reliable business partners. In this sense, already established firms tend to have more suitable partners, even beyond their locations (Holl & Rama, 2009). Along with the life cycle of firms, the firms' level of dependence on local urban formation can be changed. As expected, a firm may not have enough internal and external resources in its early stage of business, and it may lead the firm to rely more on the local environment such as market, knowledge, and infrastructure. Lemarié, Mangematin, and Torre (2001) investigate the different levels of firms' dependence on the local business environment, along with the firms' life cycle. They find that most firms move from an entry phase, which they heavily rely on local assets such as universities and public research institutes, to a mature stage, which their networks are broadened to national or international level.

1.5.3.2. Industry and business area

The above-mentioned, doing business in an industrial area can provide a handful of benefits to firms, and it includes informal networking, knowledge spillovers, and joint marketing. Prashantham (2004) argues that young firms tend to locate in industrial areas to gain such benefits.

1.5.4. High digital intensive vs low intensive firms

1.5.4.1. Key difference

Land use may be less meaningful to high digital intensive firms, as they are less dependent on location and local resources. Laudon and Laudon (2012) indicate the transformation of firms by digitalization. They are flattening, decentralization, flexibility, low transaction costs, and location independence. Digitalization makes firms much freer from their local environment, as digital infrastructure and technology allow them to connect globally beyond their host regions. In that sense, high digital intensive firms have less interaction with local urban settings than ones who have a lower level of digitalization (Laudon & Laudon, 2012).

Forman and Zeebroeck (2019) also argue digital technologies are able for firms to access new knowledge beyond their local areas, allowing them to recombine existing knowledge to newer ones. Thus, digital technologies can reduce the importance of geographic proximity.

1.5.4.2. Mixed land use

One possible exception is mixed land use. Innovation is critical to high digital intensive firms. As mentioned above, digitalization is likely to change the mechanisms of agglomeration economies.

Focusing on the effect of specialization, competition, and diversity, prior studies expect that the impact of specialization and competition on firms' performance may decrease, whereas the effect of diversity may increase. In this vein, mixed land use could be more important to high digital intensive firms.

Autio et al. (2018) argue that digitalization makes the impact of regional characteristics on firms' performance less, since digital technologies are not location-specific, nor local resource-dependent. However, each regional characteristic such as specialization, competition, and diversity have different influence from digitalization. First, decoupling between physical form and its function reduces the importance of asset specificity in vertical transactions. In other words, in earlier technologies, each product has a certain type of vertical production chain to produce the products, whereas such a vertical chain becomes less important in the digitalized world since the form-function linkage of a product is looser. Second, disintermediation, which means the disappearance of middlemen or intermediaries, decreases dependence on local middlemen and resources; it means the advantage of intermediate goods/services/labor pooling becomes smaller. Furthermore, it could dismantle vertical value chains and reorganize business activities around digital infrastructure (Autio et al., 2018). Finally, generativity enhances the role of diversity, since it makes easier a variety of innovations from heterogeneous sources. It also allows geographically diverse audiences to take part in innovation processes.

Nambisan (2017) adds the importance of digital infrastructure on altering mechanisms of agglomeration economies. Digital infrastructure is a series of digital tools and systems such as crowdsourcing, cloud computing, online communities, and digital marketplaces. It makes it easier to collaborate beyond regional boundaries. For example, crowdsourcing promotes direct interactions among producers, consumers, and innovators who have a variety of backgrounds on a global scale. In addition, digital infrastructure contributes to combining knowledge and data, even processes of various physical artifacts, which were not connected previously. Lendle et al. (2013) emphasize that digital technologies can transform the dynamics of regional competition. Digital technologies, especially for online platforms, make easier access to a broader international market. ILO (2018) also stays in line with the studies above. It stresses that innovation ecosystem such as technology hubs expedites the exchange of ideas among peers, and start-ups take advantage of e-commerce platforms to sell their products globally. Furthermore, it tends to integrate heterogeneous knowledge from distinctively specialized industries (Yoo et al., 2012). In sum, the digital infrastructure can decrease the impact of specialization and competition, whereas it can increase the effect of diversity.

Considering the impact mentioned above, overall, digitalization weakens regional characteristics' influence on firms' performance, whereas only diversity can be strengthened through generativity. Put differently, not specialization but diversity may matter for digital intensive firms, and mixed land use, as an urban formation to promote diversity, may matter as well.

1.5.5. High R&D intensive vs low intensive firms

1.5.5.1. Key difference

R&D intensive businesses tend to be less dependent on local resources. Holl and Rama (2009) argue knowledge is one of the most important assets, and knowledge is not always available locally. Thus, R&D intensive firms need to stretch their networks beyond their locality. They find the R&D intensity of firms is positively related to extra-regional cooperation, as R&D intensive firms may not find the all needed knowledge in their local areas. In the same vein, community service such as university matters to R&D intensive firms. R&D intensity tends to dampen cooperation among firms, since R&D intensive firms may want to protect their knowledge from their competitors. On the other hand, the degree of R&D intensity is correlated to the demand of knowledge from universities and research institutes.

1.5.5.2. Community services (universities and training facilities)

Rasiah and Govindaraju (2009) report a positive relationship between R&D intensity and the degree of cooperation with universities. They argue the level of in-house R&D improves the absorptive capacity, which is the capability to take advantage of knowledge outside. As a firm engages in R&D

more, the firm can benefit from the knowledge of partners outside. Agrawal and Cockburn (2003) also argue R&D oriented firms are the main consumer and supporters for local universities and research institutes. It is because R&D intensive firms can absorb and commercialize knowledge from local universities than less R&D intensive ones. Bonaccorsi et al. (2014) suggest the tendency of co-location of R&D intensive firms and universities. They explain a new R&D intensive firms could be created in an area where valuable knowledge exists, as knowledge and information are critical resources for their business performance. Therefore, it is acceptable to expect a new creation of R&D intensive firms that are correlated to the presence of knowledge organizations such as universities.

1.5.6. Born-Global vs Gradualist firms

1.5.6.1. Key difference

As explained in the firm typology section, the biggest difference between them is the target market. Born-Globals focus on the international market from its founding, whereas gradualists emphasize the domestic market first, and then expand the horizon globally. By definition, Born-Globals are less sensitive to the regional business environment, including urban spatial elements, than the gradualists. However, it does not necessarily mean that all urban elements are not important to Born-Globals, and all are critical to gradualists. Land use, which can help access to the target market, is important to each type of firms. In this sense, specialized industrial location and advanced research institutes are critical to Born-Globals.

1.5.6.2. Industry and business area

Based on Tanve (2012) and Spencer (2015), specialized industrial sites can increase the performance of Born-Global firms. As mentioned above, many of them are in the knowledge-intensive sector. This type of industry requires scientific knowledge, rather than artistic knowledge. In terms of knowledge spillovers, more specialized regional industrial characteristics are helpful to exchange technology-based knowledge among the firms. Prashantham (2004) also argues a spatially concentrated network can enhance externalities that expedite firms' internationalization more than in less spatially concentrated firms. The study mentions two main reasons. First, firms can improve the quality of their products from better access to human resources, quality intermediaries. Second, firms can take advantage of a local network which contains international connections. For example, creating a relationship with subsidiaries of global companies can provide the opportunity for firms to collaborate with them, leading to the global market.

1.5.6.3. Community services (universities and training facilities)

Community facilities such as universities and specialized industrial sites are important factors rather than other land uses to Born-Globals. On the other hand, gradualists relatively prefer to be located with better transport infrastructure. Knowledge related facilities such as universities and research institutes can be effective to improve productivity and business performance. For example, Kudina et al. (2008) argue successful Born-Globals utilize effectively three kinds of ecosystems. One of the ecosystems is anchored around universities and firms from the same industry sectors. Taking part in the ecosystem allows the firms to access technological knowledge and a capable labor force. The knowledge and expertise from the ecosystem give an international competitive edge (Tanev, 2012).

Table 1.8 summarizes the key difference by the firm type, the firm type that needs the benefits from agglomeration economies more, the agglomeration sources needed and the benefits, and the important land use by firm type.

Table 1.8. Relative importance of land use by firm type

Type	Key difference	Type needs agglomeration	Agglomeration sources needed	Bene-fits	Important land uses	Details	Authors
Large vs SMEs	SMEs can shape less their external environment than large ones. SMEs tend to have a greater degree of regional integration and higher linkages with local economic agents.	SMEs	Knowledge spillovers	TFP	Industry & business	SMEs are willing to pay for the premium industrial area to access to other firms.	Westhead & Batstone (1998)
			Knowledge spillovers	TFP	Community	SMEs benefit from the knowledge of the local network. Thus, they heavily count on knowledge resources in areas where they are located.	Fritsch & Schwirten (1999) Tödtling & Kaufmann (2001)
			Labor market pooling; Knowledge spillovers; Input sharing; Human capital	TFP; Cost; Labor quality	Transport	SMEs are dependent on infrastructure in terms of accessibility. Accessibility is central to how SMEs value urban environments.	Houston & Reuschke (2016) ESPON (2018)
			Knowledge spillovers; Labor market pooling	TFP	Mixed land use	Walkable areas allow to share workers, suppliers, ideas easier. SMEs prefer to be in more walkable places because good access to amenities can be charmed to attract a talented workforce.	Foord (2013) Yigitcanlar & Dur (2013)
Independent vs Affiliates	Independent firms engage more in local environments, as they cannot utilize knowledge from their parents.	Independent	Knowledge spillovers	TFP	Industry & business	Independent firms can benefit from inter-industry knowledge spillovers. Learning opportunities from similar firms and socializing opportunities via informal settings can be an asset to independent firms.	Westhead & Batstone (1998) Bosma et al. (2008)
			Knowledge spillovers	TFP	Community	By being located close to universities and research institutes, independent firms can reduce R&D costs.	Westhead & Batstone (1998)
Young vs Old	Young firms tend to have less suitable partners.	Young	Knowledge spillovers	TFP	Industry & business	Industrial areas provide benefits to young firms, and it includes informal networking and knowledge spillovers.	Prashantham (2004)
Digital intensive vs Low intensive	Innovation sources are critical to high digital intensive firms.	Digital intensive	Knowledge spillovers	TFP	Mixed land use	Mixed land use promotes regional diversity, and it boosts knowledge spillovers.	Yoo et al. (2012) Nambisan (2017) Autio et al. (2018)
R&D intensive vs Low intensive	Knowledge is the most important assets to R&D intensive firms	R&D intensive	Knowledge spillovers	TFP	Community	A positive relationship between R&D intensity and cooperation with universities is found. R&D-oriented firms are the main consumer of local universities.	Agrawal & Cockburn (2003) Rasiah & Govindaraju (2009)
Born-Global vs Gradualist	The biggest difference is the target market	Born-Global	Knowledge spillovers	TFP	Industry & business	The spatially concentrated network can enhance externalities that expedite firms' internationalization. Specialized industrial sites can boost knowledge spillovers for the Born-Global firms.	Prashantham (2004) Tanve (2012) Spencer (2015)
			Knowledge spillovers	TFP	Community	Successful Born globals utilize effective knowledge from universities.	Kudina et al. (2008) Tanev (2012)

1.6. Summary discussion

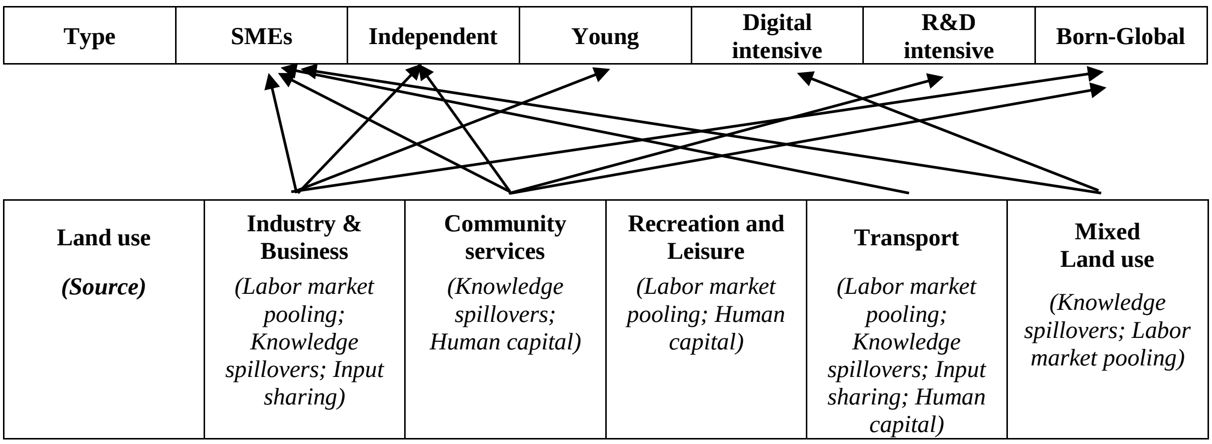
As mentioned in the earlier sections, cities provide a conducive business environment for firms through the sources of agglomeration economies. These sources includes labor market pooling, knowledge spillovers, human capital, input sharing and so on. Figure 1.1 shows the image of bundled effects from a city to firms.

Figure 1.1. Bundled effect from cities

Firm performance				
Labor market pooling	*Knowledge spillovers*	⇧	*Human capital*	*Input sharing*
Cities				

Nevertheless, the fact that cities have the sources of agglomeration economies is not practically useful, as building a city from scratch is not a common policy tool for greater performance of firms. By contrast, changing land use type is one of the common policy tools to improve economic outcomes or citizens' well-being. In this regard, unbundling the agglomeration economies sources, furthermore, exploring the differential effects by firm type are helpful to take customized policy measures for target firms or industries. Figure 1.2 shows the unbundled effects from a city to firms by land use and firm type. Understanding the differential effects by land use and firm type allows policy makers for customizing policy measures for target firms and industries by selecting or changing proper land uses.

Figure 1.2. Unbundled effects by land use and firm type



1.7. Conclusion

This paper explores the relationship between land use and firm performance, in particular, how different dynamics can be expected between each element of land uses and each type of firm. Prior studies have revealed that land use in dense urban areas can play substantial roles to support firms. This paper contributes to this topic by providing a comprehensive view and investigating the differential effects of land use on firm performance, depending on firm types.

As mentioned in earlier sections, the economic relationship between land use and firm performance is practically important from the public policy point of view, as each land use is related to policy tools that governments can handle. If policymakers have the whole picture on the relationship, they can take policy measures to change land use, leading to higher performance of firms.

A room for further improvement also exists. First, with regard to the relationship between each land use and performance of each firm type, most prior studies have interests in the impact of knowledge spillovers on firms' performance. However, other sources agglomeration economies such as labor market pooling, input sharing, and quality human capital could have substantial effects on businesses. Greater attention is needed. In addition, compared to the traditional firm types such as large firms vs SMEs, relatively studies on recent types such as digital-intensive firms are dearth. Future studies need to investigate these areas to fill the knowledge gap. Finally, future studies may need to focus on an empirical investigation on this relationship, as empirical evidence on the relationship between each type of firm and each element of land use is insufficient.

Appendix 1.1. Small and medium firm criteria table (As of 2015)

The average revenue of recent three years is less than each standard, a firm is classified as either a medium-sized firm or a small-sized firm.

(Unit: KRW million)

Industry	Sec-tion	Divi-sion	Medium -sized	Small -sized
Agriculture, forestry and fishing	A	-	100000	8000
Mining and quarrying	B	-	100000	8000
Manufacture of Food Products	C	10	100000	12000
Manufacture of Beverages	C	11	80000	12000
Manufacture of Tobacco Products	C	12	100000	8000
Manufacture of Textiles, Except Apparel	C	13	100000	8000
Manufacture of wearing apparel, Clothing Accessories and Fur Articles	C	14	150000	12000
Tanning and Dressing of Leather, Manufacture of Luggage and Footwear	C	15	150000	12000
Manufacture of Wood Products of Wood and Cork; Except Furniture	C	16	100000	8000
Manufacture of Pulp, Paper and Paper Products	C	17	150000	8000
Printing and Reproduction of Recorded Media	C	18	80000	8000
Manufacture of Coke, hard-coal and lignite fuel briquettes and Refined Petroleum Products	C	19	100000	12000
Manufacture of chemicals and chemical products except pharmaceuticals, medicinal chemicals	C	20	100000	12000
Manufacture of Pharmaceuticals, Medicinal Chemicals and Botanical Products	C	21	80000	12000
Manufacture of Rubber and Plastic Products	C	22	100000	8000
Manufacture of Other Non-metallic Mineral Products	C	23	80000	12000
Manufacture of Basic Metal Products	C	24	150000	12000
Manufacture of Fabricated Metal Products, Except Machinery and Furniture	C	25	100000	12000
Manufacture of Electronic Components, Computer, Radio, Television and Communication Equipment and Apparatuses	C	26	100000	12000
Manufacture of Medical, Precision and Optical Instruments, Watches and Clocks	C	27	80000	8000
Manufacture of electrical equipment	C	28	150000	12000
Manufacture of Other Machinery and Equipment	C	29	100000	12000
Manufacture of Motor Vehicles, Trailers and Semitrailers	C	30	100000	12000
Manufacture of Other Transport Equipment	C	31	100000	8000
Manufacture of Furniture	C	32	150000	12000
Other manufacturing	C	33	80000	8000
Electricity, gas, steam and water supply	D	-	100000	12000
Sewerage, waste management, materials recovery and remediation activities	E	-	80000	3000
Construction	F	-	100000	8000
Wholesale and retail trade	G	-	100000	5000
Transportation	H	-	80000	8000
Accommodation and food service activities	I	-	40000	1000
Information and communications	J	-	80000	5000
Financial and insurance activities	K	-	40000	8000
Real estate activities and renting and leasing	L	-	40000	3000
Professional, scientific and technical activities	M	-	60000	3000
Business facilities management and business support services	N	-	60000	3000
Education	P	-	40000	1000
Human health and social work activities	Q	-	60000	1000
Arts, sports and recreation related services	R	-	60000	3000
Membership organizations, repair and other personal services	S	-	60000	1000

Appendix 1.2. Sectoral taxonomy of digital intensity

Sector denomination	ISIC rev.4	Digital intensity (2001-03)	Digital intensity (2013-15)
Agriculture, forestry, fishing	01-03	Low	Low
Mining and quarrying	05-09	Low	Low
Food products, beverages, and tobacco	10-12	Low	Low
Textiles, wearing apparel, leather	13-15	Medium-low	Medium-low
Wood and paper products, and printing	16-18	Medium-high	Medium-high
Coke and refined petroleum products	19	Medium-low	Medium-low
Chemicals and chemical products	20	Medium-low	Medium-low
Pharmaceutical products	21	Medium-low	Medium-low
Rubber and plastics products	22-23	Medium-low	Medium-low
Basic metals and fabricated metal products	24-25	Medium-low	Medium-low
Computer, electronic and optical products	26	High	Medium-high
Electrical equipment	27	Medium-high	Medium-high
Machinery and equipment n.e.c.	28	High	Medium-high
Transport equipment	29-30	High	High
Furniture; other manufacturing; repairs of computers	31-33	Medium-high	Medium-high
Electricity, gas, steam, and air cond.	35	Low	Low
Water supply; sewerage, waste management	36-39	Low	Low
Construction	41-43	Low	Low
Wholesale and retail trade, repair	45-47	Medium-high	Medium-high
Transportation and storage	49-53	Low	Low
Accommodation and food service activities	55-56	Low	Low
Publishing, audiovisual, and broadcasting	58-60	Medium-high	Medium-high
Telecommunications	61	High	High
IT and other information services	62-63	High	High
Finance and insurance	64-66	High	High
Real estate	68	Low	Low
Legal and accounting activities, etc.	69-71	High	High
Scientific research and development	72	Medium-high	High
Advertising and market research; other business services	73-75	High	High
Administrative and support service activities	77-82	High	High
Public administration and defence	84	Medium-high	Medium-high
Education	85	Medium-low	Medium-low
Human health activities	86	Medium-high	Medium-low
Residential care and social work activities	87-88	Medium-low	Medium-low
Arts, entertainment, and recreation	90-93	Medium-low	Medium-high
Other service activities	94-96	Medium-high	High

Note: “High” identifies sectors in the top quartile of the distribution of the values underpinning the “global” taxonomy, “medium-high” the second-highest quartile, “medium-low” the second-lowest, and “low” the bottom quartile.
Source: OECD (2019c). Measuring the Digital Transformation: A Roadmap for the Future

Appendix 1.3. R&D intensity classification at a two-digit level (ISIC ver4)

	Manufacturing	Non-manufacturing
High	21: Pharmaceuticals 26: Computer, electronic and optical products	72: Scientific research and development
Medium-high	30: Other transport equipment 29: Motor vehicles, trailers, and semi-trailers 28: Machinery and equipment n.e.c. 20: Chemicals and chemical products 27: Electrical equipment	58: Publishing activities 62-63: IT and other information services
Medium	22: Rubber and plastic products 32: Other manufacturing 23: Other non-metallic mineral products 24: Basic metals 33: Repair and installation of machinery	
Medium-low	13: Textiles 25: Fabricated metal products, except machinery 15: Leather and related products 17: Paper and paper products 10-12: Food products, beverages, and tobacco 14: Wearing apparel 19: Coke and refined petroleum products 31: Furniture 16: Wood and products of wood and cork 18: Printing and reproduction of recorded media	69-75: Professional, scientific and technical activities except for scientific R&D (ISIC 69 to 75 except 72) 61: Telecommunications 05-09: Mining and quarrying
Low		64-66: Financial and insurance activities 35-39: Electricity, gas, water supply, waste mgt 59-60: Audio-visual and broadcasting activities 45-47: Wholesale and retail trade 01-03: Agriculture, forestry, and fishing 41-43: Construction 77-82: Administrative and support service activities 90-99: Arts, entertainment, repair of household goods 49-53: Transportation and storage 55-56: Accommodation and food service activities 68: Real estate activities

Source: Galindo-Rueda & Verger (2016).

Reference list

Ades, A.F. and E.L. Glaeser (1995). Trade and circuses: Explaining urban giants. *Quarterly Journal of Economics*, *110*, 195-227.

Agrawal, A., & Cockburn, I. (2003). The anchor tenant hypothesis: Exploring the role of large, local, R&D-intensive firms in regional innovation systems. *International Journal of Industrial Organization, 21*(9), 1227-1253.

Andersson, F., Burgess, S., & Lane, J. I. (2007). Cities, matching and the productivity gains of agglomeration. *Journal of Urban Economics, 61*(1), 112-128.

Audretsch, D., & Keilbach, M. (2004). Entrepreneurship and regional growth: An evolutionary interpretation. *Journal of Evolutionary Economics, 14*, 605–616. DOI: 10.1007/s00191-004-0228-6

Auckland Council (2017). The relationship between pedestrian connectivity and economic productivity in Auckland’s city centre. Technical Report 2017/007

Audretsch, D.B. & Feldman, M.P. (1996). R&D spillovers and the geography of innovation and production. *American Economic Review, 86*(3), 630-640.

Bereitschaft, B (2019). Are walkable places tech incubators? Evidence from Nebraska’s ‘Silicon Prairie.’ *Regional Studies, Regional Science, 6*(1), 339-356, DOI:10.1080/21681376.2019.1620631

Berger, Allen N., Anthoney Sanders, Joseph M. Scalise, and Gregory F. Udell, “The Effects of Bank Mergers and Acquisitions on Small Business Lending.” Journal of Financial Economics, 1998.

Bonaccorsi, A., Colombo, M. G., Guerini, M., & Lamastra, C. R. (2014). How universities contribute to the creation of knowledge-intensive firms: detailed evidence on the Italian case. In Knowledge, Diversity and Performance in European Higher Education. Edward Elgar Publishing.

Bosma, N., van Stel, A., & Suddle, K. (2008). The geography of new firm formation: Evidence from independent start-ups and new subsidiaries in the Netherlands. *International Entrepreneurship and Management Journal*, *4,* 129–146

Bradley, S., Aldrich, H., Shepherd, D., & Wirlund, J. (2011). Resources, environmental change, and survival: asymmetric paths of young independent and subsidiary organizaions. *Strategic Management Journal*, *32*, 486–509

Brunswicker, S. & W. Vanhaverbeke. (2015). Open innovation in small and medium-sized enterprises (SMEs): External knowledge sourcing strategies and internal organizational facilitators. *Journal of Small Business Management, 53*(4), 1241-1263. http://dx.doi.org/10.1111/jsbm.12120

Calvino, F. et al. (2018), "A taxonomy of digital intensive sectors", OECD Science, Technology and Industry Working Papers, No. 2018/14, OECD Publishing, Paris, https://dx.doi.org/10.1787/f404736a-en

Caragliu, A., & Del Bo, C. F. (2015). Do smart cities invest in smarter policies? Learning from the past, planning for the future. Social Science Computer Review,. doi:10.1177/0894439315610843.

Cheshire, P., Hilber, C., & Kaplanis, I. (2015). "Land use regulation and productivity—land matters: evidence from a UK supermarket chain", Journal of Economic Geography, Vol15, Issue 1, pp 43–73

Cohen, W.M. and Levinthal, D.A. (1990) 'Absorptive capacity: a new perspective on learning and innovation', Administrative Science Quarterly 35(1): 128-152.

Cohendet, P., & Simon, L. (2008). Knowledge intensive firms, communities and creative cities. Community, economic creativity, and organization, 1, 227-254.

Costa, P., & Lopes, R. (2015). Urban design, public space and the dynamics of creative milieux: A photographic approach to Bairro Alto (Lisbon), Gràcia (Barcelona) and Vila Madalena (São Paulo). Journal of Urban Design, 20(1), 28–51.

Criscuolo, C., P. Gal and C. Menon (2014), The Dynamics of Employment Growth: New Evidence from 18 Countries", OECD Science, Technology and Industry Policy Papers, No. 14, OECD Publishing, Paris. http://dx.doi.org/10.1787/5jz417hj6hg6-en

Crone, M., and H.D. Watts. (2000). MNE supply linkages and the local SME sector: Evidence from Yorkshire and Humberside. Local Economy 15, no. 4: 325–37.

De Jong, J. and O. Marsili (2006), "The fruit flies of innovations: A taxonomy of innovative small firms", Research Policy, Vol. 35/2, pp. 213-229, http://dx.doi.org/10.1016/J.RESPOL.2005.09.007.

Davis, D.R. and D.E. Weinstein (1999), "Economic geography and regional production structure: An empirical investigation," European Economic Review 43: 379-407.

Deltour, F. LeGall, S. and Lethiais, V. (2017). Innovating not Only in Cities: Evidence from SMEs. Canadian journal of regional science, 40(3), pp. 213-223.

Diamond, C.A. and C.J. Simon (1990), "Industrial Specialization and the Returns to Labor," Journal of Labor Economics 8(2): 175-201.

Doran, J, Jordan, D, & O'Leary. E. 2012. The effects of the frequency of spatially proximate and interactions on innovation by Irish SMEs. Entrepreneurship and Regional Development 24 (7-8), 705-727.

Dumais, G. G. Ellison, and E. Glaeser (1997), Geographic concentration as a dynamic process, NBER Working Paper 6270.

Duranton, G. and Puga, D. (2015). Urban Land Use, ch. Chapter 8, p. 467-560, Elsevier

E.A. van Noort and I.J.T. Reijmer, (1999). Location choice of SMEs, EIM

EC (2019). Cluster programmes in Europe and beyond

Ellison, G. and E. Glaeser (1999), "The geographic concentration of an industry: Does natural advantage explain agglomeration," American Economic Association Papers and Proceedings 89, 311-316

ESPON (2018). Small and Medium-Sized Enterprises in European Regions and Cities

Fan, T. and Phan, P. (2007). International New Ventures: Revisiting the Influences behind the 'Born-Global' Firm. Journal of International Business Studies, Vol 38 (7), pp. 1113-1131

Florio, M. 1996. Large firms, entrepreneurship and regional development policy: ‘Growth poles’ in the Mezzogiorno over 40 years. Entrepreneurship and Regional Development 3: 263–95.

Forman, C., & van Zeebroeck, N. (2019). Digital technology adoption and knowledge flows within firms: Can the Internet overcome geographic and technological distance?. Research Policy, 48(8), 103697.

Freeman, J., Styles, C., and Lawley, M. (2012). Does firm location make a difference to the export performance of SMEs? International Marketing Review. Vol. 29 No. 1, pp. 88-113

Fitjar, R. and Rodríguez-Pose, A. (2019). Where cities fail to triumph: The impact of urban location and local collaboration on innovation in Norway. Journal of Regional Science, 1–28. DOI: 10.1111/jors.12461

Florida, R., & King, K. (2016). Rise of the startup neighborhood: Micro-clusters of venture capital and startup activity at the neighborhood level. Working Paper Series, Martin Prosperity Institute at the Rotman School of Management, University of Toronto.

Gibbons, S., Lyytikäinen, T., Overman, H., and Sanchis-Guarner, R. (2019). New road infrastructure: The effects on firms. Journal of Urban Economics 110, 35–50

Gill, S., Handley, J., Ennos, R., Pauleit, S., Theuray, N., and Lindley, S. (2008). Characterising the urban environment of UK cities and towns: A template for landscape planning. Landscape and Urban Planning 87:210–222. doi:10.1016/j.landurbplan.2008.06.008

Gilman, M. and P. Edwards (2008), “Testing a Framework of the Organization of Small Firms Fast-growth, High-tech SMEs”, International Small Business Journal, Vol. 26/5, pp. 531-558, http://dx.doi.org/10.1177/0266242608094028

Giner, J., Santa-María, M., and Fuster, A. (2017). High-growth firms: does location matter? International Entrepreneurship and Management Journal, Vol 13 (1), pp 75

Glaeser, E., J. Kolko, and A. Saiz (2001), "Consumer City," Journal of Economic Geography 1:27-50.

Grimes, A. Ren, C., and Stevens, P. (2012). The need for speed: impacts of internet connectivity on firm productivity. Journal of Productivity Analysis, vol 37 (2), pp 187–201

Hacker, S. (1999). The Effect of Residential Crowding on Labor Productivity with Evidence from the Twilight of Polish Socialism. Real Estate Economics. Vol 27 (1), pp135-167

Haller, S. A., & Siedschlag, I. (2011). Determinants of ICT adoption: Evidence from firm-level data. Applied Economics, 43(26), 3775-3788.

Hart, M., McQuinness, S. (2003). Small Firm Growth in the UK Regions 1994-1997: Towards an Explanatory Framework. Regional Studies, 37 (2), 109-12.

Hanushek, E. A. and Quigley, J. M. (1990) Commercial land use regulation and local government finance, American Economic Review, 80, pp. 176–180.

Healthy Spaces & Places (2009). Design Principle – Mixed Land Use. Retrieved from https://www.healthyplaces.org.au/userfiles/file/Mixed%20Land%20Use%20June09.pdf

Henderson, J.V. (2003), "The Urbanization Process and Economic Growth: The So-What Question," Journal of Economic Growth 8: 47-71.

Holl, A. and Rama, R. (2009). The Spatial Patterns of Networks, Hierarchies and Subsidiaries, European Planning Studies, 17:9, 1261-1281

Holmes, T. J. (1999), "Localization of Industry and Vertical Disintegration," Review of Economics and Statistics, Vol. 81(2): 314-25.

Houston, D, and Reuschke, D. (2016). MICROBUSINESSES AND THE CITY, Scottish Cities Knowledge Center

Houston, D, and Reuschke, D. (2017). City economies and microbusiness growth, Urban Studies, Vol. 54(14) 3199–3217

HO, K. C. 2009. The neighbourhood in the creative economy: Policy, practice and place in Singapore. Urban Studies, 46, 1187-1201.

Hsieh, C, and Moretti, E. (2017). Housing Constraint and Spatial misallocation. NBER WORKING PAPER SERIES, Working Paper 21154, Retrieved from http://www.nber.org/papers/w21154

INDERGAARD, M. 2009. What to make of New York's new economy? The politics of the creative field. Urban Studies, 46, 1063-1093.

Institute for Local Self-Reliance (XXXX). Small Business Support. Policy Brief : Local Progress: The National Municipal Policy Network

Institute for Local Self-Reliance (2014). Older, Smaller, Better: Measuring how the character of buildings and blocks influences urban vitality," Preservation Green Lab and National Trust for Historic Preservation

Jaffe, A. B. M. Trajtenberg, and R. Henderson (1993), "Geographic Localization of Knowledge Spillovers as Evidenced by Patent Citations," Quarterly Journal of Economics 108: 577-598.

James, P. and Bound, D. (2009). Urban Morphology types and open space distribution in urban core areas. Urban Ecosyst. 12:417–424. DOI 10.1007/s11252-009-0083-1

JPMorgan Chase&Co (2014). The Missing Link: Clusters, Small Business Growth and Vibrant Urban Economies: An Analysis of Small Business Development Strategies in the Nation's Ten Largest Cities

Kalinic, I. and Forza, C. (2012). Rapid internationalization of traditional SMEs: Between gradualist models and born globals. International Business Review 21. 694–707

Kane, K., and Clark, W. (2018). Mapping the landscape of urban work: Home-based businesses and the built environment. Environment and Planning A: Economy and Space, Vol. 51(2) 323–350

Keeble, D. 1997. Small firms, innovation and regional development in Britain in the 1990s. Regional Studies, 31: 281–293

Kihonge E., (2014). The Role of Small and Medium Enterprises (SMEs) in small towns in Rural-Urban continuum: The Karatina in Mt. Kenya Region, Central Kenya. Ph.D thesis

Kim, S. (1999), Regions, resources and economics geography: Sources of U.S. regional comparative advantage, 1880-1987, Regional Science and Urban Economics, 29: 1-32.

Kim, K. (2008). The Effect of the Regional Industrial Structure and Cooperative Network on Technology Innovation. Korean Association of Governmental Studies.06, 343-365

Kim, H., Ahn S., and Ulfarsson, G (2018). Transportation infrastructure investment and the location of new manufacturing around South Korea's West Coast Expressway. Transport Policy, vol 66, 146-154

Koirala, S. (2018). SMEs: Key Drivers of Green and Inclusive Growth. Issue Paper. 2018 GGSD Forum and GGKP6 annual Conference

KPMG (2018). The Value of Community Sport Infrastructure: Investigating the value of community sport facilities to Australia.

Laudon, K. and Laudon, J. (2012). Management Information Systems: Managing the Digital Firm. Twelve edition. Prentice Hall

Lehto, E., Lähdemäki, S., & Mäkynen, E. (2018). The Role of Natural Resources and Geography for Productivity in Developed Countries. Working Papers 320. Labour Institute for Economic Research. Helsink

Lemarié, S., Mangematin, V. and Torre, A. (2001). Is the Creation and Development of Biotech SMEs Localised? Conclusions Drawn from the French Case. Small Business Economics, 17: 61–76

Levy, A. (1999). Urban morphology and the problem of the modern urban fabric: some questions for research, Urban Morphology, 3(2), 79-85

Louw, E. (2009). Changing industrial land use: a firm level analysis. 49th Congress of the European Regional Science Association in Lodz (Poland) 24-29 August 2009. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.513.215&rep=rep1&type=pdf

Łuczka, T. and Przepióra, P. (2012). Regional Determinants of Efficiency Growth of Small and Medium-Sized Enterprises: Evidence from Poland. Journal of Entrepreneurship, Management and Innovation (JEMI), Volume 8, Issue 1, 138-154

Macpherson, A. 2008. Producer service linkages and industrial innovation: results of a twelve-year tracking study of New York State manufacturers. Growth and Change 39(1), 1-23.

Mazzarol, T. and S. Reboud (2009), Strategic Innovation in Small Firms, Edward Elgar Publishing, Cheltenham, (UK) and Northampton (MA, USA).

McCann, P. and Ortega-Argile´s, R., (2016). Smart specialisation, entrepreneurship and SMEs: issues and challenges for a results-oriented EU regional policy, Small Bus Econ, 46:537–552, DOI 10.1007/s11187-016-9707-z

Medium (2019). 10 Ways Small Businesses Benefit Their Local Communities. Retrieved from https://medium.com/@BBBNWP/10-ways-small-businesses-benefit-their-local-communities-7273380c90a9

Metzemakers, P & Louw, E. (2005). "Land as production factor," ERSA conference papers ersa05p220, European Regional Science Association.

Miller, D. and P. Friesen (1982), “Innovation in conservative and entrepreneurial firms: Two models of strategic momentum”, Strategic Management Journal, Vol. 3/1, pp. 1-25, http://dx.doi.org/10.1002/smj.4250030102.

Miller, J. P. (1990). Survival and growth of independent firms and corporate affiliates in metro and nonmetro America. United States Department of Agriculture, Economic Research Service.

Moretti, E. (2000), "Estimating the social return to higher education," NBER Working Paper No.9018.

North D and Smallbone D (1996), Small business development in remote rural areas: The example of mature manufacturing firms in Northern England. Journal of Rural Studies 12(2): 151–167.

North, D, & Smallbone, D. (2000). The innovativeness and growth of rural SMEs during the 1990s. Regional Studies 34(2), 145–157.

OECD (2005). OECD SME and Entrepreneurship Outlook: 2005, OECD Paris

OECD (2009), Promoting Pro-Poor Growth: Employment, OECD Publishing, Paris

OECD (2017a), Spatial Planning and Policy in Israel: The Cases of Netanya and Umm al-Fahm, OECD Publishing, Paris. http://dx.doi.org/10.1787/9789264277366-en

OECD (2017b), Increasing productivity in small traditional enterprises: programmes for upgrading management skills and practices, OECD Working Party on SMEs and Entrepreneurship.

OECD (2017c), The Governance of Land Use in OECD Countries: Policy Analysis and Recommendations, OECD Publishing, Paris. http://dx.doi.org/10.1787/9789264268609-en

OECD (2019a), An OECD Strategy for SMEs: Review of SME and entrepreneurship typologies from the literature. Unpublished paper.

OECD (2019b), "Online platform typologies", in An Introduction to Online Platforms and Their Role in the Digital Transformation, OECD Publishing, Paris, https://dx.doi.org/10.1787/620d0ca9-en.

OECD (2019c), Measuring the Digital Transformation: A Roadmap for the Future, OECD Publishing, Paris. https://doi.org/10.1787/9789264311992-en

OECD (2019d), OECD SME and Entrepreneurship Outlook 2019, OECD Publishing, Paris, https://doi.org/10.1787/34907e9c-en.

OECD (forthcoming), The Spatial Dimension of Productivity: Connecting the dots across industries, firms and places, OECD Publishing, Paris

O'Farrell PN and Hitchens DMWN (1988) Alternative theories of small-firm growth: A critical review. Environment and Planning A 20: 1365–1383.

Okamuro, H., Kobayashi, N. (2006). The Impact of Regional Factors on the Startup Ratio in Japan. Journal of Small Business Management, 44, 310-13.

Parent, O., & LeSage, J. P. (2008). Using the variance structure of the conditional autoregressive spatial specification to model knowledge spillovers. Journal of applied Econometrics, 23(2), 235-256.

Parida, V., Westerberg, M., Ylinenpää, H., and Roininen, S. (2010). Exploring the effects of network configurations on entrepreneurial orientation and firm performance: an empirical study of new ventures and small firms. Annals of Innovation & Entrepreneurship. Vol 1, Issue 1

Rauch, J. (1993a), "Productivity gains from geographic concentration of human capital: Evidence from the cities," Journal of Urban Economics 34: 380-400.

Rasiah, R., and Govindaraju, C. V. (2009). University-industry R&D collaboration in the automotive, biotechnology and electronics firms in Malaysia. Georgia Institute of Technology.

Reuschke, D. and Houston, D. (2016) The importance of housing and neighbourhood resources for microbusinesses. European Planning Studies, 24:6, p.1216-1235. Open Access advance on-line publication available at: http://www.tandfonline.com/doi/abs/10.1080/09654313.2016.1168364

Reuschke, D. and Houston, D. (2017). City economies and microbusiness growth. Urban Studies. Vol. 54(14) 3199–3217

Richardson, H. W., Gordon, P., Jun, M. J. and Kim, M. H. (1993) PRIDE and prejudice: the economic impacts of growth controls in Pasadena, Environment and Planning A, 25, pp. 987–1002.

Pickernell, D., Senyard, J., Jones, P., Packham, G., and Ramsey, E. (2013). New and young firms: Entrepreneurship policy and the role of government – evidence from the Federation of Small Businesses survey. Journal of Small Business and Enterprise Development. Vol 20(2).

Pollard, J. (2003). Small firm finance and economic geography. Journal of Economic Geography. 3. Pp429-452

Prashantham, S. (2004). Local network relationships and the internationalization of small knowledge-intensive firms. The Copenhagen Journal of Asian Studies, 19, 5-26.

Robb, A. (2002). Small Business Financing: Differences Between Young and Old Firms. The Journal of Entrepreneurial Finance. Vol 7 (5).

Romero, I., and F.J. Santos. (2007). Firm size and regional linkages. A typology of manufacturing establishments in Southern Spain. Regional Studies 41, no. 5: 571–84

Romero, I (2011) Analysing the composition of the SME sector in high and low-income regions: Some research hypotheses, Entrepreneurship & Regional Development, 23:7-8, 637-660, DOI: 10.1080/08985626.2010.491872

Rosenthal, S. S. and W. C. Strange (2001), "The Determinants of Agglomeration," Journal of Urban Economics 50: 191-229.

Rosenthal, S. and Strange, W. (2003). Geography, Industrial Organization, and Agglomeration. The Review of Economics and Statistics. vol. 85 (2), pp. 377-393

Rosenthal, S. and Strange, W. (2004). Evidence on the Nature and Sources of Agglomeration Economies. Handbook of Regional and Urban Economics, vol 4, pp 2119-2171

Russo, P., Rossi, P. (2001). Credit constraints in Italian industrial districts. Applied Economics, 33(11): 1469-1477

Santamaria-Varas, M. and Martinez-Diez, P. (2015). How urban fabric fosters knowledge transfer and innovation: the example of Barcelona. 51st ISOCARP Congress 2015. Retrieved from https://www.eventure-online.com/parthen-uploads/95/15ROT/add_1_270030_BHwGFjmHYm.pdf

Schutjens, V. and Stam, E. (2003). The Evolution and Nature of Young Firm Networks: A Longitudinal Perspective Small Business Economics 21: 115–134

Shearmur, R. 2012. Are cities the font of in-novation? A critical review of the literature on cities and innovation. Cities 29, 9-18.

Shinada, N. (2011). "Quality of Labor, Capital, and Productivity Growth in Japan: Effects of employee age, seniority, and capital vintage," Discussion papers 11036, Research Institute of Economy, Trade and Industry (RIETI).

Sleutjes, B., Van Oort, F., amd Schutjens, V. (2012) A Place for Area-Based Policy? The Survival and Growth of Local Firms in Dutch Residential Neighborhoods, Journal of Urban Affairs, 34:5, 533-558, DOI: 10.1111/j.1467-9906.2012.00616.x

Spencer, G (2015). Knowledge Neighbourhoods: Urban Form and Evolutionary Economic Geography, Regional Studies, 49:5, 883-898

Steiner A and Atterton J (2014), The contribution of rural businesses to community resilience. Local Economy 29(3): 228–244.

Tabuchi, T. and A. Yoshida (2000), "Separating Agglomeration Economies in Consumption and Production," *Journal of Urban Economics* 48, 70-84.

Tanev, S. (2012), Global from the Start: The Characteristics of Born-Global Firms in the Technology Sector. Technology Innovation Management Review. Retrieved from https://timreview.ca/article/532

Tödtling, F. and Kaufmann, A. (2001). The Role of the Region for Innovation Activities of SMEs. European Urban and Regional Studies 8(3): 203–215

Toussaint-Comeau, M., Newberger, R., and Augustine, D. (2016). Inclusive Cluster-Based Development Strategies for Inner Cities: A Conference Summary, Economic Development Quarterly, Vol. 30(2) 171–184

Tranos, E., & Mack, E. A. (2016). Broadband provision and knowledge-intensive firms: A causal relationship?. Regional Studies, 50(7), 1113-1126.

UN-Habitat (2013). Streets as Public Spaces and Drivers of Urban Prosperity. UN-Habitat. Nairobi

UN-Habitat (2015). Issue paper on public space. UN-Habitat. Nairobi

Van Biesebroeck, J. (2008). The sensitivity of productivity estimates: Revisiting three important debates. Journal of Business & Economic Statistics, 26(3), 311-328.

Veugelers, R. et al. (2018), “Young SMEs: Driving Innovation in Europe?”, Economics - Working Papers, No. 2018/07, European Investment Bank, Luxembourg

Waldfogel, J. (2003), “Preference Externalities: An Empirical Study of Who Benefits Whom in Differentiated Product Markets,” RAND Journal of Economics

Westhead, P., & Batstone, S. (1998). Independent technology-based firms: the perceived benefits of a science park location. Urban Studies, 35(12), 2197-2219.

Chapter 2

Effects of regional industrial features on firm performance in digital age

Abstract

Digitalization is one of the game-changing trends in the world. However, there have been few studies on the relationship between agglomeration economies and digitalization from a regional perspective. To fill this gap, this study revisits the relationship between regional industrial characteristics (e.g. specialization, competition, and diversity) and employment growth from the perspective of digitalization. In other words, it evaluates the differential effects of regional features on agglomeration economies measured by employment across industries with different degrees of digital intensity. Establishment-level fixed effect estimations, using firm-level panel data, show that "industries as a whole" benefit from intermediate goods/services/skilled labor pooling and within-industry transmissions of knowledge, which are created by specialized regional industrial settings. However, the effects of diversity become greater whereas the effects of specialization and competition get smaller as digital intensity increases. Furthermore, this study finds that only diversity matters for digital intensive industries. Compared to prior studies, the contribution of this paper centers on revealing the differential effects of regional features across digital intensity and shedding light on the importance of regional diversity in the digital age.

Keywords: Digitalization, agglomeration, regional industrial characteristics, employment.

2.1. Introduction

There has been a long debate on the effects of regional industrial characteristics on employment. Prior studies have paid attention to which regional industrial characteristics, such as specialization, competition, and diversity, are more apt to create agglomeration economies (Marshall, 1890; Arrow, 1962; Romer, 1986; Porter, 1990; Jacobs, 1969). People live in a world increasingly marked by digitalization, and it should go without saying that digitalization is transforming many societies extensively in almost every aspect. In this context, it calls for a crucial need to revisit this debate from the viewpoint of digitalization, in particular, the differential effects of regional industrial characteristics on employment across digital intensity. Regional features may have varying effects on a firm's economic performance, depending on the firms' degree of digital intensity. If the regional features do impact a firm's performance, this can be taken into consideration when designing regional settings for optimal agglomeration economies in response to digitalization.

Employment is one of the hot topics in the aftermath of digitalization as it has influenced the labor market. It has threatened existing jobs while creating new opportunities. For instance, automation replaces people with machines whereas it increases the labor demand for non-routine tasks (OECD, 2018). Unlike many negative estimations of its impact on employment, to date, total employment in most developed countries has shown a net increase over the decade. It is mainly because digital intensive industries have contributed to job creation. In addition, they are less threatened by automation (OECD, 2019a). In this context, it is worth considering the relationship between regional features and digital intensive industries. To put it differently, the effect of regional industrial characteristics on employment, especially for digital intensive industries, needs to be investigated.

I investigate the relationship between employment and regional industrial characteristics, such as specialization, competition, and diversity from the perspective of digitalization. Specifically, I explore the relationship on an industry-wide basis, and then check the differential effects of regional features across different levels of digitalization. Furthermore, this study focuses on which regional characteristics are important for digital intensive sectors as the main driver for job creation.

OECD proposes a new industrial taxonomy based on digital intensity by industry. Fixed effect estimation results, using firm level panel data and digital intensity industry taxonomy, show that "industries as a whole" benefit from regional industrial specialization through intermediate goods pooling and within-industry transmissions of knowledge. However, once the models are split by digital intensity, the effect of diversity on employment becomes greater whereas the effects of specialization and competition get smaller, as the digitalization level increases. Diversity is only positively significant in digital intensive industries. This study contributes to reveal the differential effects of regional features across different digitalization levels.

This paper is organized as follows. The next section provides a review of literature on the digital intensity based industry taxonomy, digitalization and employment change, and digitalization and agglomeration economies. Section 2.3 presents employment dynamics in Korea over the past decade. Section 2.4 explains the research questions and hypotheses. Section 2.5 and 2.6 outline the dataset and methodology used in this study. Section 2.7 and 2.8 explain the estimation results and robustness checks. Finally, in section 2.9, I draw conclusions as to the significance of regional diversity and how this might open further avenues of research.

2.2. Literature Review

2.2.1. Industrial taxonomy based on digital intensity

It is essential to use a taxonomy when ascertaining digitalization. This is so, because different industries vary in terms of levels of digital intensity. Therefore, using an industrial taxonomy with respect to digitalization is crucial to test differential effects of regional industrial characteristics on firms' performance across industries in the different pages of digitalization. Digitalization means bringing something new or changing existing activities by using digital technologies (OECD, 2019a). Now, it is important to bear in mind that there is a multiplicity of criteria according to which one can deem a firm digitalized; this can be related to technological components, such as ICT investment, or associated with human capital, such as the proportion of staff specializing in ICT, or even linked to market transaction channels like e-commerce. This means that a single indicator is not enough to measure the various facets of digitalization, and it is therefore required to construct multifaceted indicators to accurately assess the levels of digitalization (OECD, 2019b).

The OECD (2019b) recommends using five indicators when evaluating industry-wide digitalization. These indicators have been shown to hold good across a majority of industries. They are: i) share of ICT investment (e.g. computer hardware and software); ii) share of intermediate purchases of ICT goods (e.g. computer and electronics) and services (e.g. software consultancy and maintenance of computing equipment); iii) the number of industrial robots per hundreds of employees; iv) share of ICT specialists in whole employment; and v) share of turnover from online sales. Furthermore, the OECD determines the overall ranking of digitalization levels across industries by calculating an average of the values of five indicators based on data from twelve OECD countries. Table 2.1 presents the taxonomy based on digital intensity. OECD classifies the industries into four categories; low, mid-low, mid-high, and high.

This study uses this taxonomy to classify industries according to their respective degree of digital intensity. One modification is this study combines “mid-low” and “mid-high” into “mid,” which results in a total of three categories (i.e. low, mid, and high).

Table 2.1. Industry taxonomy by digital intensity, overall ranking (based on data 2013-2015)

Industry denomination (ISIC Rev. 4)	**Digital intensity**	**Industry denomination (ISIC Rev. 4)**	**Digital intensity**
Agriculture, forestry, fishing	Low	Wholesale and retail trade, repair	Mid-high
Mining and quarrying	Low	Transportation and storage	Low
Food products, beverages and tobacco	Low	Accommodation and food service activities	Low
Textiles, wearing apparel, leather	Mid-low	Publishing, audiovisual and broadcasting	Mid-high
Wood and paper products, and printing	Mid-high	Telecommunications	High
Coke and refined petroleum products	Mid-low	IT and other information services	High
Chemicals and chemical products	Mid-low	Finance and insurance	High
Pharmaceutical products	Mid-low	Real estate	Low
Rubber and plastics products	Mid-low	Legal and accounting activities, etc.	High

Basic metals and fabricated metal products	Mid-low	Scientific research and development	High
Computer, electronic and optical products	Mid-high	Advertising and market research, etc.	High
Electrical equipment	Mid-high	Administrative and support service activities	High
Machinery and equipment n.e.c.	Mid-high	Public administration and defense	Mid-high
Transport equipment	High	Education	Mid-low
Furniture; other manufacturing, etc.	Mid-high	Human health activities	Mid-low
Electricity, gas, steam and air cond.	Low	Residential care and social work activities	Mid-low
Water supply; sewerage, waste management	Low	Arts, entertainment and recreation	Mid-high
Construction	Low	Other service activities	High

Note: see appendix 2.1 for more details.
Source: OECD (2019b). Measuring the Digital Transformation: A Roadmap for the Future

2.2.2. Digitalization and importance of digital intensive industries for job creation

OECD (2018) argues that technological progress, such as digitalization, has both positive and negative effects on the labor market. In this analysis, I briefly summarize effects of digitalization on the labor market in terms of employment, employment composition, and wage. This section clarifies how digital intensive industries are one of the key driving forces in job creation.

Firstly, one key factor is employment. Nedelkoska and Quintini (2018) have found that aggregated employment has increased globally in the 20th century. Autor and Salomons (2018) also have revealed that nineteen advanced economies, such as the U.S., Germany, and Korea, have experienced drastic employment growth during decades ranging from the 1970s to the 2000s. In addition, OECD (2019b) has found that the total employment has grown by 6.9% over the period of 2006-2016 across OECD countries, which corresponds to a net increase of 38 million employments. Once again, this net increase runs counter to expectations. The OECD study explains this discrepancy as follows; direct negative effects (e.g. job losses due to automation) are offset by higher indirect positive effects. In other words, the employment increase in other industries that are influenced by digitalization outweighs the employment decrease from industries where technology progress occurs. As such, job creation by growing industries is greater than job losses by shrinking industries. These indirect effects are several. One can cite the input-output linkage effect, where higher productivity in supplier industries allows customer industries to enjoy higher quality of intermediate products for the same prices, or same quality products at lower prices, resulting in inducement of more employment in the customer industries. One can also mention the income effect, where an increase in productivity leads to high profits, which in turn can boost employment wages. These equally entail great employment across industries.

A second factor is employment composition. Even if they occasionally cite different figures, most recent studies concur that digitalization has reduced the number of jobs available. For example, the ILO (2018) stresses digitalization, especially automation, transforms types and reduces the amount of work available. The organization estimates 15% of current works would disappear, and 3-14% of labors globally need to change their tasks, including newly created positions. MGI (2017) estimates about 51% of total working hours are likely to be automated, based on data from more than 40 countries. Walwei (2016) explains the mechanism of such structural change as what can be termed the “polarization of skills”. This term means that the demand for routine-task jobs will decrease whereas the demand for non-routine tasks will increase. This change is because routine tasks are more liable to be automated than non-routine tasks as the former can just as readily be done by machines. According to OECD (2015), these routine tasks are highly associated with middle-skilled and middle-paying jobs. Those whose work consists of completing routine tasks are likely to be moved to non-routine cognitive tasks or low-skilled manual tasks. Kurer and Gallego (2019) have provided empirical evidence, where the relative proportion of middle-skilled routine jobs has decreased while non-routine tasks in both high and low-skilled positions have increased during the period of 1991-2015 in the UK.

Third is the effect on wage. There are mixed evidences. ILO (2017) presented two mixed findings on the relationship between uses of robots and wages. One study showed that more usage of industrial robots are related to higher wages from an industry level dataset for the period 1990s to 2007 in 17 advanced economies. On the other hand, other research presented that robots are related to lower wages during the same period in the U.S. Kurer and Gallego (2019) found that although digitalization increases wages of both non-routine and routine jobs, high-skilled non-routine workers benefit more from digitalization than routine workers, resulting in higher inequality across tasks.

The interest of this study centers on the differential effects of regional industrial characteristics on firms' employments depending on digital intensity of industries. It relates to the first dynamics (i.e. the effect of digitalization on employment), rather than the effects on employment composition or wage. Therefore, it requires further exploring the relationship between digitalization and employment by digital intensity. Digital intensive industries, such as industries with "high" digital intensity, have led to employment growth. Such industries have also contributed to the net employment gain by 42%, which is the greatest share across digital intensity industry taxonomy. Other industry sectors have contributed to the net increase smaller than high digital intensity industries; mid-high 3.7%, mid-low 39.5%, and low 14.8% during the same period. It suggests that digital intensive sectors can contribute more to employment growth than the others (OECD, 2019b).

Another characteristic of digital intensive industries with regard to employment is that they are less vulnerable to job losses from automation. Nedelkoska and Quintini (2018) present top and bottom 20 industries of risk of automation, based on human capital characteristics by industry. As presented in Table 2.2, higher digital intensity tends to have lower risk of automation. It also suggests more digital intensive sectors can contribute more to employment growth as they are less affected by automation.

In sum, digitalization has increased the aggregated employment worldwide, and digital intensive industries have led to aggregated employment growth. In addition, they are more robust against the risk of automation, and they may keep leading the employment growth at least for the present and near future. Therefore, digital intensive industries are one of the key factors in job creations.

Table 2.2. Risk of automation by industry

Digital intensity	Number of industries	Risk of automation		Share of industry with "High" risk
		High	Low	
Low	15	10	5	66.7%
Mid	14	8	6	57.1%
High	11	2	9	18.2%

Note: Only top and bottom 20 industries in terms of mean probability of automation are presented.
Source: Nedelkoska & Quintini (2018). Automation, skills use and training.

2.2.3. Regional industrial characteristics and agglomeration economies

Glaeser et al. (1992) explain different mechanisms of agglomeration economies that Marshall-Arrow-Romer (Marshall 1890; Arrow 1962; Romer 1986), Porter (1990), and Jacobs (1969) argued. First, Marshall-Arrow-Romer (MAR) emphasized the mechanisms from regional industrial specialization. They argue that specialization allows firms to pool intermediate goods/services and skilled labor force since firms in a same industry need similar goods/services/labors; it results in lower cost. In addition, the specialized industrial setting can enhance knowledge spillovers among firms by making within-industry transmissions of knowledge easier. They further argue that a firm's knowledge can help other firms' business activities when they are similar. Evidences are mixed in the Korean context. Kim and Lee (2007) and Kim and Ko (2009) compare the effects of regional industrial settings on employment growth, focusing on manufacturing industries. The results showed that specialization is more important for employment growth in most manufacturing industries whereas light industries showed positive association with diversity. On the other hand, Lee and Jang (2001) found that specialization relates negatively to employment in Korea.

Second, Porter stands by MAR, but he adds another factor: competition. He argues that competition makes innovation faster, and it allows regions and business entities to grow faster. There are also mixed findings. Glaeser et al. (1992) found a positive impact of competition on employment growth in the U.S between 1956 and 1987. In contrast, Kim (2010) found that local competition is negative to employment.

Third, Jacobs' argument is that the main externality in cities occurs across different industries by promoting greater interchange of diverse ideas. In this context, diversified regional industrial settings are beneficial for economic growth. Glaeser et al. (1992), focusing on the U.S. context, found that diversity had a positive impact on employment growth. However, they have also found that specialization does not stimulate employment growth in the U.S. In the context of Korea, Yim and Kim (2003) revealed that regional diversity is positively associated with city-industry employment growth.

Conversely, Kim and Ko (2009) made the case that diversity did not significantly impact employment in Korea.

As the world has entered a digital age, it calls for re-examining the mechanisms of agglomeration economies. Since digital technologies are distinctly different from previous technologies, and digitalization has transformed the means of production, consumption, and interactions among economic agents, it is necessary to look at these mechanisms from a renewed perspective.

2.2.4. Impact of digitalization on agglomeration economies

Digitalization is likely to change the mechanisms and strengths of agglomeration economies. It is because digital technologies have different features from traditional ones. In addition, these differences are impacting the channels running from agglomeration economies to industries. Focusing on the effects of specialization, competition, and diversity, prior studies expected that the impact from specialization and competition on firms' employment may decrease whereas the effects from diversity may increase.

Yoo et al. (2010) argue that there are two distinct differences between digital technologies and earlier technologies. The first difference is "re-programmability." A digital device consists of processing parts and storage parts; if the processing of instructions and data are changed (i.e., re-programmed), the device can function differently. For example, a digital word processor can be reprogrammed as a chatting device. The second difference is what they term "the homogenization of data". This term means data from diverse sources can be merged on a single platform. For example, a range of formats, from text to audio to video, that are previously circulated on separate analogue platforms, can now be converted into a single 0 and 1 format. In other words, digitization is to transform analogue data into digital format that is a set of 0 and 1 (OECD, 2019a), and all kinds of digital contents, such as text, audio, and video, can be resolved into 0 and 1 ultimately. Therefore, heterogeneous digital information can be combined and transformed to other types of digital information.

These aforementioned differences lead to three features in digitalization. Autio et al. (2018) explain the three characteristics. First, digitalization facilitates "decoupling" between a physical form and its function. Physical forms and functions are closely linked in physical technologies. For instance, an analog telephone should have a dial and a receiver to function properly, and the analog telephone is not suitable for another purpose, such as a calculator. By contrast, the re-programmability of digital technologies allows digital devices to be used for various functions, regardless of their physical forms. For example, a smart phone can be a phone and a calculator, depending on the processing units and applications on it. Second, digitalization makes "disintermediation" stronger. Disintermediation means disappearance of middlemen or intermediaries (Jallet & Capek, 2001). For example, the internet makes it much easier to interact directly between manufactures/service providers and resource suppliers/end-users, resulting in increases of flexibility in outsourcing and decreases of importance of location-specific intermediaries (Autio et al., 2018). Third, digitalization promotes "generativity", which means a technology's overall ability to produce unintended change by large, various, and uncoordinated sources (Yoo et al., 2012). It is because digitalization reduces transaction cost by using the internet (Autio et al., 2018), and also the homogenization of data supports this characteristics.

Autio et al. (2018) argue that digitalization is likely to transform mechanisms of agglomeration economies. They maintain that digitalization makes impact of regional characteristics on firms' performance reduced since digital technologies are not location-specific nor local resource dependent. However, each regional characteristic, such as specialization, competition, and diversity, has different influence from digitalization. First, decoupling reduces the importance of asset specificity in vertical transactions. In other words, in earlier technologies, each product had a certain type of vertical production chain to produce products whereas such vertical chain became less important in digitalized world since the form-function linkage of a product is looser. Second, disintermediation decreases dependence on local middlemen and resources; this means advantage of intermediate goods/services/labor pooling becomes smaller. Furthermore, it could dismantle vertical value chains and reorganize business activities around digital infrastructure (Autio et al., 2018). Finally, generativity enhances the role of diversity as it makes easier for a variety of innovations from heterogeneous sources. It also allows geographically diverse audiences to take part in innovation processes.

Nambisan (2017) adds to the importance of digital infrastructure on altering mechanisms of agglomeration economies. Digital infrastructure is a series of digital tools and systems, such as crowdsourcing, cloud computing, online communities, and digital marketplaces. It makes it easier to collaborate beyond regional boundaries. For example, crowdsourcing promotes direct interactions among producers, consumers, and innovators who have a variety of backgrounds on a global scale. In addition, digital infrastructure contributes to combining knowledge and data, even processes of various physical artifacts, which were not connected previously. Lendle et al. (2013) emphasize that digital technologies transform the dynamics of regional competition. Digital technologies, especially for online platforms, provide easier access to a broader international market. ILO (2018) also stays in line with the studies above. It stresses that innovation ecosystems, such as technology hubs, expedite the exchange of ideas among peers, and start-ups can take advantage of e-commerce platforms to sell their products globally. Furthermore, it tends to integrate heterogeneous knowledge from distinctively specialized industries (Yoo et al., 2012). In sum, digital infrastructure can decrease the impact of specialization and competition while increasing the effect of diversity.

Table 2.3 summarizes: i) the effects of regional characteristics on non-digitalized industries, ii) characteristics of digitalization, and iii) whether these characteristics increase or decrease the effects of regional industrial characteristics on firms' performance. Overall, digitalization weakened regional characteristics' influence on firms' performance whereas only diversity could be strengthened through generativity.

Table 2.3. Changes of effects of regional characteristics by digitalization

	i) Impact channels of regional features to firms (non-digitalized industry)	ii) Characteristics of digitalization	iii) Effect of ii) on i) (digitalized industry)

Regional specialization	Pooling of intermediate goods/services/labor force	Decoupling Disintermediation	Weaken
	within-industry knowledge spillover lower transaction costs	Generativity	Weaken
Regional competition	Faster innovation	Competition beyond regional boundaries (digital infrastructure)	Weaken
Regional diversity	Interchange of different ideas	Generativity	Strengthen
		Interchanges beyond regional boundaries (digital infrastructure)	Weaken

As digital intensity gets higher, industries tend to have stronger characteristics of digitalization, such as disintermediation, generativity, and competition/interchanges of ideas beyond regional boundaries. One caveat is, as Tilson et al. (2010) mention, digitalization takes time since it is the process of applying digital technologies into various economic and social contexts. Therefore, industries, even digital intensive industries, are somewhere between non-digitalized industries and fully-digitalized industries.

2.3. Employment dynamics over the past decade in Korea

This section presents several trends of the Korean labor market over the past decade. The purpose is to evaluate whether the labor market dynamics in Korea are similar to the dynamics the previous literature presented.

The first is aggregated employment and its growth rates. Table 2.4 shows employment and growth rates over the period 2006-2016. Disaggregation by region and digital intensity are also presented. Total employments by establishments show a 37.8% increase (a net gain of about 5.8 million jobs). However, disaggregation by region does not show substantial differences; the Seoul Metropolitan Area (SMA), including Seoul, Incheon, and Gyeonggi, and non-SMA have similar employment and growth rates. Focusing on industries with "high" digital intensity, the industries show the highest growth rate (52.1%) nationwide, which means they have led the employment growth in Korea. In addition, the industries with "high" digital intensity have the highest growth rates in both SMA and non-SMA (61.0% in SMA and 41.3% in non-SMA). Notably, there is a considerable gap between the growth rates of the industries with "high" digital intensity in SMA and non-SMA. In other words, the growth rate in SMA is 1.5 times higher than that of non-SMA.

Table 2.4. Employment growth by digital intensity (2006-2016)[1]

<table>
<tr><th colspan="2" rowspan="2"></th><th rowspan="2">Digital intensity</th><th colspan="2">Employment (mil)</th><th rowspan="2">Share of net gain of jobs (%)</th><th rowspan="2">Growth ('06→'16, %)</th></tr>
<tr><th>2006</th><th>2016</th></tr>
<tr><td colspan="2" rowspan="4">All industries</td><td>Low</td><td>4.2</td><td>5.7</td><td>25.9</td><td>35.9</td></tr>
<tr><td>Mid</td><td>8.2</td><td>10.9</td><td>46.6</td><td>33.4</td></tr>
<tr><td>High</td><td>3.0</td><td>4.6</td><td>27.6</td><td>52.1</td></tr>
<tr><td>Total</td><td>15.4</td><td>21.2</td><td>100.0</td><td>37.8</td></tr>
<tr><td rowspan="8">By region</td><td rowspan="4">Seoul Metropolitan Area (SMA)</td><td>Low</td><td>2.0</td><td>2.7</td><td>22.6</td><td>35.1</td></tr>
<tr><td>Mid</td><td>4.2</td><td>5.6</td><td>45.2</td><td>33.4</td></tr>
<tr><td>High</td><td>1.6</td><td>2.6</td><td>32.3</td><td>61.0</td></tr>
<tr><td>Sub-total</td><td>7.8</td><td>10.9</td><td>100.0</td><td>39.5</td></tr>
<tr><td rowspan="4">Non-Seoul Metropolitan Area (Non-SMA)</td><td>Low</td><td>2.1</td><td>2.9</td><td>30.8</td><td>35.7</td></tr>
<tr><td>Mid</td><td>4.0</td><td>5.3</td><td>50.0</td><td>32.1</td></tr>
<tr><td>High</td><td>1.5</td><td>2.0</td><td>19.2</td><td>41.3</td></tr>
<tr><td>Sub-total</td><td>7.6</td><td>10.2</td><td>100.0</td><td>34.8</td></tr>
</table>

Note: Employments and growth rates are rounded off to first decimal places. Data are from http://kosis.kr/statHtml/statHtml.do?orgId=118&tblId=DT_118N_SAUP50 (Accessed on 16 March 2019) by Korea Statistics Agency.

The second is the compositional change and wage. Table 2.5 presents average employment by occupation[2] over the period 2011-2018. Routine task occupations show relatively lower employment growth rates. It may imply, to some degree, that routine tasks are more threatened than non-routine ones as digitalization progresses. In terms of wage by occupation, Table 2.5 also shows that average wages per hour of routine task based occupations, which are middle paying jobs, have a tendency of lower wage increase rates than others. In addition, it was revealed that managers are the occupation with the

[1] The table shows industries with "mid" digital intensity have the lowest growth rates. As these growth rates include both the growth of existing firms and net entry to these industries, the lowest growth rates of the industries with "mid" digital intensity may suggest either lowest growth rates or lowest net entry.

[2] The occupation classification is based on Korean Standard Classifications of Occupations version 6. In addition, the tables show whether each occupation is routine task or not, based on Kim (2014).

highest average wage and the highest growth rate, which leads to the concern of equality issue among occupations.

Table 2.5. Average employment and wage per hour by occupation[3] (2011-2018)

Occupation	Non-routine	Employment (mil)		Growth ('11→'18, %)	Wage per hour (KRW)		Growth ('11→'18, %)
		2011	2018		2011	2018	
Service Workers	Yes	0.3	0.5	67.8	7,436	11,047	48.6
Clerks	No	2.1	3.0	40.4	16,202	22,683	40.0
Professionals and Related Workers	Yes	2.0	2.8	40.0	17,856	24,088	34.9
Elementary Workers	Yes	0.7	0.9	30.6	7,804	12,604	61.5
Sales Workers	No	0.5	0.7	23.9	11,887	15,651	31.7
Equipment, Machine Operating Workers	No	1.6	1.8	10.6	12,292	17,505	42.4
Craft and Related Trades Workers	No	0.6	0.7	10.5	12,897	18,961	47.0
Managers	Yes	0.1	0.1	-6.9	33,458	55,613	66.2
All		8.1	10.5	30.3	13,769	19,522	41.8

Note: Average employment and growth rates are rounded off to first decimal places. Data are from http://kosis.kr/statisticsList/statisticsListIndex.do?menuId=M_01_01&vwcd=MT_ZTITLE&parmTabId=M_01_01&statId=1968001&themaId=B#SelectStatsBoxDiv (Accessed on 21 May 2019) by Korea Statistics Agency.

Table 2.6 shows average monthly wage per person and its growth rates by digital intensity. Interestingly, industries with "high" digital intensity have the highest level of average wage whereas its growth rate is the lowest. Although this study does not touch the relationship between digitalization and wage, one possible explanation is if labor-capital substitution effect is bigger in the industries with "low" and "mid" digital intensity than in "high", which means more low productive workers are replaced by machines in the "low" and "mid" digital intensive industries, it can contribute to a higher growth rate.

Table 2.6. Average wage growth by digital intensity

	Digital intensity	Average monthly wage per person (KRW)		Growth ('11→'18, %)
		2011	2018	
All industries	Low	2,020,893	2,659,067	31.6

[3] International Standard Classifications of Occupations by ILO consist of 10 groups. Two groups (Skilled agricultural, Forestry and Fishery Workers, Armed Forces) were dropped.

	Mid	2,570,890	3,355,749	30.5
	High	3,181,266	3,984,657	25.3
	Total	2,607,006	3,375,933	29.5

Note: Growth rates are rounded off to first decimal places. Data are from http://kosis.kr/statisticsList/statisticsListIndex.do?menuId=M_01_01&vwcd=MT_ZTITLE&parmTabId=M_01_01&statId=1968001&themaId=B#118_ATITLE_1.3 (Accessed on 13 May 2019) by Korea Statistics Agency.

Table 2.4 suggests that, as the global trends in the labor market mentioned in the literature review section, industries with "high" digital intensity remain important to job creation in Korea. In this context, it is necessary to understand which regional factors can influence positively on employment growth, especially for industries with "high" digital intensity. Furthermore, any differential effects by region should be investigated since there are substantial differences of employment growth rates by region, especially for industries with "high" digital intensity.

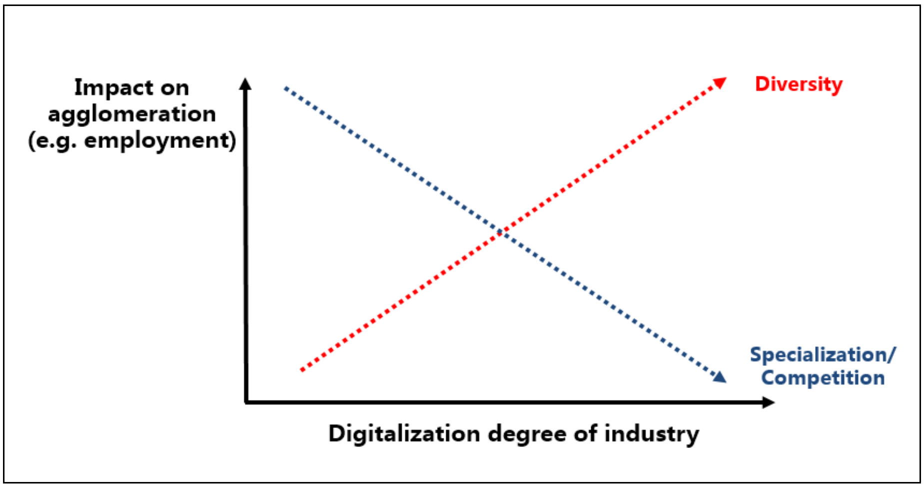
2.4. Research question and hypothesis

The aim of this study is to shed light on the relationship between regional industrial characteristics and agglomeration economies from the perspective of digitalization. Using employment as an indicator of agglomeration, the question of interest is how differential effects of regional industrial characteristics (i.e. specialization, competition, and diversity) lead to firms' employment based on digital intensity.

The previous findings suggest that the effects of regional specialization and competition on firms' employment weaken along with technological progress, mainly because of the characteristics of digitalization, such as disintermediation and competition beyond regional boundaries through digital infrastructure. On the other hand, the effect of diversity can be greater, as digitalization gets stronger, because of generativity. Based on the prior studies, I expect that the effects of specialization and competition on employment decrease as digital intensity of industries rises. By contrast, I expect that the effects of diversity on employment increase as digital intensity of industries steps up. To put it differently, once industries are split into "low", "mid", and "high" digital intensive industries, the coefficients of specialization and competition become smaller as industry samples move from "low" to "mid" to "high" digital intensive industries. Contrary to this, the coefficients of diversity become greater as industry samples move from "low" to "mid" to "high" digital intensive industry.

Previous literature and employment growth rates by digital intensity in Korea also suggest that industries with "high" digital intensity are critical to job creation. In this context, it is important to identify which regional characteristics are influential to employment growth of digital intensive industries. Based on the prior studies, I expect that only diversity has a positive impact on the employment growth of digital intensive industries whereas specialization and competition do not have any impact on digital intensive industries.

Figure 2.1. Theorization based on prior studies



2.5. Description of the dataset

2.5.1. Construction of the dataset

The main dataset is Workplace Panel Survey (WPS). It is nation-wide panel data, collected at the establishment level, every two years over the period 2005-2015 (i.e. WPS 2005, 2007, 2009, 2011, 2013, 2015). The population of WPS is all establishments with more than thirty employees in Korea, except the agriculture, forestry, fishing, and mining industries. WPS 2005 consists of 1,600 private establishments and 100 public ones, and the samples are expanded to 3,331 private establishments and

100 public ones in WPS 2015. The stratified random sampling method was used to draw the samples, considering industries, regions, and sizes. It has information of each establishment on industry sector, location, employments, and financial information, such as revenue (KLI, 2017). Another dataset is Census of Establishment. It is an annual census and includes industry sector, location, and employment at the establishment level. It was used for creating values of three independent variables, which means the region-industry specialization level, the region-industry competition level, and the regional diversity level.

Some data were dropped. First, WPS 2005 was excluded since its industry classification is different from the rest[4]. Second, observations from Jeju Islands were excluded. It is the only region which consists of islands, therefore its agglomerations effects can be different from regions in the mainland.

All private entities were used for this study, but five industries were excluded. First, “finance & insurance” and “electricity, gas, steam and water supply” were dropped since their information is collected at the firm level[5] whereas the others were done at the establishment level. Second, “manufacture of tobacco products” was not used because of its monopoly or oligopoly, which has different agglomeration mechanisms, such as knowledge spillover. The industry was monopolized by the government previously, and it still has the least number of establishment across industries (on average 14 establishments during the period 2007-2015). Third, “remediation activities and other waste management services” and “manufacture of coke, hard-coal and refined petroleum products” were excluded since their independent variable coefficients, especially for the relative levels of region-industry specialization and competition, leave concerns of inaccurate interpretation. To put it differently, the coefficients of independent variables were calculated based on the number of employments by region and industry. If an industry has a small number of employment, small changes of regional

---

[4] Korea Statistics Agency changed industrial classification in 2006. Before 2006, industries were classified by the 8th edition of Korean Standard Industrial Classification. After that, they are done by the 9th edition.

[5] WPS contains information on human resource management. Since human resource related decisions are made by headquarters of firms in the sectors, not by establishment, WPS collects firm level data for the two sectors.

employment in the industry may create relatively big changes of region-industry levels of specialization and competition. The two industries are in bottom 5% in terms of the average number of employment during the period 2007-2015, and they are almost 40% of region-industries where specialization and competition levels have fluctuated from 2007 to 2015 (see appendix 2.2 for the detail).

Finally, observations without internal consistency were excluded. WPS collects employment information through two different questions; one is average employment throughout a year, and the other is employment at the end of the year. These are not necessarily same, but if they have a huge gap, it concerns the internal inconsistency and measurement error. Therefore, observations with more than five times difference were dropped to have good enough values of Cronbach's Alpha, which is higher than 0.9.

Table 2.7 presents the industries used in this study. By digitalization, industries with "mid' digital intensity had the greatest share, and the others were around the half of the former. By industry type, manufacturing and non-manufacturing industries were around half-and-half. One caveat is that the composition of digital intensity level by industry type was not balanced; most industries with "mid" intensity were in manufacturing whereas most industries with "low" and "high" intensity were in non-manufacturing. Therefore, it is not proper to analyze differential effects of regional characteristics across industries with different digitalization level by industry type (manufacturing vs non-manufacturing).

Table 2.7. List of industries used in this study

Digital intensity	Manufacturing (22)	Non-manufacturing (32)
Low (14)	Food products; Manufacture of Beverages	Water supply; Sewage; Materials recovery; General construction; Special construction; Land transport; Water Transport; Air Transport; Storage; Accommodation; Beverage; Real estate activities

Mid (26)	Textiles; Apparel; Luggage & Footwear; Chemicals; Pharmaceuticals; Plastic; Non-metallic; Basic metal; Fabricated metal; Wood; Paper; Printing; Electronic components; Medical; Electrical equipment; Other machinery; Furniture; Other manufacturing;	Motor Vehicles Sale; Wholesale; Retail; Publishing; Motion picture; Broadcasting; Recreation; Sports
High (14)	Motor Vehicles; Other transport equipment	Telecom; Computer programming; Information service; Renting; Research and Development; Professional services; Engineering services; Scientific services; Business facilities management; Business support; Repair; Personal services

Note: see appendix 2.3 for more details.

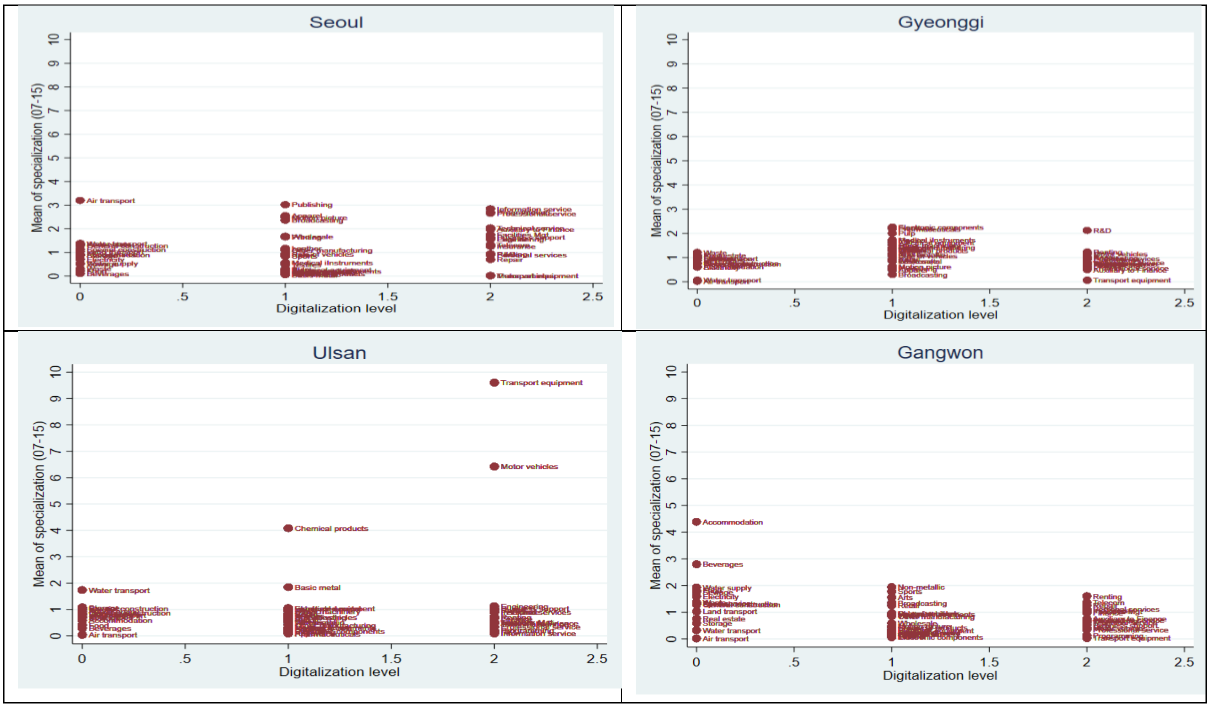
2.5.2. Description of the dataset

Figure 2.2-2.4 show average levels of specialization and competition in selected regions and diversity trend over time in all regions. It is not surprising that levels of specialization and competition are quite different across industries and regions although, by definition, each region has the same diversity level in a given year, regardless of industry.

First, the specialization level ranges from 0.2 to 11.3 (appendix 2.4). When looking at the industries, transport equipment, motor vehicle, and R&D had the three highest difference between minimum and maximum levels across regions, which means some regions were highly specialized whereas others were not specialized in the industries. In contrast, retail, personal services, and beverage showed the three lowest difference, which indicates that regions tend to have similar levels of specialization. Notably, the three industries with the highest difference belonged to the industry with “high” level of digitalization; it suggests that the specialization levels of digitally intensive industries show substantial regional disparity.

Here shows some selected regions. Seoul is notable. It shows that the city has relatively specialized in industries with mid and high digital intensity. In addition, it presents a bi-polarized industrial characteristic; it had the greatest number of industries with the minimum level of specialization (60% of all industries in ‘07 and ‘15), and the greatest number of industries with the maximum level of specialization (54% of all industries in ’07 and ’15, see appendix 2.4). The former tends to belong to the lower levels of digitalization whereas the latter does to the higher levels of digitalization. On the contrary, in Ulsan, some industries such as chemical product, motor vehicle, and transport equipment had high specialization levels whereas other ones showed relatively low levels of specialization. In the case of Gangwon, it specialized in industries with low digital intensity.

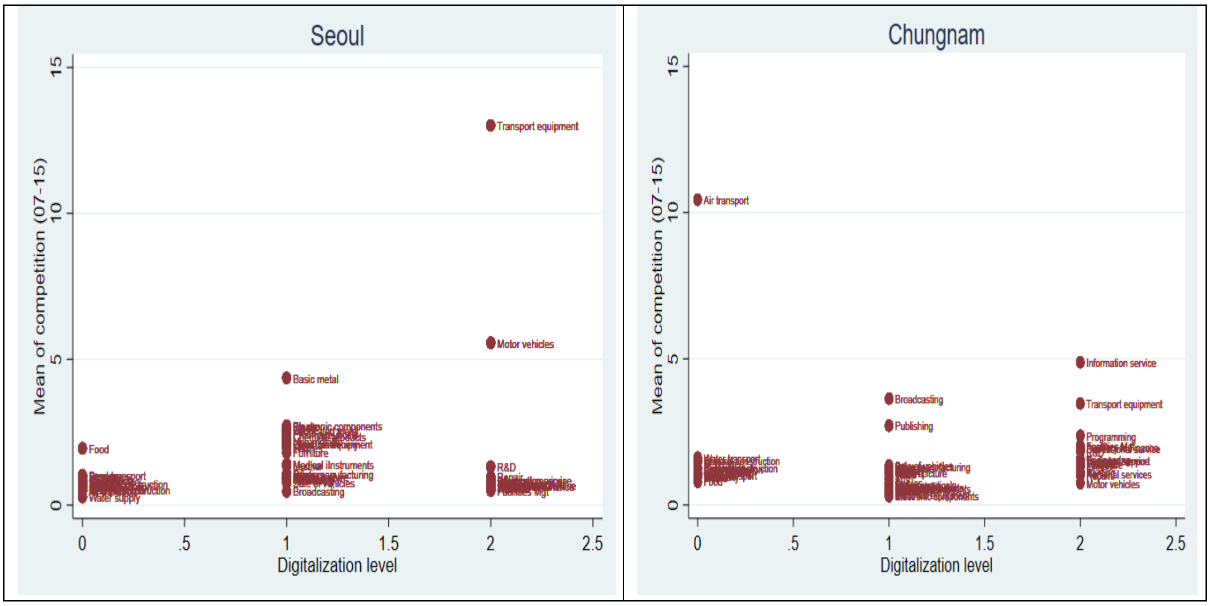
Figure 2.2. Average specialization level (07-15) in selected regions



Second, the competition level ranges from 0.2 to 41.4 (appendix 2.5). When looking at the industries, transport equipment, motor vehicle, and information services had the three highest difference between minimum and maximum levels across regions whereas land transport, personal services, and repair showed the three lowest difference.

From a regional perspective, Seoul is again notable. It shows the greatest number of industries with the minimum level of competition (35% of all industries in ’07 and ’15), and the greatest number of industries with the maximum level of competition (20% of all industries in ’07 and ’15). When compared to Chungnam, levels of competition in "high" digital intensive industries located in Seoul became lower than ones in Chungnam although transport equipment and motor vehicle were exceptions.

Figure 2.3. Average competition level (07-15) in selected regions



Third, the diversity level ranges from 16.6 to 25.6 (appendix 2.6). Gyeonggi and Incheon had the highest level of diversity on average over 2007-2015 whereas Gangwon showed the lowest levels on average. Although the value of Seoul was lower than that of Gyeonggi and Incheon, on average, the Seoul Metropolitan Area (SMA) showed a higher level of diversity than non-SMA. In addition, relatively, the SMA shows more stable trend than non-SMA. For example, in non-SMA, Ulsan and Gyeongnam showed sharp decreases over 2011-2013 and then rebounded in 2015. This is because relative employment shares of two industries (manufacture of motor vehicles and manufacture of other transport equipment) spiked and plummeted between 2011-2015[6].

[6] Employment share of Manufacture of Motor Vehicles in Ulsan has changed 0.09 ('11), 0.19('13), and 0.09 ('15). Employment share of Manufacture of Other Transport Equipment in Gyeongnam has changed 0.07 ('11), 0.16('13), and 0.05 ('15).

Figure 2.4. Diversity over time by region

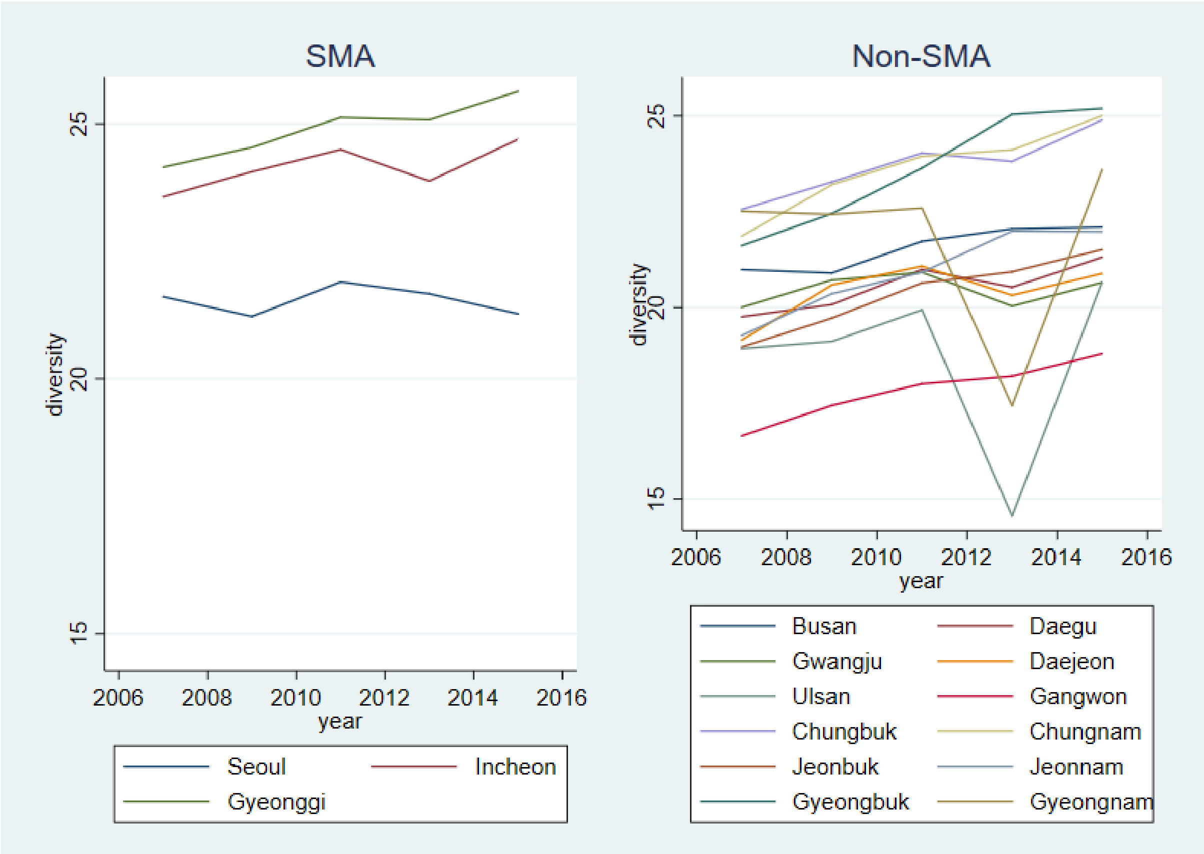


Table 2.8 shows the descriptive statistics of establishments in the dataset. The number of establishments is 3,537, and total observations are 7,239. By digitalization, industries with "mid" intensity had the greatest establishments and observations, almost double the industries with "low" and "high".

Region groups are as follows: regional group 1 is Seoul; 2 Incheon and Gyeonggi; 3 Daejeon; Chungbuk, Chungnam, and Gwangwon; 4 Gwangju, Jeonbuk, and Jeonnam; and 5 Busan, Daegu, Ulsan, Gyeongbuk, and Gyeongnam. Each region is either metropolitan (e.g. Seoul, Incheon, Daejeon, Gwangju, Busan, Daegu, and Ulsan) or province, which means it has both urban and rural areas within the area (e.g. Gyeonggi, Chungbuk, Chungnam, Gwangwon, Jeonbuk, Jeonnam, Gyeongbuk, and Gyeongnam). As mentioned, SMA consists of regional groups 1 and 2. In general, regions 1, 2, and 5 have more establishments than regions 3 and 4. Notably, although region 5 had the greatest number of establishment, region 1 showed the greatest number of establishments with “high” digital intensity. Only region 1 had higher employment than the average, and regions 1 and 4 had higher revenues than the average.

Comparing SMA to non-SMA, their establishments were similar whereas SMA had more establishments with “high” digital intensity. Average employment of SMA was higher than the other while the average revenue of non-SMA was higher than that of SMA. Since both standard deviations of employment and revenue in SMA were higher than non-SMA, establishments in SMA had larger gaps among establishments.

Figure 2.5. Regions by group

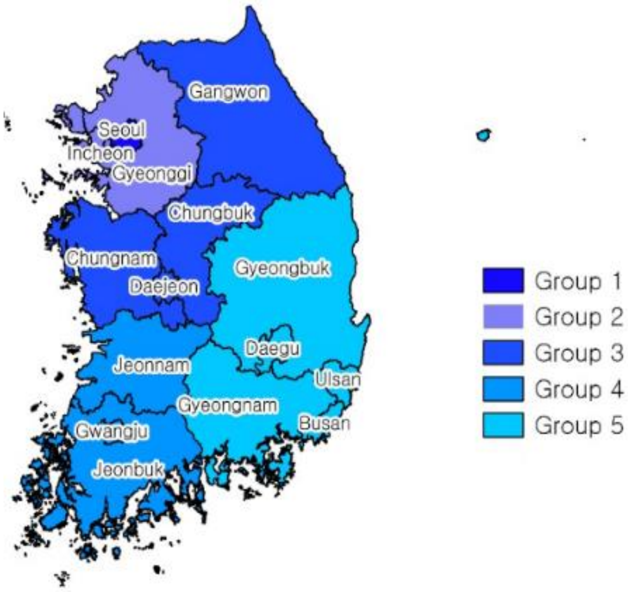


Table 2.8. Descriptive statistics of establishments by region

	Total	Region Group 1	Region Group 2	Region Group 3	Region Group 4	Region Group 5	SMA	Non-SMA
Observations	N=7,239 n=3,537	N=1,870 n=877	N=1,990 n=927	N=851 n=465	N=475 n=254	N=2,053 n=1,014	N=3,860 n=1,804	N=3,379 n=1,733
Digital_Low	N=1,979 n=950	N=523 n=226	N=506 n=232	N=296 n=152	N=174 n=91	N=480 n=249	N=1,029 n=458	N=950 n=492

Digital_Mid	N=3,720 n=1,753	N=714 n=331	N=1,216 n=557	N=406 n=225	N=231 n=116	N=1,153 n=524	N=1,930 n=888	N=1,790 n=865
Digital_High	N=1,540 n= 834	N=633 n=320	N=268 n=138	N=149 n=88	N=70 n=47	N=420 n=241	N= 901 n=458	N=639 n=376
Employment	226.9 (785.9)	311.3 (1234.6)	194.1 (669.6)	212.1 (513.6)	209.0 (646.8)	191.1 (352.2)	250.4 (983.8)	199.2 (451.5)
Revenue (mil KRW)	102,178.7 (555268.3)	130,750.9 (895154.5)	61,444.1 (184109.7)	94,890.7 (318000.6)	193,182.9 (847053.8)	97,450.8 (329634.5)	94,650.8 (634422.3)	111,018.8 (444771.2)
Wage (mil KRW)	2.9 (0.8)	2.8 (0.9)	2.9 (0.8)	2.9 (0.8)	3.0 (0.8)	3.0 (0.8)	2.9 (0.8)	3.0 (0.8)
Capital/labor ratio (mil KRW)	214.0 (326.4)	237.4 (518.5)	211.0 (196.7)	207.5 (195.3)	203.9 (213.3)	202.1 (273.2)	223.8 (388.1)	203.8 (246.0)
Hour (hours per week)	43.6 (5.0)	43.2 (4.1)	44.2 (5.3)	43.3 (5.4)	42.8 (4.6)	43.7 (5.3)	43.7 (4.8)	43.5 (5.2)
Education (1-5)	3.8 (1.3)	4.0 (1.1)	3.7 (1.4)	4.0 (1.3)	4.1 (1.3)	3.8 (1.4)	3.8 (1.3)	3.9 (1.4)
Experience (year)	13.4 (7.3)	11.4 (7.4)	12.9 (7.3)	14.6 (7.1)	15.8 (6.4)	14.3 (6.9)	12.2 (7.4)	14.6 (6.9)

Note: N means the number of observations, and n means the number of establishments. Standard deviations in parentheses.

2.6. Methodology and Models

2.6.1. Methodology

The establishment level fixed effects estimation was adopted for this study. This methodology can control both time-invariant characteristics of each establishment and heterogeneous time, industry, and region effects. As digitalization gives effects to employment at both firm/industry level and regional level, it is important to control firm and industry level characteristics to estimate the effects of regional features on employment by using fixed effects estimation.

Fixed effect is more appropriate than random effect because unobserved characteristics of establishments can be associated with regressors. In addition, since fixed effect allows any correlations between unobserved characteristics of establishments and independent variables, it is a more convincing estimation (Wooldridge, 2009). Furthermore, the Hausman test also shows that fixed effect is more appropriate way to estimate.

I also checked heteroscedasticity for model specification with the Breusch-Pagan test. The results revealed that it has a heteroscedasticity issue. To minimize the effect of heteroscedasticity, I used clustered standard error[7].

2.6.2. Models and Variables

The model was modified from Glaeser et al. (1992) and Lee and Jang (2001),

$$Employment_{it} = F\,(Specialization_{jrt},\ Competition_{jrt},\ Diversity_{rt},\ \textit{time-varying establishment characteristics (revenue, hour, education, experience), time-varying industry characteristics (wage, K/L), time-invariant variables (establishment, region, industry)},\ \gamma_{j\cdot t}),\ t=1, 2, 3, 4, 5$$

where *i* denotes establishment, *j* denotes industry, *r* denotes region, and *t* denotes time.

The dependent variable is total employment by establishment. Average annual employment is measured as a proxy of the agglomeration economies. It is level variable, not growth rate.

The independent variables are regional industrial characteristics: i) region-industry "specialization"; ii) region-industry "competition"; and iii) regional "diversity." The independent variables capture influences of regional industrial characteristics on employment. First, specialization of an industry in a region was measured as the share of the region-industry employment in the whole regional employment was divided by the share of the industry employment in the whole national employment. It can measure relative levels of regional industrial specialization. In other words, the specialization variable measures

[7] Clusters (50) are at regional groups (5) and industry groups (10) because the samples were collected by stratified sampling at regional and industry group levels. Since this research draws the conclusion beyond the clusters based on sampling, cluster errors was adopted. To put it differently, the cluster error approach is related to sampling, so industry groups used for clustering, although industries were not grouped in the main analysis. The ten industry groups include: light industry, chemical, metal/motors, electronics, construction, wholesale/retail/food/accommodation, transport, telecommunication, finance/insurance, business support, social welfare, and electric/gas/water supply. The regional groups are as same as the groups as shown in Figure 5.

relative concentration of a given industry in a region, which MAR and Porter argue it is more opt for agglomeration economies.

Second, competition of an industry in a region was measured as the number of establishments per employer in the industry in the region compared to the number of establishments the industry in whole Korea. If this coefficient has a value greater than one, it means that the industry in a given region has more firms relative to its employment than the industry has in whole Korea. One possible interpretation of the coefficient which is higher than one is that the industry in the region is under more competitive environment than other regions in Korea (Glaeser et al., 1992).

Third, diversity variable measures how various economic activities take place in a given region, which is aligned with Jacobs (1969). Diversity was calculated as the inverse of the Herfindahl-Hirschman Index. The Herfindahl-Hirschman Index measures a level of market concentration by summing the squares of a firm's market share in an industry. This index ranges from 0 to 1. If an industry is in monopoly, the value of the index is 1. If an industry has a lot of small size firms, the value is close to 0. This study changed this index to an industry's employment share in a region. By taking the inverse of it, this index shows whether some industries dominate employments in a region, or many industries contribute to employments in the region. If an industry employs all labors in a region, the diversity coefficient would be 1. If a huge amount of industries evenly share total employments in a region, the diversity value can be close to infinity.

In addition, I used several control variables, as literature on labor economics argues they are related to employment of firms (Yoon, 2013): total revenue by establishment, average wage by industry, average capital/labor ratio by industry[8], average working hours per week by establishment, average experience level of majority occupation by establishment, education level of majority occupation by

[8] Wage and capital/labor ratio are critical factors that can influence on employment. However, if establishment level information was used, they would be endogenous in this model since the dependent variable is the level of employment. Yoon (2007) mentions that average wage and capital/labor ratio by industry are regarded as exogenous to each establishment. Therefore, those two variables are incorporated in the model.

establishment (n=5), digital intensity (n=3), region (n=16), industry (n=48), year (n=5), and an interaction term between industry and year to capture industry specific linear time trend.

Finally, I transformed the dependent and control variables into natural logarithm form.

Here, I present the expected signs of the variables. Firstly, prior studies suggest positive signs of independent variables, as they are the sources of agglomeration economies. In addition, I expect that the magnitudes of specialization and competition on employment decrease as digital intensity of industries rises. In contrast, I expect that the magnitude of diversity becomes greater as digital intensity of industries increases.

Studies on labor economics suggest positive sign of revenue, as revenue is closely related to consumption of labor and capital. In case of other control variables, literature suggest negative signs. Wage is the cost of labor, therefore, higher average wage is associated with lower employment. Greater capital/labor ratio means more fixed asset per employee. Thus, if an industry has high capital/labor ration, a firm in the industry is likely to have tendency to consume more capital than labor. Working hour is related to labor supply. If an employee works longer, it can substitute new recruits. Level of education and experience measure the quality of labor. In theory, hiring quality labor costs more, thus, greater levels of education and experience may be negatively related to the employment.

Table 2.9. Variable definitions

Variable	Definition	Source
Employment	Total employment by establishment$_{it}$	WPS
Specialization (region-industry)	$\frac{\text{Employment in region} - \text{industry} \div \text{Total employment in the region}}{\text{Employment in nation} - \text{industry} \div \text{Total employment in the nation}}$	Census on Establishment
Competition (region-industry)	$\frac{\text{Establishments in region} - \text{industry} \div \text{Employment in region} - \text{industry}}{\text{Establishments in nation} - \text{industry} \div \text{Employment in nation} - \text{industry}}$	Census on Establishment
Diversity (region)	$1/\sum_{i=1}^{n}(\text{Employment share by industry in given region and year})^2$	Census on Establishment
Revenue	Total revenue by establishment$_{it}$	WPS

Wage	Average wage by $industry_{jt}$	Report on labor force survey at establishments
Capital/labor ratio	Average capital/labor ratio by industry (Net fixed $asset_{jt}$/Regular $employment_{jt}$)	Bank of Korea, Statistics Korea
Hour	Average working hours per week by $establishment_{it}$	WPS
Education	Education level (1-5) of majority $occupation_{it}$	WPS
Experience	Average experience level of majority $occupation_{it}$	WPS

2.7. Results

The results of pooled OLS and fixed-effects (FE) estimations are presented in Table 2.10. Five models were used. Model (1) is pooled OLS, and the other four models (2)-(5) are FE. Models (1) and (2) use full samples whereas models (3) to (5) use sub-samples split by digitalization level (i.e. low, mid, and high).

Pooled OLS indicates no significance of independent variables, and control variables show the expected signs. FE models show that regional industrial characteristics had statistically significant impact on firms' employment. Model (2) shows that specialization was statistically significant. To be specific, one unit increase of specialization level contributes around 7.9% employment growth of firms on average. Among control variables, revenue, wage, and experience were significant whereas education was not significant. Model (2) implies that "firms as a whole" benefit from intermediate goods/services/labor pooling and within-industry transmissions of knowledge, which are created by specialized regional industrial settings.

In models (3)-(5), I split the samples by digital intensity in order to detect differential effects of regional industrial characteristics on employments across digitalization levels. The coefficients of the split models basically supported the hypothesis, where the coefficients of specialization and competition became smaller as industry samples moved from "low" to "high" digital intensive industry. However, the diversity coefficient became greater while moving along the same direction. First, specialization shows the expected results. When the samples moved from "low" to "mid", the coefficients decreased by around 50%, and the coefficient from the samples "high" became insignificant. To be specific, in the model (3), one unit increase of specialization level was associated with around 30.3% employment increase, however, the effect became about 15.7% in model (4), and the specialization coefficient of model (5) was insignificant.

Second, the coefficients of competition show partially aligned results with the hypothesis. One difference from the hypothesis is that the coefficients turned from insignificant to significant from model (3) to model (4). However, from model (4) to (5), the coefficients became less from "mid" to "high", supporting the hypothesis.

Third, diversity shows expected results. The coefficients in both "low" and "mid" were insignificant, but the coefficient in "high" turns significant. To be specific, one unit increase of diversity level contributes 2.7% employment growth on average to the industries with "high" digital intensity. This result suggests that when the digitalization level becomes higher, it makes convergence of diverse technical sources and ideas easier, then regional industrial diversity starts to have positive externality on employment.

As mentioned in the literature review section (Yoo et al., 2010; OECD, 2019a; Autio et al., 2018; Jallet & Capek, 2001; Yoo et al., 2012; Nambisan, 2017; Lendle et al., 2013; ILO, 2018), some characteristics of digitalization (e.g. decoupling, disintermediation, and generativity) and digital infrastructure could make the effects of specialization and competition smaller whereas generativity could make the effect of diversity become greater. Since low and mid-digitalization industries did not have strong characteristics of digitalization, such as decoupling and disintermediation, it can be deduced that they benefitted from regional characteristics, such as specialization and competition. However, focusing on the industries with "high" digital intensity, regional specialization and competition did not give significant effects on employment. Only diversity matters for the industries with "high" digital intensity. In short, in case of firms with "high" digital intensity, regional diversity can be the source of the agglomeration economies, whereas regional specialization and competition have limited influence on the agglomeration economies.

"Silicon Alley" is a good example. Silicon Alley is an area of tech firms in New York City in the US. Traditionally, New York was famous for fashion, legal service, media, and finance. In addition, it has reputation, especially for creativity and entrepreneurship, leading diverse industrial setting.

Tech firms, or firms with digitally-enabled business models chose Silicon Alley to start their businesses. Because of industrial diversity in New York, it is easier for digital intensive firms to converge around technologies and industries. Thus, unlike the fact that firms in Silicon Valley are concentrated on IT industry, firms in Silicon Alley has become a hub for "any industry plus tech" for example, Fin-tech, Ed-tech, Ad-tech, Health-tech and so on. Digital intensive firms can take advantage of regional industrial diversity, and Silicon Alley shows real cases (Buyniski & Glasgow, 2017).

Compared to the previous research, the contribution of this study is to reveal the differential effect of regional features across different digitalization levels.

Table 2.10. Estimation results

	(1) OLS_All	**(2) FE_All**[9]	**(3) FE_Low**	**(4) FE_Mid**	**(5) FE_High**
Specialization	0.002 (0.02)	0.079** (0.03)	0.303* (0.16)	0.157* (0.08)	0.065 (0.04)
Competition	-0.021 (0.03)	-0.005 (0.01)	-0.005 (0.02)	0.119** (0.05)	-0.016 (0.11)
Diversity	0.015 (0.01)	0.006 (0.01)	-0.002 (0.02)	-0.002 (0.00)	0.027** (0.01)
Log (Total revenue)	0.587*** (0.03)	0.546*** (0.05)	0.439*** (0.06)	0.547*** (0.08)	0.742*** (0.03)
Log (Wage)	-0.036 (0.26)	0.309** (0.14)	0.246 (0.27)	0.098 (0.24)	-0.152 (0.36)
Log (Capital/labor)	-0.024 (0.25)	0.258 (0.15)	-0.110 (0.17)	0.583** (0.24)	0.192 (0.48)
Log (Hour)	-0.030 (0.06)	0.027 (0.05)	0.040 (0.04)	0.011 (0.08)	0.043 (0.26)
Log (Experience)	-0.028** (0.01)	-0.012* (0.01)	-0.019 (0.01)	-0.005 (0.01)	-0.009 (0.01)

[9] When an interaction term between regional industrial characteristics and digital intensity was added to model (2) to capture the differential effects of regional industrial characteristics on employments across digital intensity, the results were similar with the subsample models (models 3-5).

Education level (Medium Low)	-0.038 (0.07)	0.004 (0.05)	0.002 (0.14)	0.023 (0.05)	-0.057 (0.07)
Education level (Medium)	-0.198*** (0.07)	-0.014 (0.05)	0.066 (0.14)	-0.013 (0.06)	-0.110 (0.09)
Education level (Medium High)	-0.197*** (0.07)	-0.030 (0.06)	-0.031 (0.17)	0.037 (0.06)	-0.177 (0.15)
Education level (High)	-0.086 (0.08)	-0.050 (0.06)	-0.044 (0.13)	-0.060 (0.08)	-0.127 (0.17)
Constant	-28.323 (119.07)	103.812*** (14.65)	90.570** (33.22)	90.857*** (21.78)	90.337*** (23.75)
R-squared	0.7145	0.5030	0.3905	0.5388	0.6155
Sample	Full	Full	Split	Split	Split
Observations (Establishments)	5,691 (2,794)	5,691 (2,794)	1,413 (696)	3,129 (1,486)	1,149 (612)

Note: Standard errors clustered at the region and industry group level are in parentheses. Models (3) to (5) are separate regression by split sample, i.e. low, medium and high digitalization industry. All regressions include, but do not report, six dummies such as industry, region, year, large establishment, the Seoul Metropolitan Area, and digital intensity, and industry specific linear time trend.

* Significant at 10%, ** at 5%, *** at 1%.

Based on the results above, I investigated the average effects of statistically significant characteristics on employment over the period 2007-2015. It allows for evaluating economic significance, indicating how much employment growth each regional industrial characteristic has contributed to during the period.

Table 2.11 presents statistically significant regional industrial characteristics, their coefficients, average change of regional industrial characteristics over 2007-2015, and their average effect on employment during the same period. This table suggests that diversity could be an important source for employment growth. For example, average change of specialization levels across region-industries is 0.01 over the period 2007-2015. Therefore, the increase of specialization over the period has contributed around 0.08% employment growth, on average, to each establishment. Among regional industrial characteristics from split models, diversity had the greatest impact on employment over the period 2007-2015. Average change of diversity levels across regions was 1.8 over the same period. Thus, the increase of diversity level has contributed around 4.86% employment growth, on average, during the period.

Table 2.11. Effects on employment from regional characteristics (07-15)

Model	**(2) FE_All**	**(3) FE_Low**	**(4) FE_Mid**		**(5) FE_High**
Significant characteristics	Specialization	Specialization	Specialization	Competition	Diversity
Coefficient	0.079	0.303	0.157	0.119	0.027
Average change (07-15)	0.01	0.12	0.007	-0.28	1.8
Effect on employment (07-15)	0.08%	3.64%	0.11%	-3.33%	4.86%

2.8. Robustness check

I checked the robustness of these results. First, I ran the same model without dropping the two industries which are in bottom 5% in terms of the average number of employment during the period 2007-2015. As presented in Table 2.12, FE with all sample models shows that only specialization was significant as model (2) did. In the split of the sample models, competition was significant only in the industries with "mid" digital intensity, and diversity was significant only in the industries with "high" digital intensity. One difference from the main results in table 2.10 is that all specialization coefficients were insignificant. This result was aligned with the main finding, which is that competition became smaller and diversity became larger as industry samples moved from "low" to "high" digital intensive industries.

Table 2.12. Estimation results

	OLS_All	**FE_All**	**FE_Low**	**FE_Mid**	**FE_High**
Specialization	-0.003 (0.02)	0.051* (0.03)	0.200 (0.17)	0.049 (0.05)	0.065 (0.04)
Competition	-0.017 (0.02)	0.008 (0.01)	0.001 (0.01)	0.052** (0.02)	-0.016 (0.11)
Diversity	0.016 (0.01)	0.007 (0.01)	0.003 (0.02)	0.000 (0.00)	0.027** (0.01)
Log (Total revenue)	0.586*** (0.03)	0.544*** (0.05)	0.438*** (0.06)	0.546*** (0.07)	0.742*** (0.03)
Log (Wage)	-0.050 (0.25)	0.283* (0.14)	0.300 (0.27)	0.048 (0.23)	-0.152 (0.36)
Log (Capital/labor)	-0.037 (0.25)	0.249 (0.15)	-0.092 (0.17)	0.566** (0.24)	0.192 (0.48)
Log (Hour)	-0.030 (0.06)	0.026 (0.05)	0.036 (0.04)	0.009 (0.08)	0.043 (0.26)

Log (Experience)	-0.027** (0.01)	-0.013* (0.01)	-0.021 (0.01)	-0.006 (0.01)	-0.009 (0.01)
Education level (Medium Low)	-0.039 (0.07)	0.003 (0.05)	0.000 (0.14)	0.018 (0.05)	-0.057 (0.07)
Education level (Medium)	-0.199*** (0.07)	-0.016 (0.05)	0.066 (0.14)	-0.018 (0.06)	-0.110 (0.09)
Education level (Medium High)	-0.195*** (0.07)	-0.032 (0.06)	-0.028 (0.17)	0.029 (0.06)	-0.177 (0.15)
Education level (High)	-0.087 (0.08)	-0.053 (0.06)	-0.039 (0.13)	-0.065 (0.08)	-0.127 (0.17)
Constant	-27.375 (118.94)	101.693*** (14.18)	96.663*** (32.47)	86.441*** (21.71)	90.337*** (23.75)
R-squared	0.7164	0.5058	0.3865	0.5443	0.6155
Sample	Full	Full	Split	Split	Split
Observations (Establishments)	5,712 (2,803)	5,712 (2,803)	1,418 (698)	3,145 (1,493)	1,149 (612)

Note: Standard errors clustered at the region and industry group level are in parentheses. All regressions include, but do not report, six dummies such as industry, region, year, large establishment, Seoul Metropolitan Area, and digital intensity, and industry specific linear time trend.

* Significant at 10%, ** at 5%, *** at 1%.

Second, I did robustness check by splitting samples, depending on whether establishments were in SMA since it would create some possibilities that the effects of digitalization can be different between SMA and non-SMA. In addition, it was necessary to check whether SMA leads to the significance of diversity coefficients. In order to check, I ran the same FE models of two regions; SMA and non-SMA.

Like model (2), all SMA sample model (6) and all non-SMA sample model (10) showed that only specialization was statistically significant (Table 2.13). Focusing on the split models, regarding specialization in SMA, when the samples moved from “low” to ”mid”, the coefficients decreased, and the coefficient from the samples “high” became insignificant. It is similar to the main result. Likewise, the specialization coefficients in non-SMA decreased when the digitalization level moved from “mid” to “high”. Second, competition coefficients showed a different pattern from the main model. In SMA, the coefficient of “high” was negative and significant. In contrast, in non-SMA, the coefficient of “low” was negative and significant, and one from the “mid” was positive and significant. This was different from the main result. Future studies may need to investigate this issue. Third, diversity also showed similar results to the main ones. Both coefficients in model (9) and (13) were significant. Although the effect of diversity was more than four times stronger in SMA than in non-SMA, both regions had positive influence of diversity on employment growth.

Table 2.13. Estimation results

	Seoul metropolitan area (SMA)				**Non-Seoul metropolitan area (non-SMA)**			
	(6) All	**(7) Low**	**(8) Mid**	**(9) High**	**(10) All**	**(11) Low**	**(12) Mid**	**(13) High**
Specialization	0.197** (0.07)	0.351*** (0.11)	0.341** (0.13)	-0.120 (0.15)	0.060** (0.02)	-0.132 (0.29)	0.183** (0.08)	0.081* (0.04)
Competition	0.001 (0.01)	0.009 (0.01)	0.086 (0.06)	-0.152** (0.06)	0.054 (0.08)	-0.665* (0.34)	0.359** (0.10)	0.093 (0.13)
Diversity	0.028 (0.02)	0.036 (0.05)	0.013 (0.03)	0.147*** (0.03)	0.004 (0.01)	0.013 (0.02)	-0.006 (0.00)	0.031*** (0.01)
Log (Total revenue)	0.531*** (0.08)	0.393*** (0.07)	0.518*** (0.11)	0.781*** (0.03)	0.585*** (0.05)	0.503*** (0.08)	0.600*** (0.05)	0.709*** (0.05)
Log (Wage)	0.124 (0.17)	0.012 (0.16)	0.395 (0.32)	-0.548 (0.46)	0.355 (0.31)	0.539 (0.46)	-0.325 (0.37)	-0.079 (0.84)
Log (Capital/labor)	0.065 (0.20)	-0.011 (0.19)	0.414 (0.29)	-0.335 (0.86)	0.468* (0.25)	-0.300 (0.30)	0.690* (0.38)	-0.842 (0.53)
Log (Hour)	0.040 (0.07)	0.071 (0.07)	-0.131 (0.08)	0.353* (0.15)	-0.023 (0.08)	-0.036 (0.07)	0.113 (0.15)	-0.440** (0.19)
Log (Experience)	-0.020* (0.01)	-0.016 (0.02)	-0.018 (0.02)	-0.010 (0.02)	-0.006 (0.01)	-0.023 (0.02)	0.005 (0.01)	-0.020 (0.02)
Education level (Medium Low)	0.041 (0.04)	0.171 (0.16)	0.042 (0.05)	-0.082 (0.08)	-0.029 (0.08)	-0.079 (0.21)	0.013 (0.09)	-0.020 (0.13)
Education level (Medium)	0.036 (0.05)	0.224 (0.14)	0.023 (0.07)	-0.113* (0.06)	-0.041 (0.08)	0.049 (0.20)	-0.030 (0.10)	-0.143 (0.17)
Education level (Medium High)	0.008 (0.07)	0.123 (0.17)	0.082 (0.08)	-0.247* (0.10)	-0.060 (0.11)	-0.152 (0.31)	0.014 (0.08)	0.082 (0.25)
Education level (High)	-0.045 (0.06)	0.066 (0.17)	-0.060 (0.06)	-0.222* (0.10)	0.018 (0.14)	-0.024 (0.22)	0.030 (0.27)	0.069 (0.25)
Constant	87.008*** (14.74)	64.785*** (15.51)	124.261*** (25.06)	56.165* (26.36)	107.264*** (30.37)	119.739* (56.84)	45.435 (32.98)	56.289 (57.42)
R-squared	0.4851	0.3394	0.5154	0.6464	0.5619	0.5239	0.6082	0.6194
Sample	Split	Split	Split	Split	Split	Split	Split	Split
Observations (Establishments)	3,164 (1,509)	791 (368)	1,675 (781)	698 (360)	2,527 (1,285)	622 (328)	1,454 (705)	451 (252)

Note: Standard errors clustered at the region and industry group level are in parentheses. Models (7) to (9) and models (11) to (13) are separate regression by split sample, i.e. low, medium and high digitalization industry. All regressions include, but do not report, five dummies such as industry, region, year, large establishment, and digital intensity, and industry specific linear time trend.

* Significant at 10%, ** at 5%, *** at 1%.

Third, I checked if there was a systematic difference between large firms and medium-sized firms. Appendix 2.7 presents detailed criteria for firm size classification. Large firm models showed similar results to the main results. Regarding the specialization, when the samples moved from "mid" to "high", the coefficients plummeted. In addition, the diversity coefficient was significant only in the "high" digitalization level. Competition did not have any significant coefficient.

In the case of medium-sized firm models, diversity showed similar results to the large firm models. The coefficient was significant only in the "high" digitalization level. For competition, the coefficients became insignificant when the digitalization level moved from "mid" to "high" although the coefficients became greater when the digitalization level moved from "low" to "mid". Specialization is difficult to explain. The coefficient was significant only in the "high" digitalization level. Future studies may need to investigate this issue.

Table 2.14. Estimation results

	Large firms				Medium-sized firms[10]			
	(14) All	**(15) Low**	**(16) Mid**	**(17) High**	**(18) All**	**(19) Low**	**(20) Mid**	**(21) High**
Specialization	0.068 (0.05)	-0.029 (0.43)	0.329* (0.15)	0.094* (0.04)	0.103** (0.03)	-0.233 (0.28)	0.105 (0.06)	0.097** (0.03)
Competition	-0.006 (0.01)	-0.028 (0.02)	0.101 (0.11)	0.170 (0.22)	0.002 (0.05)	-0.793** (0.27)	0.107* (0.05)	0.007 (0.12)
Diversity	0.018 (0.01)	-0.005 (0.03)	0.013 (0.02)	0.037*** (0.01)	0.004 (0.01)	0.033 (0.03)	-0.012 (0.01)	0.031* (0.01)
Log (Total revenue)	0.478** (0.15)	0.442*** (0.09)	0.433* (0.19)	0.748*** (0.05)	0.623*** (0.04)	0.534*** (0.08)	0.614*** (0.03)	0.815*** (0.04)
Log (Wage)	0.083 (0.40)	1.227 (1.52)	-0.700 (0.63)	-1.017* (0.36)	0.212 (0.16)	0.352 (0.25)	-0.210 (0.26)	-0.533 (0.52)
Log (Capital/labor)	1.381* (0.52)	2.460 (1.37)	1.160 (0.65)	-0.234 (0.63)	-0.138 (0.18)	-0.580 (0.30)	0.358 (0.31)	-0.186 (0.66)
Log (Hour)	-0.006 (0.12)	0.068 (0.21)	-0.203 (0.12)	0.561 (0.31)	0.072 (0.10)	0.121 (0.13)	0.071 (0.11)	-0.110 (0.27)
Log (Experience)	0.005 (0.02)	-0.033 (0.04)	0.031 (0.02)	-0.031 (0.02)	-0.015* (0.01)	-0.006 (0.01)	-0.014 (0.01)	-0.047* (0.02)
Education level (Medium Low)	-0.209 (0.27)	-0.244 (0.38)	0.148* (0.06)	0.000 (.)	0.099* (0.05)	0.323** (0.09)	0.101 (0.07)	0.023 (0.10)

[10] The estimations with small-sized firm samples do not show similar patterns to main results. Future studies may need to investigate this issue.

Education level (Medium)	-0.256 (0.28)	-0.239 (0.44)	0.092 (0.07)	0.011 (0.09)	0.095 (0.06)	0.394*** (0.10)	0.078 (0.08)	-0.044 (0.12)
Education level (Medium High)	-0.181 (0.28)	-0.176 (0.46)	0.226* (0.09)	-0.088 (0.09)	0.040 (0.07)	0.260** (0.09)	0.088 (0.08)	-0.130 (0.24)
Education level (High)	-0.198 (0.27)	-0.117 (0.61)	0.060 (0.14)	0.079 (0.10)	0.068 (0.08)	0.282** (0.09)	0.086 (0.12)	-0.121 (0.24)
Constant	116.126** (34.15)	269.708* (109.30)	25.837 (56.84)	39.532 (41.81)	85.527*** (13.49)	88.150** (30.02)	62.047** (19.30)	59.949 (34.05)
R-squared	0.5194	0.5158	0.5062	0.8250	0.5790	0.5147	0.6038	0.6649
Sample	Split	Split	Split	Split	Split	Split	Split	Split
Observations (Establishments)	1,059 (457)	199 (90)	637 (271)	223 (96)	3,359 (1621)	824 (381)	1,794 (837)	741 (403)

Note: Standard errors clustered at the region and industry group level are in parentheses. Model (9) to (11) and model (13) to (15) are separate regression by split sample, i.e., low, medium and high digitalization industry. All regressions include, but do not report, five dummies such as industry, region, year, large establishment, and digital intensity, and industry specific linear time trend.

* Significant at 10%, ** at 5%, *** at 1%.

2.9. Conclusion

2.9.1. Policy Implication

Literature and the results of this study have revealed that digital intensive industries are crucial for job creation and that regional industrial diversity can lead to positive effects on firms' employment growth, especially for the digital intensive sector. This calls for a new approach for industry policies. Until now, various industrial polices have been implemented; some polices focus on fostering specialized industries in a given region, and other policies emphasize inter-cooperation among firms and industries. To maximize the effects of these policies, policymakers need to consider the digital intensity of industries. In other words, if a policy target industry is highly digital intensive, the industry can benefit from more diverse regional settings, rather than specialized or highly competitive circumstances. Customized industry policies, considering digital intensity of industries, can improve the impact of the policies.

Another implication is that the diversity in Seoul needs to be improved. Seoul is the only region where the diversity level decreased from 2007 to 2015. Considering a number of digital intensive tech companies in Seoul, diversity upscaling remains important for further job creation. Seoul may be able to provide better industrial settings by increasing the level of diversity.

2.9.2. Future Study

The first limitation is that this study did not touch the issue of job quality. Its dependent variable was the number of employment per establishment; it only measured the quantity of jobs and did not touch quality aspects, such as job security (e.g. permanent vs temporary jobs), earnings, and working environments. Both quantity and quality need to be explored for more balanced views on the differential effects of regional characteristics on employment across industries having different digitalization level.

The second limitation comes from characteristics of the data source. The main dataset was collected from WPS, and its sampling frame consists of establishments with more than thirty employees. Therefore, those who are not hired by establishments, such as self-employed people, and employment by small establishments with less than thirty employees were excluded from the dataset.

Appendix 2.1. Sectoral taxonomy of digital intensity

Sector denomination	ISIC rev.4	Digital intensity (2001-03)	Digital intensity (2013-15)
Agriculture, forestry, fishing	01-03	Low	Low
Mining and quarrying	05-09	Low	Low
Food products, beverages and tobacco	10-12	Low	Low
Textiles, wearing apparel, leather	13-15	Medium-low	Medium-low
Wood and paper products, and printing	16-18	Medium-high	Medium-high
Coke and refined petroleum products	19	Medium-low	Medium-low
Chemicals and chemical products	20	Medium-low	Medium-low
Pharmaceutical products	21	Medium-low	Medium-low
Rubber and plastics products	22-23	Medium-low	Medium-low
Basic metals and fabricated metal products	24-25	Medium-low	Medium-low
Computer, electronic and optical products	26	High	Medium-high
Electrical equipment	27	Medium-high	Medium-high
Machinery and equipment n.e.c.	28	High	Medium-high
Transport equipment	29-30	High	High
Furniture; other manufacturing; repairs of computers	31-33	Medium-high	Medium-high
Electricity, gas, steam and air cond.	35	Low	Low
Water supply; sewerage, waste management	36-39	Low	Low
Construction	41-43	Low	Low
Wholesale and retail trade, repair	45-47	Medium-high	Medium-high
Transportation and storage	49-53	Low	Low
Accommodation and food service activities	55-56	Low	Low
Publishing, audiovisual and broadcasting	58-60	Medium-high	Medium-high
Telecommunications	61	High	High
IT and other information services	62-63	High	High
Finance and insurance	64-66	High	High
Real estate	68	Low	Low
Legal and accounting activities, etc.	69-71	High	High
Scientific research and development	72	Medium-high	High
Advertising and market research; other business services	73-75	High	High
Administrative and support service activities	77-82	High	High
Public administration and defence	84	Medium-high	Medium-high
Education	85	Medium-low	Medium-low
Human health activities	86	Medium-high	Medium-low
Residential care and social work activities	87-88	Medium-low	Medium-low
Arts, entertainment and recreation	90-93	Medium-low	Medium-high
Other service activities	94-96	Medium-high	High

Note: "High" identifies sectors in the top quartile of the distribution of the values underpinning the "global" taxonomy, "medium-high" the second highest quartile, "medium-low" the second lowest, and "low" the bottom quartile.
Source: OECD (2019b). Measuring the Digital Transformation: A Roadmap for the Future

Appendix 2.2. Industries in bottom 5% employment and its standard deviations of specialization and completion levels during the period 2007-2015

Industries in bottom 5% in terms of average employment level (2007-2015)

- Remediation activities and other waste management services
- Manufacture of Coke, hard-coal and lignite fuel briquettes and refined petroleum products

Industry-regions which standard deviation of specialization level (2007-2015) is higher than 1

Industry	Region	Standard deviation of specialization
Manufacture of Other Transport Equipment	Ulsan	2.87
Manufacture of Coke, hard-coal and lignite fuel briquettes and Refined Petroleum Products	Ulsan	1.96
Remediation activities and other waste management services	Ulsan	1.57
Manufacture of Coke, hard-coal and lignite fuel briquettes and Refined Petroleum Products	Jeonnam	1.41
Remediation activities and other waste management services	Jeonnam	1.14
Manufacture of Other Transport Equipment	Gyeongnam	1.06

Industry-regions which standard deviation of competition level (2007-2015) is higher than 1

Industry	Region	Standard deviation of competition
Air Transport	Jeonbuk	17.70
Manufacture of Other Transport Equipment	Gwangju	9.70
Air Transport	Gyeongbuk	7.46
Air Transport	Ulsan	7.45
Air Transport	Daejeon	7.38
Air Transport	Gyeongnam	6.97
Water Transport	Daejeon	6.91
Air Transport	Gangwon	6.34
Air Transport	Daegu	6.05
Air Transport	Gyeonggi	6.04
Manufacture of Other Transport Equipment	Seoul	5.65
Air Transport	Chungnam	4.45
Remediation activities and other waste management services	Daegu	4.39
Air Transport	Jeonnam	4.16
Manufacture of Other Transport Equipment	Gangwon	3.91
Air Transport	Chungbuk	3.59
Remediation activities and other waste management services	Gwangju	3.56

Manufacture of chemicals and chemical products except pharmaceuticals, medicinal chemicals	Gwangju	3.33
Water Transport	Daegu	3.14
Air Transport	Gwangju	3.14
Manufacture of Motor Vehicles, Trailers and Semitrailers	Seoul	2.70
Manufacture of Coke, hard-coal and lignite fuel briquettes and Refined Petroleum Products	Gyeonggi	2.63
Manufacture of chemicals and chemical products except pharmaceuticals, medicinal chemicals	Ulsan	2.56
Manufacture of Coke, hard-coal and lignite fuel briquettes and Refined Petroleum Products	Seoul	2.50
Water Transport	Gwangju	2.28
Manufacture of Coke, hard-coal and lignite fuel briquettes and Refined Petroleum Products	Daegu	2.28
Manufacture of Coke, hard-coal and lignite fuel briquettes and Refined Petroleum Products	Daejeon	2.22
Manufacture of Coke, hard-coal and lignite fuel briquettes and Refined Petroleum Products	Chungbuk	2.19
Manufacture of Coke, hard-coal and lignite fuel briquettes and Refined Petroleum Products	Jeonbuk	1.99
Information service activities	Jeonnam	1.99
Tanning and Dressing of Leather , Manufacture of Luggage and Footwear	Jeonnam	1.87
Manufacture of Coke, hard-coal and lignite fuel briquettes and Refined Petroleum Products	Gangwon	1.83
Manufacture of Other Transport Equipment	Daegu	1.77
Manufacture of Coke, hard-coal and lignite fuel briquettes and Refined Petroleum Products	Gyeongnam	1.69
Remediation activities and other waste management services	Incheon	1.67
Manufacture of Coke, hard-coal and lignite fuel briquettes and Refined Petroleum Products	Gyeongbuk	1.67
Manufacture of Other Transport Equipment	Incheon	1.65
Remediation activities and other waste management services	Busan	1.35
Remediation activities and other waste management services	Gangwon	1.28
Information service activities	Gyeongbuk	1.23
Information service activities	Chungnam	1.17
Manufacture of Other Transport Equipment	Gyeongbuk	1.08
Manufacture of Other Transport Equipment	Chungbuk	1.06
Manufacture of Coke, hard-coal and lignite fuel briquettes and Refined Petroleum Products	Busan	1.03
Manufacture of Other Transport Equipment	Gyeonggi	1.01

Appendix 2.3. List of industries used in this study

Digital Intensity	KSIC (rev.9)	Industry
Low	10	Manufacture of Food Products
Low	11	Manufacture of Beverages
Low	36	Water Supply
Low	37	Sewage, Wastewater and Human Waste Treatment Services
Low	38	Waste Collection, Disposal and Materials Recovery
Low	41	General Construction
Low	42	Special Trade Construction
Low	49	Land Transport ; Transport Via Pipelines
Low	50	Water Transport
Low	51	Air Transport
Low	52	Storage and support activities for transportation
Low	55	Accommodation
Low	56	Food and beverage service activities
Low	68	Real Estate Activities
Mid	13	Manufacture of Textiles, Except Apparel
Mid	14	Manufacture of wearing apparel, Clothing Accessories and Fur Articles
Mid	15	Tanning and Dressing of Leather , Manufacture of Luggage and Footwear
Mid	16	Manufacture of Wood Products of Wood and Cork ; Except Furniture
Mid	17	Manufacture of Pulp, Paper and Paper Products
Mid	18	Printing and Reproduction of Recorded Media
Mid	20	Manufacture of chemicals and chemical products
Mid	21	Manufacture of Pharmaceuticals, Medicinal Chemicals and Botanical Products
Mid	22	Manufacture of Rubber and Plastic Products
Mid	23	Manufacture of Other Non-metallic Mineral Products
Mid	24	Manufacture of Basic Metal Products
Mid	25	Manufacture of Fabricated Metal Products, Except Machinery and Furniture
Mid	26	Manufacture of Electronic Components, Computer, Radio, Television etc
Mid	27	Manufacture of Medical, Precision and Optical Instruments, Watches and Clocks
Mid	28	Manufacture of electrical equipment
Mid	29	Manufacture of Other Machinery and Equipment
Mid	32	Manufacture of Furniture
Mid	33	Other manufacturing
Mid	45	Sale of Motor Vehicles and Parts
Mid	46	Wholesale Trade and Commission Trade, Except of Motor Vehicles etc
Mid	47	Retail Trade, Except Motor Vehicles and Motorcycles
Mid	58	Publishing activities
Mid	59	Motion picture, video and television programme production, sound recording etc
Mid	60	Broadcasting
Mid	90	Creative, Arts and Recreation Related Services
Mid	91	Sports activities and amusement activities
High	30	Manufacture of Motor Vehicles, Trailers and Semitrailers
High	31	Manufacture of Other Transport Equipment
High	61	Telecommunications
High	62	Computer programming, consultancy and related activities
High	63	Information service activities
High	69	Renting and leasing; except real estate
High	70	Research and Development
High	71	Professional Services
High	72	Architectural, Engineering and Other Scientific Technical Services
High	73	Professional, Scientific and Technical Services, n.e.c.
High	74	Business Facilities Management and Landscape Services
High	75	Business Support Services
High	95	Maintenance and Repair Services
High	96	Other Personal Services Activities

Appendix 2.4. Descriptive statistics of independent variables (Specialization)

Dig	Industry	Seoul		Busan		Daegu		Incheon		Gwangju		Daejeon		Ulsan		Gyeonggi	
	Year	07	15	07	15	07	15	07	15	07	15	07	15	07	15	07	15
0	Food products	0.3	0.2	0.8	0.8	0.8	0.7	0.8	0.8	0.6	0.6	0.6	0.6	0.4	0.4	0.8	0.8
0	Water supply	0.6	0.5	0.9	0.8	1.3	1.1	1.3	0.9	1.0	0.9	3.4	3.1	0.7	0.8	1.3	1.2
0	Materials recovery	0.3	0.3	1.1	0.9	0.7	0.6	1.4	1.4	1.1	0.8	0.9	0.7	1.0	0.9	0.9	0.7
0	General construction	1.2	1.1	0.8	0.8	0.9	0.9	0.7	0.9	1.8	1.3	0.8	0.9	0.8	1.0	0.8	0.8
0	Special construction	1.1	1.1	1.1	1.2	0.9	1.0	0.8	0.7	1.5	1.4	0.9	1.0	1.2	1.0	0.9	1.0
0	Land transport	1.0	1.0	1.2	1.2	1.2	1.2	1.1	1.3	1.2	1.2	1.1	1.1	0.8	0.8	0.9	1.0
0	Storage	0.9	0.8	2.6	2.3	0.5	0.6	2.1	2.1	0.5	0.5	0.8	0.9	0.9	1.2	0.6	0.6
0	Accommodation	1.0	0.8	0.9	0.9	0.6	0.5	0.8	0.9	0.7	0.6	0.7	0.6	0.6	0.6	1.0	1.0
0	Beverage	0.9	0.9	1.0	1.1	1.1	1.1	1.0	1.0	1.0	1.0	1.1	1.1	0.9	0.9	1.2	1.0
0	Real estate	1.4	1.4	0.8	1.0	0.9	1.0	1.0	0.9	0.9	1.3	1.1	1.0	0.7	0.8	1.3	1.4
1	Textiles	0.6	0.5	1.0	1.0	3.8	4.0	0.4	0.4	0.6	0.6	0.4	0.4	0.7	0.8	0.5	0.5
1	Apparel	2.5	2.6	1.3	1.3	0.9	1.0	0.6	0.5	0.4	0.3	0.4	0.4	0.1	0.1	1.3	1.4
1	Luggage	1.1	1.3	4.3	4.0	0.2	0.2	0.6	0.6	0.2	0.1	0.4	0.3	0.3	0.2	1.3	1.3
1	Chemicals	0.2	0.1	0.4	0.4	0.3	0.3	1.2	1.1	0.1	0.2	0.7	0.8	4.0	4.1	1.8	1.7
1	Plastic	0.1	0.1	0.7	0.8	1.0	1.0	1.5	1.3	1.2	1.1	0.6	0.6	0.5	0.7	1.2	1.2
1	Non-metallic	0.1	0.1	0.3	0.3	0.5	0.4	0.7	0.7	0.3	0.3	0.3	0.4	0.6	0.6	0.9	0.9
1	Basic metal	0.1	0.0	1.4	1.3	0.7	0.5	2.1	1.6	0.4	0.4	0.3	0.2	1.8	2.0	1.5	1.4
1	Fabricated metal	0.2	0.1	1.2	1.2	1.7	1.9	2.0	1.7	0.7	0.7	0.4	0.4	0.9	1.1	1.3	1.3
2	Wood	0.2	0.1	1.0	0.9	0.7	0.6	4.6	4.1	0.5	0.5	0.4	0.3	0.9	1.1	1.9	2.0
2	Paper	0.4	0.3	0.4	0.4	1.1	1.1	0.8	0.8	0.4	0.4	1.0	0.8	0.6	0.8	1.3	1.4
2	Printing	1.8	1.6	0.7	0.7	1.0	1.2	0.6	0.7	0.8	0.7	0.8	0.8	0.3	0.3	2.1	2.3
2	Electro-components	0.3	0.2	0.3	0.3	0.4	0.3	1.1	1.4	0.6	0.7	0.5	0.5	0.4	0.1	1.7	1.8
2	Medical	0.7	0.5	0.6	0.7	1.1	1.4	1.1	1.1	0.5	0.7	1.4	1.7	0.2	0.4	1.8	1.6
2	Electrical equipment	0.4	0.2	0.8	0.9	0.6	0.7	1.8	1.4	1.8	1.4	0.4	0.4	0.7	1.6	1.5	1.6
2	Other machinery	0.3	0.1	1.0	1.1	1.0	1.1	2.2	1.9	0.8	0.9	0.7	0.7	1.0	1.0	2.3	2.2
2	Furniture	0.2	0.1	0.7	0.8	0.6	0.5	2.3	1.8	0.7	0.8	0.4	0.5	0.9	1.1	1.3	1.4
2	Other manufacturing	1.2	1.1	0.9	0.8	0.7	0.8	1.6	1.2	0.7	0.7	0.9	0.9	0.4	0.4	1.0	1.1
2	Motor vehicles sales	1.0	0.9	0.9	1.0	1.1	1.2	1.4	1.6	1.2	1.3	1.6	1.3	0.7	0.7	0.8	0.9
2	Wholesale	1.7	1.6	1.2	1.1	1.1	1.0	0.7	0.7	1.0	0.9	1.0	0.9	0.5	0.5	0.9	1.0
2	Retail	0.9	0.9	1.1	1.1	1.2	1.1	1.0	1.0	1.2	1.1	1.1	1.1	0.8	0.8	0.5	0.8
2	Publishing	3.0	2.8	0.3	0.3	0.5	0.4	0.2	0.2	0.4	0.3	0.8	0.8	0.2	0.2	0.7	0.7
2	Motion picture	2.4	2.6	0.7	0.7	0.7	0.6	0.5	0.5	1.1	0.7	0.6	0.5	0.4	0.3	0.9	0.9
2	Recreation	1.1	1.2	0.7	0.8	1.0	0.9	0.7	0.7	1.0	1.3	1.1	0.9	0.6	0.6	1.2	1.2
2	Sports	0.8	0.8	1.0	0.9	1.0	0.9	0.9	1.0	1.0	1.0	0.9	0.9	0.8	0.8	1.1	0.9
3	Motor Vehicles	0.1	0.0	0.6	0.6	1.2	1.3	1.8	1.4	1.4	1.5	0.3	0.3	6.1	5.6	0.1	0.1
3	Transport equipment	0.0	0.0	0.9	0.8	0.1	0.0	0.1	0.1	0.0	0.0	0.1	0.1	11.3	10.9	0.8	0.7
3	Telecom	1.2	1.4	1.0	0.9	0.9	1.0	0.6	0.7	1.2	0.9	1.1	1.1	0.5	0.5	0.8	0.8
3	Computer programming	2.8	2.8	0.4	0.4	0.3	0.3	0.2	0.2	0.5	0.4	0.7	1.0	0.2	0.2	0.8	1.0
3	Information service	2.8	2.6	0.3	0.2	0.2	0.2	0.2	0.2	0.4	0.3	0.3	0.7	0.1	0.1	1.3	1.2
3	Renting	1.0	1.0	1.0	1.1	0.9	0.9	0.9	0.9	0.9	0.8	0.9	0.8	0.7	0.8	2.1	2.1
3	R & D	0.8	0.9	0.4	0.2	0.2	0.3	0.5	0.8	0.4	0.4	6.0	4.1	0.2	0.2	0.5	0.6
3	Professional services	2.6	2.6	0.7	0.6	0.7	0.6	0.6	0.5	0.7	0.6	0.7	0.7	0.3	0.5	1.0	1.0
3	Engineering services	1.7	1.4	0.8	1.0	0.7	0.7	0.5	0.6	0.9	0.8	0.7	0.8	1.0	1.4	0.7	0.7
3	Technical services	2.0	2.1	0.7	0.8	0.9	0.9	0.5	0.5	0.9	1.0	0.8	0.8	0.5	0.5	0.7	0.8
3	Business facilities	1.9	1.6	0.8	0.9	0.5	0.6	0.9	1.2	0.9	0.7	1.2	1.1	0.5	0.5	0.6	0.8
3	Business support	1.8	1.6	1.3	1.1	1.0	1.0	0.8	0.8	1.0	1.0	1.3	1.4	1.3	0.9	1.0	1.0
3	Repair	0.7	0.7	1.2	1.2	1.2	1.1	1.0	1.0	1.2	1.1	1.1	1.1	0.9	1.0	1.0	0.9
3	Personal services	0.9	0.9	1.2	1.2	1.2	1.2	1.0	1.0	1.3	1.2	1.2	1.1	1.0	0.8	0	1
	#min	12	17	0	1	2	1	2	2	2	1	0	0	10	11	3	3
	#max	13	13	3	2	1	1	2	3	4	1	3	2	3	4		

		Gangwon		Chungbuk		Chungnam		Jeonbuk		Jeonnam		Gyeongbuk		Gyeongnam		Min	Max
0	Food products	1.8	1.9	2.2	2.8	2.2	2.1	2.2	2.4	2.5	2.3	1.5	1.6	1.4	1.3	0.2	2.8
0	Water supply	1.7	2.0	1.3	1.6	0.9	1.2	1.6	1.5	1.4	1.8	1.3	1.6	1.1	1.1	0.5	3.4
0	Materials recovery	1.3	1.4	1.3	1.6	1.5	1.6	1.3	1.4	1.6	1.7	1.4	1.7	1.3	1.4	0.3	1.7
0	General construction	1.2	1.4	1.1	1.0	0.9	1.0	1.0	1.2	1.1	1.7	0.8	1.2	0.9	0.8	0.7	1.8
0	Special construction	1.3	1.2	1.1	1.0	0.9	0.9	0.9	1.0	1.3	1.5	0.9	0.9	0.9	1.0	0.7	1.5
0	Land transport	1.1	1.0	0.9	0.9	0.8	0.8	1.1	1.1	0.9	0.9	0.8	0.8	0.8	0.8	0.8	1.3
0	Storage	0.6	0.6	0.8	0.6	0.6	0.7	0.5	0.6	1.1	1.3	0.6	0.8	0.7	0.8	0.5	2.6
0	Accommodation	4.2	4.2	1.0	1.0	1.4	1.3	1.1	1.1	1.2	1.5	1.2	1.2	0.9	1.1	0.5	4.2
0	Beverage	1.4	1.3	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.0	1.1	1.0	1.0	1.0	0.9	1.4
0	Real estate	0.7	0.8	0.6	0.7	0.6	0.6	0.8	0.8	0.5	0.5	0.5	0.6	0.6	0.8	0.5	1.4
1	Textiles	0.1	0.1	1.0	0.8	0.8	0.7	0.6	0.8	0.3	0.3	2.4	2.5	0.8	0.8	0.1	4.0
1	Apparel	0.2	0.2	0.1	0.1	0.3	0.2	0.8	0.8	0.2	0.2	0.2	0.2	0.2	0.2	0.1	2.6
1	Luggage	0.0	0.0	0.5	0.5	0.2	0.2	0.1	0.1	0.0	0.0	0.4	0.1	0.5	0.5	0.0	4.3
1	Chemicals	0.4	0.5	2.2	2.4	2.0	2.3	1.5	1.9	2.9	2.7	1.6	1.6	0.8	0.7	0.1	4.1
1	Plastic	0.3	0.2	1.8	2.1	1.6	1.7	0.5	0.5	0.7	0.6	1.6	1.6	1.6	1.7	0.1	2.1
1	Non-metallic	1.9	1.9	2.7	2.7	2.8	2.8	1.9	1.8	1.9	1.7	2.5	2.6	1.6	1.3	0.1	2.8
1	Basic metal	0.1	0.2	0.7	0.8	1.5	2.6	0.7	1.1	2.0	2.2	3.7	3.5	2.0	1.9	0.0	3.7
1	Fabricated metal	0.2	0.3	0.9	1.1	0.9	1.1	0.5	0.7	0.7	0.7	1.2	1.5	2.2	2.3	0.1	2.3
2	Wood	0.8	0.9	0.9	1.2	0.8	1.0	1.9	1.6	0.9	1.1	1.2	1.4	1.3	1.4	0.1	4.6
2	Paper	0.3	0.3	1.8	2.2	1.6	1.4	1.4	1.1	0.5	0.4	1.1	1.3	1.0	1.0	0.3	2.2
2	Printing	0.2	0.2	0.5	0.5	0.3	0.4	0.4	0.4	0.2	0.2	0.4	0.3	0.4	0.4	0.2	1.8
2	Electro-components	0.1	0.0	2.0	2.0	2.3	2.3	0.3	0.3	0.1	0.1	2.8	2.4	0.5	0.3	0.0	2.8
2	Medical	0.8	1.0	2.2	1.0	0.9	1.1	0.2	0.3	0.2	0.2	0.9	1.1	1.5	0.7	0.2	2.2
2	Electrical equipment	0.3	0.4	1.6	2.3	1.3	1.8	0.3	0.5	0.3	0.3	1.1	1.3	1.6	1.7	0.2	2.3
2	Other machinery	0.2	0.2	0.7	0.8	1.3	1.5	0.4	0.6	0.3	0.3	0.8	1.1	2.6	2.3	0.1	2.6
2	Furniture	0.3	0.4	0.9	1.0	1.3	1.2	0.5	0.6	0.5	0.3	0.9	1.5	0.8	0.8	0.1	2.3
2	Other manufacturing	0.8	1.0	0.9	1.0	0.6	0.5	0.9	1.0	0.6	0.6	0.5	0.8	0.6	0.7	0.4	1.6
2	Motor vehicles sales	1.0	0.9	1.0	0.9	0.9	0.9	1.1	1.1	0.8	0.7	0.8	0.8	0.8	0.8	0.7	1.6
2	Wholesale	0.6	0.6	0.6	0.6	0.5	0.6	0.6	0.7	0.6	0.7	0.5	0.6	0.6	0.6	0.5	1.7
2	Retail	1.3	1.2	1.0	1.0	1.0	1.0	1.3	1.2	1.2	1.1	1.0	1.0	0.9	1.0	0.8	1.3
2	Publishing	0.2	0.3	0.2	0.2	0.1	0.1	0.2	0.2	0.1	0.1	0.3	0.1	0.2	0.1	0.1	3.0
2	Motion picture	0.4	0.5	0.3	0.3	0.2	0.3	0.6	0.4	0.3	0.3	0.3	0.2	0.3	0.3	0.2	2.6
2	Recreation	1.5	1.7	0.9	0.7	1.0	0.8	1.4	1.2	1.3	1.2	0.8	0.9	0.9	0.8	0.6	1.7
2	Sports	1.7	1.7	0.9	1.1	0.8	0.8	0.9	0.9	0.9	1.0	0.9	1.0	0.9	0.9	0.8	1.7
3	Motor Vehicles	0.4	0.5	0.7	1.0	2.3	2.7	1.8	1.8	0.1	0.1	1.4	1.9	1.6	1.9	0.0	6.1
3	Transport equipment	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.4	2.4	3.6	0.3	0.3	7.7	7.6	0.0	11.3
3	Telecom	1.4	1.3	0.9	0.9	1.0	0.9	1.4	1.2	1.4	1.2	1.0	0.9	0.9	0.8	0.5	1.4
3	Computer programming	0.2	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.2	0.1	2.8
3	Information service	0.9	0.8	0.4	0.1	0.0	0.1	0.3	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.0	2.8
3	Renting	1.7	1.5	0.9	1.0	0.8	0.9	1.1	0.9	0.7	0.7	0.7	0.8	0.8	0.8	0.7	1.7
3	R & D	0.5	0.4	0.3	0.4	0.5	0.4	0.4	0.6	0.2	0.3	0.6	0.4	0.3	0.3	0.2	6.0
3	Professional services	0.4	0.3	0.4	0.3	0.3	0.3	0.4	0.3	0.3	0.2	0.3	0.3	0.3	0.3	0.2	2.6
3	Engineering services	0.7	0.7	0.9	0.9	0.6	0.6	0.5	0.7	0.6	0.7	0.5	0.7	0.7	1.1	0.5	1.7
3	Technical services	0.7	0.5	0.6	0.5	0.6	0.5	0.8	0.7	0.6	0.5	0.6	0.4	0.5	0.5	0.4	2.1
3	Business facilities	0.8	1.1	0.7	0.9	0.4	0.7	0.6	0.9	0.8	0.9	0.6	0.6	0.5	0.6	0.4	1.9
3	Business support	0.4	0.6	0.7	0.7	0.5	0.7	0.6	0.6	0.4	0.4	0.5	0.6	0.5	0.6	0.4	1.8
3	Repair	1.3	1.3	1.1	1.1	1.1	1.2	1.2	1.2	1.4	1.4	1.2	1.2	1.0	1.0	0.7	1.4
3	Personal services	1.1	1.1	0.9	0.9	0.9	1.0	1.1	1.1	1.1	1.0	1.0	1.0	0.9	1.0	0.8	1.3
	#min	4	3	0	0	6	2	0	0	7	7	3	2	0	0		
	#max	5	6	1	4	1	1	1	0	4	3	2	3	2	1		

Note: Red colored cells are minimum values across regions in a given industry, and blue colored cells are maximum values.

Appendix 2.5. Descriptive statistics of independent variables (Competition)

Dig	Industry	Seoul		Busan		Daegu		Incheon		Gwangju		Daejeon		Ulsan		Gyeonggi	
	Year	07	15	07	15	07	15	07	15	07	15	07	15	07	15	07	15
0	Food products	1.5	2.0	1.2	1.1	1.5	1.5	1.0	1.0	1.6	1.6	1.5	1.4	1.7	1.8	0.7	0.7
0	Water supply	0.3	0.3	0.8	0.8	0.8	0.7	0.8	0.6	0.8	1.0	0.2	0.2	0.9	1.3	0.8	0.7
0	Materials recovery	0.7	0.7	0.8	0.9	1.6	1.2	0.9	0.9	0.8	1.0	0.8	0.8	0.9	1.1	0.9	1.0
0	General construction	0.6	0.5	1.0	1.0	1.0	1.1	1.2	0.8	0.8	1.1	1.3	1.0	1.1	1.0	1.1	1.2
0	Special construction	0.8	0.7	0.8	0.9	1.3	1.2	1.2	1.2	0.8	0.9	1.1	1.1	0.7	0.9	1.2	1.2
0	Land transport	1.0	1.0	0.8	0.8	1.0	1.1	1.1	1.0	0.8	0.9	1.0	1.1	0.9	0.9	1.0	1.0
0	Storage	0.9	1.0	1.2	1.2	2.0	1.5	0.6	0.7	1.4	1.4	0.5	0.5	0.9	0.7	0.8	0.9
0	Accommodation	0.6	0.6	0.9	0.8	1.0	0.9	1.2	1.0	1.1	1.0	1.0	0.9	1.2	1.1	1.2	1.1
0	Beverage	0.8	0.8	1.0	1.0	1.1	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.1	0.9	0.9
0	Real estate activities	0.9	0.8	1.0	1.0	0.9	1.0	1.2	1.2	0.9	0.9	0.9	1.0	0.9	1.0	1.1	1.1
1	Textiles	1.8	2.0	1.1	1.0	1.0	0.9	1.2	1.2	0.9	0.7	1.6	1.5	0.6	0.5	0.8	0.9
1	Apparel	0.8	0.9	1.0	0.9	1.6	1.4	0.9	0.9	2.6	2.4	1.7	1.4	2.9	2.0	0.9	0.9
1	Luggage	1.3	1.3	0.8	0.7	2.4	2.2	1.1	1.0	3.3	2.5	0.8	0.9	1.0	0.5	0.9	0.9
1	Chemicals	1.4	2.6	1.3	1.4	2.7	2.7	1.1	1.0	2.8	2.2	0.8	0.8	0.3	0.3	1.3	1.3
1	Plastic	2.4	2.6	1.5	1.2	1.4	1.2	1.0	1.0	0.5	0.5	0.6	0.6	0.5	0.5	1.2	1.2
1	Non-metallic	1.7	2.4	1.4	1.4	1.2	1.3	1.0	1.1	1.5	1.5	1.5	1.2	1.0	1.1	1.2	1.2
1	Basic metal	3.4	4.1	1.2	1.3	1.8	2.1	1.1	1.0	1.6	1.3	1.8	1.7	0.4	0.5	1.6	1.6
1	Fabricated metal	2.3	2.5	1.2	1.2	1.3	1.3	0.9	1.0	1.2	1.2	1.5	1.3	0.6	0.6	0.9	1.0
2	Wood	2.1	2.7	1.2	1.1	1.5	1.4	0.5	0.5	1.6	1.6	1.5	1.9	0.7	0.7	0.9	1.0
2	Paper	1.5	2.1	1.9	1.7	1.1	1.0	1.3	1.1	1.3	1.2	0.6	0.7	0.4	0.3	1.0	1.0
2	Printing	1.0	1.1	1.4	1.3	1.3	1.1	1.1	0.9	1.3	1.2	1.5	1.3	1.5	1.5	0.6	0.7
2	Electronic components	2.4	2.9	1.3	1.1	1.0	1.4	2.5	2.0	0.6	0.8	1.5	1.3	0.3	1.7	1.0	1.0
2	Medical	1.3	1.3	1.3	1.1	2.0	1.7	1.1	1.1	1.9	1.3	1.0	1.0	2.0	1.7	1.0	0.8
2	Electrical equipment	1.9	2.2	1.4	1.4	1.7	1.6	1.0	1.2	0.6	0.7	1.9	1.6	0.9	0.5	1.0	1.2
2	Other machinery	1.9	2.0	1.4	1.1	1.4	1.2	0.9	0.9	0.8	0.9	1.1	0.9	0.6	0.6	1.1	1.0
2	Furniture	1.5	1.7	1.5	1.4	1.9	1.9	0.6	0.7	1.2	1.1	2.0	1.8	0.9	0.7	0.9	0.9
2	Other manufacturing	1.0	1.1	1.2	1.2	1.6	1.4	0.6	0.8	1.4	1.5	1.1	1.0	1.4	1.4	0.7	0.8
2	Motor vehicles sales	0.8	0.7	1.0	1.0	1.3	1.3	0.8	0.9	1.1	1.1	0.9	0.9	1.1	1.2	0.9	0.9
2	Wholesale	0.9	0.8	1.1	1.2	1.2	1.2	1.1	1.1	1.0	1.1	1.0	1.1	1.1	1.2	0.9	1.0
2	Retail	0.9	0.8	1.0	1.1	1.0	1.1	1.0	1.0	0.9	1.0	1.0	1.0	1.0	1.0	0.9	0.9
2	Publishing	0.9	0.9	1.8	1.6	1.4	1.4	1.7	1.9	1.8	1.8	1.3	1.1	1.2	1.2	1.2	0.9
2	Motion picture	0.9	1.1	1.1	0.8	1.0	0.9	1.1	0.6	1.0	1.1	1.3	1.1	1.4	0.9	1.0	0.8
2	Recreation	1.0	1.0	1.3	1.1	1.0	1.2	1.2	1.1	1.5	1.2	0.9	1.1	1.3	1.2	1.0	0.9
2	Sports	1.0	0.9	1.1	1.1	1.2	1.3	1.2	1.2	1.3	1.3	1.2	1.3	1.3	1.4	0.8	0.9
3	Motor Vehicles	2.0	6.5	1.6	1.6	1.4	1.2	0.9	0.9	0.7	0.7	1.4	1.0	0.3	0.3	1.0	1.1
3	Transport equipment	4.4	11.4	2.1	2.3	7.5	6.7	6.2	5.9	41.4	15.1	3.7	2.9	0.3	0.5	6.2	5.0
3	Telecom	0.6	0.5	0.9	1.1	0.9	0.9	1.1	1.0	0.9	1.0	1.1	1.0	1.3	1.2	0.7	0.9
3	Computer programming	0.7	0.8	3.1	2.2	3.3	2.7	3.1	2.4	2.6	2.2	1.9	1.3	2.7	1.8	0.8	1.0
3	Information service	0.9	0.9	3.0	2.7	3.8	2.6	2.7	2.4	2.3	2.5	2.8	1.3	3.3	3.3	0.6	0.6
3	Renting	0.8	0.8	1.1	0.9	1.1	1.1	1.1	1.0	1.2	1.3	1.2	1.1	1.1	1.0	0.9	0.9
3	R & D	1.4	1.4	2.1	3.9	3.0	2.6	1.1	0.9	3.4	2.5	0.4	0.6	3.2	1.7	0.6	0.5
3	Professional services	0.7	0.8	1.6	1.5	1.7	1.7	1.3	1.3	1.6	1.8	1.3	1.3	1.5	1.1	1.5	1.1
3	Engineering services	0.7	0.8	1.2	1.1	1.6	1.7	1.2	1.1	1.3	1.4	1.3	1.2	1.0	0.8	1.0	1.0
3	Professional services	0.7	0.8	1.2	1.1	1.3	1.2	1.4	1.3	1.2	1.2	1.2	1.1	1.4	1.2	1.1	1.0
3	Business facilities	0.5	0.5	1.2	1.1	1.5	1.5	1.1	0.9	1.5	1.8	1.1	1.3	2.4	2.0	1.4	1.2
3	Business support	0.7	0.7	1.1	1.1	1.2	1.1	1.0	1.1	1.2	1.2	0.9	0.8	0.7	1.0	1.2	1.0
3	Repair	1.0	1.0	1.1	1.0	1.1	1.2	0.9	0.9	1.0	1.0	1.0	1.0	1.0	0.9	0.9	0.9
3	Personal services	0.9	0.8	1.0	1.0	1.1	1.1	1.0	1.0	1.0	1.1	1.0	1.0	1.0	1.1	0.9	1.0
	#min	6	11	0	1	0	0	1	2	0	0	3	0	3	3	2	2
	#max	0	10	0	1	2	0	0	0	3	0	0	0	1	1	0	0

		Gangwon		Chungbuk		Chungnam		Jeonbuk		Jeonnam		Gyeongbuk		Gyeongnam		Min	Max
0	Food products	1.0	1.0	0.7	0.6	0.8	0.8	0.9	0.9	1.0	1.2	1.2	1.3	0.9	1.0	0.6	2.0
0	Water supply	1.8	1.9	0.8	0.7	1.2	1.1	1.7	1.8	3.0	2.0	2.2	1.9	1.1	1.4	0.2	3.0
0	Materials recovery	1.4	1.1	1.4	1.1	0.9	0.9	1.0	1.0	0.9	1.0	1.4	1.2	1.1	1.2	0.7	1.6
0	General construction	1.4	1.3	1.3	1.5	1.4	1.4	1.3	1.3	1.2	1.1	1.5	1.4	1.3	1.5	0.5	1.5
0	Special construction	1.2	1.3	1.2	1.2	1.3	1.2	1.2	1.2	1.0	1.0	1.3	1.4	1.1	1.1	0.7	1.4
0	Land transport	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.1	0.8	0.9	1.0	1.1	1.0	1.0	0.8	1.1
0	Storage	1.2	1.2	0.9	1.2	1.1	1.0	1.7	1.3	1.1	0.8	1.3	1.1	1.4	1.2	0.5	2.0
0	Accommodation	1.1	1.1	1.1	1.1	1.2	1.3	1.1	1.2	1.4	1.3	1.1	1.2	1.4	1.3	0.6	1.4
0	Beverage	1.2	1.2	1.1	1.2	1.1	1.1	1.1	1.1	1.2	1.2	1.2	1.3	1.1	1.2	0.8	1.3
0	Real estate activities	1.2	1.0	1.2	1.0	1.4	1.3	0.9	1.1	0.9	0.9	1.1	1.2	1.2	1.1	0.8	1.4
1	Textiles	2.6	2.3	0.6	0.6	0.8	0.8	0.8	0.7	1.3	1.4	0.6	0.7	0.7	0.8	0.5	2.6
1	Apparel	2.6	1.5	2.4	1.7	1.4	1.0	0.9	0.8	2.5	1.7	2.1	1.4	2.1	1.8	0.8	2.9
1	Luggage	2.1	1.9	0.5	0.5	0.4	0.5	1.5	1.6	6.4	2.4	0.4	1.1	0.7	0.6	0.4	6.4
1	Chemicals	1.4	1.5	0.9	0.8	0.7	0.6	0.7	0.6	0.4	0.4	1.0	1.2	1.5	1.7	0.3	2.8
1	Plastic	1.1	1.3	0.6	0.6	0.5	0.5	0.9	1.0	0.7	0.8	0.6	0.8	0.7	0.7	0.5	2.6
1	Non-metallic	0.8	0.9	0.6	0.7	0.7	0.7	1.1	1.1	1.1	1.1	0.8	0.8	1.0	1.1	0.6	2.4
1	Basic metal	1.2	1.1	1.1	1.3	0.5	0.4	0.6	0.6	0.2	0.3	0.4	0.6	1.0	1.1	0.2	4.1
1	Fabricated metal	1.8	1.3	0.7	0.7	0.7	0.6	1.1	0.8	0.9	0.8	0.7	0.7	0.6	0.7	0.6	2.5
2	Wood	1.5	1.5	1.1	1.0	1.2	1.0	1.0	1.0	1.6	1.4	1.2	1.2	1.1	1.1	0.5	2.7
2	Paper	1.1	1.2	0.6	0.6	0.5	0.6	0.6	0.7	0.8	0.9	0.8	0.8	0.8	0.8	0.3	2.1
2	Printing	1.9	1.8	1.3	1.1	1.3	1.1	1.7	1.6	2.0	1.7	1.4	1.5	1.3	1.2	0.6	2.0
2	Electronic components	0.9	3.2	0.4	0.4	0.2	0.3	0.6	0.9	0.6	1.6	0.5	0.6	1.1	1.5	0.2	3.2
2	Medical	0.7	0.7	0.3	0.7	0.5	0.6	1.8	2.1	1.6	2.0	0.7	0.8	0.4	1.0	0.3	2.1
2	Electrical equipment	1.5	1.3	0.5	0.4	0.4	0.4	1.3	1.1	1.6	1.2	0.6	0.6	0.6	0.6	0.4	2.2
2	Other machinery	0.7	0.8	0.8	0.8	0.5	0.6	0.8	0.7	0.8	0.9	0.8	1.0	0.6	0.9	0.5	2.0
2	Furniture	2.0	2.1	0.9	0.9	0.6	0.6	1.3	1.2	1.5	2.0	1.0	0.7	1.3	1.2	0.6	2.1
2	Other manufacturing	1.3	1.1	1.0	0.8	1.4	1.3	1.4	1.2	1.8	1.6	1.6	1.1	1.2	1.1	0.6	1.8
2	Motor vehicles sales	1.4	1.3	1.2	1.3	1.4	1.3	1.2	1.2	1.3	1.5	1.5	1.5	1.3	1.3	0.7	1.5
2	Wholesale	1.1	1.2	1.2	1.2	1.3	1.3	1.2	1.3	1.2	1.3	1.3	1.3	1.1	1.2	0.8	1.3
2	Retail	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.2	1.2	1.2	1.2	1.2	1.1	1.1	0.8	1.2
2	Publishing	1.7	1.2	1.6	1.5	2.1	2.9	1.5	1.9	2.0	2.4	1.2	2.1	1.6	1.8	0.9	2.9
2	Motion picture	1.7	0.8	1.5	1.2	1.9	0.8	1.1	1.0	1.5	0.8	1.7	1.1	1.6	0.8	0.6	1.9
2	Recreation	0.9	0.9	1.1	1.2	0.9	1.0	0.9	1.0	0.9	1.0	1.0	0.9	1.0	1.1	0.9	1.5
2	Sports	0.7	0.8	1.1	1.1	1.2	1.3	1.1	1.1	1.1	1.0	1.2	1.1	1.1	1.1	0.7	1.4
3	Motor Vehicles	0.6	0.6	1.0	1.0	0.8	0.7	0.6	0.7	2.7	2.3	1.1	1.2	1.8	1.6	0.3	6.5
3	Transport equipment	4.6	7.9	2.9	2.5	4.3	2.3	3.5	1.5	1.1	1.1	3.2	3.9	0.8	0.8	0.3	41.4
3	Telecom	1.5	1.5	1.5	1.5	1.4	1.5	1.4	1.6	1.7	1.9	1.6	1.7	1.4	1.6	0.5	1.9
3	Computer programming	3.0	3.7	4.0	3.2	2.7	3.3	3.3	3.2	2.5	2.7	4.0	3.6	2.0	1.9	0.7	4.0
3	Information service	0.7	0.6	1.0	2.6	6.5	4.4	1.5	1.6	7.0	4.8	7.3	5.2	2.5	3.5	0.6	7.3
3	Renting	1.2	1.4	1.1	1.2	1.1	1.2	1.1	1.3	1.2	1.3	1.3	1.3	1.1	1.3	0.8	1.4
3	R & D	2.9	2.6	2.0	2.4	1.5	1.6	1.7	1.7	2.5	1.9	1.6	2.0	1.5	1.9	0.4	3.9
3	Professional services	1.8	1.8	1.5	1.8	1.7	1.8	2.2	2.2	2.1	1.8	1.7	1.5	1.7	1.9	0.7	2.2
3	Engineering services	1.7	1.5	1.1	1.1	1.5	1.4	1.6	1.3	1.3	1.3	1.7	1.3	1.2	1.0	0.7	1.7
3	Professional services	1.4	1.6	1.5	1.4	1.5	1.5	1.5	1.5	1.7	1.4	1.7	1.7	1.6	1.5	0.7	1.7
3	Business facilities	2.1	1.4	1.9	1.4	2.5	1.6	2.0	1.4	1.5	1.4	1.6	1.8	1.7	1.6	0.5	2.5
3	Business support	2.1	1.6	1.3	1.4	1.8	1.3	1.7	1.7	1.9	1.9	1.3	1.5	1.6	1.4	0.7	2.1
3	Repair	1.1	1.1	1.1	1.1	1.1	1.0	1.2	1.2	1.0	1.0	1.0	1.1	1.1	1.1	0.9	1.2
3	Personal services	1.1	1.1	1.1	1.1	1.1	1.0	1.1	1.2	1.2	1.2	1.2	1.1	1.1	1.1	0.8	1.2
	#min	1	0	2	1	5	1	0	1	1	0	1	0	1	0		
	#max	2	3	1	1	3	1	0	4	5	3	2	5	0	0		

Note: Red colored cells are minimum values across regions in a given industry, and blue colored cells are maximum values.

Appendix 2.6. Descriptive statistics of independent variables (Diversity)

Region	Year		Mean	Annual growth rate (%)
	'07	'15		
Seoul	21.6	21.3	21.5	-0.2
Busan	21.0	22.1	21.6	0.5
Daegu	19.8	21.3	20.5	0.8
Incheon	23.6	24.7	24.1	0.5
Gwangju	20.0	20.6	20.5	0.3
Daejeon	19.1	20.9	20.4	0.9
Ulsan	18.9	20.7	18.6	0.9
Gyeonggi	24.2	25.6	24.9	0.6
Gangwon	16.6	18.8	17.8	1.2
Chungbuk	22.6	24.9	23.7	1.0
Chungnam	21.9	25.0	23.6	1.4
Jeonbuk	19.0	21.5	20.4	1.3
Jeonnam	19.3	22.0	20.9	1.3
Gyeongbuk	21.6	25.2	23.6	1.5
Gyeongnam	22.5	23.6	21.7	0.5
Min	16.6	18.8	17.8	
Max	24.2	25.6	24.9	

Note: Red colored cells are minimum values across regions in a given industry, and blue colored cells are maximum values.

Appendix 2.7. Small and medium firm criteria table (As of 2015)

Average revenue of recent three years was less then each standard, and each firm was classified as either medium-sized or small-sized.

(Unit: KRW million)

Industry	Sec-tion	Divi-sion	Medium -sized	Small -sized
Agriculture, forestry and fishing	A	-	100000	8000
Mining and quarrying	B	-	100000	8000
Manufacture of Food Products	C	10	100000	12000
Manufacture of Beverages	C	11	80000	12000
Manufacture of Tobacco Products	C	12	100000	8000
Manufacture of Textiles, Except Apparel	C	13	100000	8000
Manufacture of wearing apparel, Clothing Accessories and Fur Articles	C	14	150000	12000
Tanning and Dressing of Leather , Manufacture of Luggage and Footwear	C	15	150000	12000
Manufacture of Wood Products of Wood and Cork ; Except Furniture	C	16	100000	8000
Manufacture of Pulp, Paper and Paper Products	C	17	150000	8000
Printing and Reproduction of Recorded Media	C	18	80000	8000
Manufacture of Coke, hard-coal and lignite fuel briquettes and Refined Petroleum Products	C	19	100000	12000
Manufacture of chemicals and chemical products except pharmaceuticals, medicinal chemicals	C	20	100000	12000
Manufacture of Pharmaceuticals, Medicinal Chemicals and Botanical Products	C	21	80000	12000
Manufacture of Rubber and Plastic Products	C	22	100000	8000
Manufacture of Other Non-metallic Mineral Products	C	23	80000	12000
Manufacture of Basic Metal Products	C	24	150000	12000
Manufacture of Fabricated Metal Products, Except Machinery and Furniture	C	25	100000	12000
Manufacture of Electronic Components, Computer, Radio, Television and Communication Equipment and Apparatuses	C	26	100000	12000
Manufacture of Medical, Precision and Optical Instruments, Watches and Clocks	C	27	80000	8000
Manufacture of electrical equipment	C	28	150000	12000
Manufacture of Other Machinery and Equipment	C	29	100000	12000
Manufacture of Motor Vehicles, Trailers and Semitrailers	C	30	100000	12000
Manufacture of Other Transport Equipment	C	31	100000	8000
Manufacture of Furniture	C	32	150000	12000
Other manufacturing	C	33	80000	8000
Electricity, gas, steam and water supply	D	-	100000	12000
Sewerage, waste management, materials recovery and remediation activities	E	-	80000	3000
Construction	F	-	100000	8000
Wholesale and retail trade	G	-	100000	5000
Transportation	H	-	80000	8000
Accommodation and food service activities	I	-	40000	1000
Information and communications	J	-	80000	5000
Financial and insurance activities	K	-	40000	8000
Real estate activities and renting and leasing	L	-	40000	3000
Professional, scientific and technical activities	M	-	60000	3000
Business facilities management and business support services	N	-	60000	3000
Education	P	-	40000	1000
Human health and social work activities	Q	-	60000	1000
Arts, sports and recreation related services	R	-	60000	3000
Membership organizations, repair and other personal services	S	-	60000	1000

Reference list

Aghion, P., & Jaravel, X. (2015). Knowledge spillovers, innovation and growth. *The Economic Journal*, *125*(March), 533–573

Autor, D., Levy, F., & Murnane, R. (2003), The skill content of recent technological change: An empirical exploration. *The Quarterly Journal of Economics*, 118(4), 1279-1333

Autio E, Nambisan S, Thomas LDW, & Wright M. (2018). Digital affordances, spatial affordances, and the genesis of entrepreneurial ecosystems. *Strategic Entrepreneurship Journal*, 2:72–95. https://doi.org/10.1002/sej.1266

Buyniski, T & Glasgow, A. (2017). Silicon Alley vs. Silicon Valley: Comparing and Contrasting Compensation Practices. Retrieve from https://rewards.aon.com/en-us/insights/articles/2017/silicon-alley-vs-silicon-valley-compensation-practices

Calvino, F. et al. (2018). *A taxonomy of digital intensive sectors* (OECD Science, Technology and Industry Working Papers, 2018/14). Paris: OECD Publishing. http://dx.doi.org/10.1787/f404736a-en

De Groot, H.L.F., Poot, J., & Smit, M.J. (2007). Agglomeration, innovation and regional development: Theoretical perspectives and meta-analysis. *Tinbergen Institute Discussion Paper*, no. TI 2007-079/3

Desrochers, P. (2001). Local diversity, human creativity, and technological innovation. *Growth and Change*, *32*, 369-394.

De Vor, F., & de Groot, H.L.F. (2008). Agglomeration externalities and localized employment growth (*Tinbergen Institute Discussion Paper*, 2008-033/3).

Glaeser, E., Kallal, H., Scheinkman, J., & Shleifer, A. (1992). Growth in cities. *Journal of Political Economy*, *100*(6).

Henderson, V. (1986). Efficiency of resource usage and city size. *Journal of Urban Economics*, *19*, 47-70.

Henderson, V., Lee, T., & Lee, J. (2001). Scale externalities in Korea. *Journal of Urban Economics*, *49*(3), 479-504.

ILO. (2017). New automation technologies and job creation and destruction dynamics (Employment Policy Brief). Retrieved from https://www.researchgate.net/publication/317041734_New_automation_technologies_and_job_creation_and_destruction_dynamics

ILO. (2018). The impact of technology on the quality and quantity of jobs (Issue Brief #6). Retrieved from https://www.ilo.org/wcmsp5/groups/public/---dgreports/---cabinet/documents/publication/wcms_618168.pdf

Jallat, F., & Capek, M. (2001). Disintermediation in question: New economy, new networks, new middlemen, *Business Horizons*, *March-April*.

Kim, A. (2014). Structural analysis of occupation change based on task characteristics. *Working Paper of the* Korea Labor Institute, *Korea*, *2014*. Retrieved from https://www.kli.re.kr/klips/selectBbsNttView.do?bbsNo=47&key=159&nttNo=101490

Kim, K. (2010). *The effects of industrial specialization and diversity on regional employment growth and income inequality: With a special reference to the wage-earners in the manufacturing sector* [(Unpublished?) doctoral dissertation]. Dankuk University

Kim, K., & Ko, S. (2009). The effects of agglomeration economy on regional employment growth. *Journal of Korea Planning Association* ,*44*(7).

Kim , M., & Lee, Y. (2007). Decentralization of urban industries and urban scale economies in Korea. *The Korea Spatial Planning Review*, *2007*(6).

Korea Labor Institute. (2017). *Workplace panel survey user's guide* (Version 14).

Kurer, T, & Gallego, A. (2019). Distributional consequences of technological change: Worker-level evidence. *Research and Politics*, *January-March*.

Lee, B., & Jang, M. (2001). Study on productivity of manufacturing firms by regions. *The Korean Economic Review, 49*(3).

Lee, Y. (2008), Metro cities' and provinces' total factor productivity and its determinants in Korea. *The Korea Spatial Planning Review, 58.*

Lendle, A., Olarrega, M., Schropp, S., & Vézina, P.L. (2013). *eBay's anatomy. Economics Letters, Elsevier, 121*(1), 115-120. Retrieved from https://www.sciencedirect.com/science/article/pii/S0165176513003492

Lelivelda, A., & Knorringa, P. (2017). Frugal innovation and development research. *The European Journal of Development Research, 30*(1), 1–16.

McKinsey Global Institute. (2017). A future that works: Automation, employment, and productivity.

Mueller, S., Bakhirev, A., Böhm, M, Schröer, M., Krcmar, H., & Welpe, I. (2017). Measuring and mapping the emergence of the digital economy: A comparison of the market capitalization in selected countries. *Digital Policy, Regulation and Governance, 19*(5).

Nambisan, S. (2016). Digital entrepreneurship: Toward a digital technology perspective of entrepreneurship. *Entrepreneurship Theory and Practice, 1042*(2587), doi: 10.1111/etap.12254.

Nedelkoska, L., & Quintini, G. (2018). *Automation, skills use and training* (OECD Social, Employment and Migration Working Papers No. 202*).* https://doi.org/10.1787/1815199X

OECD. (2015). *In it together: Why less inequality benefits all.* Paris: OECD Publishing. https://www.oecd.org/social/in-it-together-why-less-inequality-benefits-all-9789264235120-en.htm

OECD. (2018). *Job creation and local economic development 2018: Preparing for the future of work.* Paris: OECD Publishing. https://doi.org/10.1787/9789264305342-en

OECD. (2019a). *Going digital: Shaping policies, improving lives*. Paris: OECD Publishing. https://doi.org/10.1787/9789264312012-en.

OECD. (2019b). *Measuring the digital transformation: A roadmap for the future.* Paris: OECD Publishing. https://doi.org/10.1787/9789264311992-en

Office for National Statistics of UK (2015). *What defines the Digital Sector?*

Rosenthal, S., & Strange, W. (2004). Evidence on the nature and sources of agglomeration economies. *Handbook of Regional and Urban Economics*, *4*, 2119-2171.

Stel, A., Jong, M., & Hodzic, N. (2012). *Knowledge spillovers and employment growth in Great Britain* (SCALES-paper N200206*).*

Tilson, D., Lyytinen, K., & Sørensen, C. (2010). Digital infrastructures: The missing IS research agenda. *Information Systems Research*, *21*(4), 748–759.

Walwei, U. (2016). *Digitalization and structural labour market problems: The case of Germany* (ILO Research Paper No. 17). Retrieved from https://www.ilo.org/wcmsp5/groups/public/---dgreports/---inst/documents/publication/wcms_522355.pdf

Wooldrige, J. (2009). *Introductory econometrics 4e: A modern approach*

Yim, C., & Kim, J. (2003). Impact of dynamic externalities on urban economic growth. *Journal of Korea Planning Association*, *38*(3).

Yoo, Y., Henfridsson, O., & Lyytien, K. (2010). The new organizing logic of digital innovation: An agenda for information systems research *Information Systems Research*, *21*(4), 724-735.

Yoo, Y., Boland, R., Lyytinen, K., & Majchrzak, A. (2012). Organizing for innovation in the digitized world. *Organization Science*, *23*(5), 1398–1408. http://dx.doi.org/10.1287/orsc.1120.0771.

Yoon, Y. (2007). *Study on firm's employment adjustment.* Sejong: Korea Labor Institute.

Yoon, Y. (2013). Determinants on firms' employment decisions. *Monthly Labor Review, 6,* 21-34.

Chapter 3

Differential effects of having parent companies on subsidiaries' total factor productivity by geographic proximity

Abstract

Many empirical evidences are accumulated on the impact of having a foreign parent company on its subsidiary. However, the effect from a domestic parent company have not as much as studied. This study aims to investigate the impact of having a domestic parent company on its subsidiary's economic performance. Among the studies focused on the effect from a domestic parent, many of them explore the effect of easing access to production factors, such as labor and capital. By contrast, this study emphasizes the impact on total factor productivity (TFP) of a subsidiary by sharing better knowledge and organizational practices. The empirical strategy is fixed effect (FE). In addition, propensity score matching (PSM) and difference-in-differences (DID) are used for robustness check. The results show a positive effect of having a domestic parent company when firms have high absorptive capacity and geographical proximity to their parent companies. On the contrary, no positive impact is found from firms that have high absorptive capacity but do not have geographic proximity to their parent companies. This study suggests that geographic proximity is an important factor for subsidiaries to enjoy the benefits from knowledge transfer of their parent companies.

Keywords: domestic parent companies, absorptive capacity, geographic proximity, fixed effect

3.1. Introduction

Many empirical evidences are accumulated on the impact of having a foreign parent company on its subsidiary. For example, Bentivogli and Mirenda (2017) argue that having multi-national parent companies is advantageous since foreign investors are able to share better technologies and organizational practices to their subsidiaries. By contrast, studies on the impact of domestic parent companies reveal that firms acquired by domestic firms do not show any positive increase with respect to total factor productivity (TFP) or labor productivity in the UK, France, and Japan. On the other hand, researchers claim that firms acquired by foreign firms have increased TFP or labor productivity after the acquisitions (Bertrand & Zitouna, 2005; Conyon et al., 2002; Fukao et al., 2006). Some other research focused on positive effects from domestic firms argue that the main sources of the positive impact are the internal capital market creation or higher leverage, not from better knowledge and organizational practices.

This study aims to investigate the impact of having a domestic parent company on its subsidiary's economic performance. Narrowing down the research topic, it further addresses the impact from better knowledge and organizational practices of domestic parent companies. In other words, it investigates the impact of having domestic parent companies on subsidiaries' total factor productivity (TFP). As many prior studies explore the effect of greater access to production factors by having a domestic parent company, this study can fill the gap by focusing on TFP. In addition, this study is timely as the corporate ownership structure has recently changed in Korea. The share of independent firms has decreased while the ratio of business group, the parent-subsidiary firm structure, has increased. Cho (2016) finds that the share of firms that belong to business groups has inflated from 38% in 2008 to 48% in 2014.

The empirical strategy to tackle this issue is fixed effect (FE) in this study. In addition, propensity score matching (PSM) and difference-in-differences (DID) are also adopted for robustness check. These methodologies are effective tools as not only having a domestic parent company, but also both the subsidiaries' absorptive capacity and geographical proximity between the parents and the subsidiaries are considered as the factors for the differences. Knowledge transfer from parent companies to subsidiaries can be different depending on the absorptive capability of subsidiaries and geographical closeness, thus this study intends to detect the differential effect of having a domestic parent company on its subsidiary based on the absorptive capacity of subsidiaries and geographical proximity.

This paper is organized as follows. The next section provides a literature review on benefits of having a parent company, characteristics of technological knowledge, and boosters for knowledge transfer. Section 3.3 presents the preliminary analysis using Korean data, aligned with the literature review. Section 3.4 explains research question and hypothesis. Section 3.5 describes the dataset used in this study. Section 3.6 shows the methodology and analysis models this study adopts. Section 3.7 and 3.8 explain the estimation results and robustness checks. Finally, in Section 3.9, I draw conclusions.

3.2. Literature Review

3.2.1. Benefits from parent companies

Campbell et al. (1995) found that parent companies can function to their subsidiaries as a double-edged sword. If the parent companies possess superior capabilities or resources that can improve the subsidiaries' performance, or the parent companies understand sufficiently how they can make the subsidiaries' businesses successful, they can create new values for the subsidiaries. However, if the parent companies behave inefficiently, including pressing for improper business targets, pushing wasteful expenditure, and appointing incapable managers, it can hamper the successful business of the subsidiaries. In this regard, it is understandable that each individual set of parent-subsidiary companies performs differently.

Moving the focus from an individual case to a systematic view, two kinds of systematic advantages are usually mentioned in prior studies. The first one is easing the access to production factors, such as labor and capital. Park and Jung (2011) have explained that a business group can create an internal capital market to support each other. For those who are in trouble to finance from outside due to, for example, asymmetric information, the parent company can invest in its subsidiary instead of the outside capital market. Cho (2016) also argues that the vertical structure allows subsidiaries to enjoy higher leverage. From the inter-temporal risk sharing perspective, a business group is also helpful. A business cycle affects firms differently in a different time, depending on their business sectors and locations. For example, a subsidiary can be negatively affected from industry-specific shocks whereas its parent company would not be damaged from the shocks. In this case, the subsidiary can receive financial support from the parent company. Second one is knowledge sharing. Sharing parents' knowledge and know-how with their subsidiaries can improve the total factor productivity (TFP). Wang et al. (2004) empathize that the parent-subsidiary structure allows easily to share a variety of knowledge from a technical one (e.g. manufacturing-related knowledge) to a managerial one (e.g. sales skills, HRM skills, and business strategy), which are more difficult to learn from competitors or strategic alliances.

Many empirical studies support these above-mentioned arguments. Cho (2016) found that companies that changed their status from an independent firm to a subsidiary of a business group have increased the input of production factors 1.3 times higher in five years than those who stayed as independent firms. He also found that the former showed 4.8% point higher leverage than the latter. Kim (2011) found the market value (Tobin's q) of firms that belonged to a business group was greater than the independent companies when he constructed the comparable firm group by propensity score matching. Kim's study explains that business groups are beneficial to their subsidiaries by investing in the subsidiaries or sharing knowledge with them.

3.2.2. Technological knowledge of parent companies

Knowledge is regarded as one of the crucial assets to empower firms to have competitive advantage. Phaal et al. (2001) argue that features of technological knowledge are that it is applied and focuses on know-how. In addition, they emphasize that technological knowledge makes firms invent new products and innovate production processes. Fang et al. (2010) also put an emphasis on technological knowledge.

It is related to product-related activities and can be embodied in research and development (R&D), production equipment, and know-how. It enables business entities to enjoy economies of scale in production, purchase, and R&D. Moreover, it gives a firm edge for a greater market share, compared to ones which do not have similar levels of technological knowledge. A firm with technological knowledge can pass it to its subsidiary, and the subsidiary that can absorb the knowledge from its parent company will enjoy sustained competitive gains (Fang et al., 2007).

3.2.3. Technology intensity by industry

OECD proposes a new industry taxonomy based on R&D intensity (Galindo-Rueda & Verger, 2016). Previously, OECD proposed a similar taxonomy, called technology intensity. Renewing the previous one based on technology intensity, OECD expands the classification scopes; the previous taxonomy covered only the manufacturing industry. The new one, however, takes in both the manufacturing and non-manufacturing industries. R&D intensity has five groups from low to high (Table 3.1).

This study uses this taxonomy for technology intensity. The reason why OECD changed the term from “technology intensity” to “R&D intensity” was due to the concern of inappropriately using the term “technology intensity”. Nevertheless, both are substantially consistent with one another (Galindo-Rueda & Verger, 2016). Thus, this R&D intensity taxonomy can be used as a proxy for technology intensity by industry.

Table 3.1. R&D intensity by industry (ISIC version 4)

R&D intensity	Manufacturing	Non-manufacturing
High	Pharmaceuticals Computer, electronic and optical products	Scientific research and development
Medium-high	Motor vehicles, trailers and semi-trailers Machinery and equipment Chemicals and chemical products etc	Publishing activities IT and other information services
Medium	Rubber and plastic products Basic metals Repair and installation of machinery etc	-
Medium-low	Textiles, leather and related products Coke and refined petroleum products Wood and products of wood and cork etc	Professional, scientific, technical activities Telecommunications Mining and quarrying

Low	-	Financial and insurance activities Wholesale and retail trade Accommodation and food service etc

Note: See Appendix 3.1 for details. ISIC stands for International Standard Industrial Classification.
Source: Galindo-Rueda & Verger (2016).

3.2.4. Boosters for technology knowledge transfer

Parent companies usually have superior technological knowledge, which allows their subsidiaries to enjoy competitive advantage through knowledge transfer from the parent companies. While some firms may enjoy such benefit, others may not. Van Wijk et al. (2008) suggest some factors to explain the boosters for knowledge transfer from parent companies to their subsidiaries.

The first is absorptive capacity of a subsidiary. Cohen and Levinthal (1990) first introduced the concept of absorptive capacity. It is organizational capability that allows firms to identify valuable knowledge and apply it to commercial ends. To put it differently, a firm with high absorptive capacity can assess the possibility of successfully transforming a piece of knowledge into a profitable product (Fang et al., 2007).

Cohen and Levinthal (1990) argue that a firm's capability to take advantage of knowledge from outside is developed as a by-product of its R&D. In other words, they argue that the capability to take advantage of knowledge outside is a function of its R&D investment. Thus, they maintain that R&D contributes to firms' absorptive capacity. Griffith et al. (2003) also claim that engaging in R&D activities especially for technological field, firms can obtain tacit knowledge. This tacit knowledge allow them for easily understanding and incorporating findings from others. This knowledge can be called absorptive capacity.

The second is geographical proximity. Von Hipple (1994) argues that uncertain knowledge can be transmitted well by face-to-face contact. In this vein, geographic proximity is crucial for transferring knowledge. Agrawal and Cockburn (2003) also claim that knowledge, which is tacit and flows through a direct two-way communication channel, is more sensitive to geographical proximity than knowledge delivered by the publication route. Moreover, Feldman (1994a; 1994b) argues that location eases the inherent uncertainty of innovation. This means that proximity increases the capability of firms to share knowledge and be cognizant of important new knowledge, and it allows to reduce uncertainty for firms' innovation activities. Some studies on patents also reveal that proximity matters for knowledge spillovers (Audretsch & Feldman, 2004).

3.3. Preliminary check

This section roughly checks if the prior studies are valid in the Korean context. Two things are evaluated in this section. First, it looks at whether subsidiaries have different effects from their parents, relying on the nationalities of the parents. In other words, it tests if foreign parent companies give substantially different benefits to their subsidiaries, unlike domestic parent companies. Second, among the firms with domestic parent companies, it is checked if it is likely to have differential effects from the domestic parent companies, depending on the absorptive capacity and geographical closeness.

The estimation model was as below, and FE was adopted for this test (see the data and methodology section for the details). Business Activities Panel Survey (BAPS) from Korean Statistics Agency was used.

Revenue$_{it}$ *= F (Parent*$_{it}$*) + time-varying control variables (employment, asset, and outsourcing cost) + four fixed effects (firm, region, industry, and year) + two linear time trends (region and industry)*

where i denotes firm, and t denotes time.

The dependent variable is revenue by firm. The independent variables are parent company possession. In addition, I used several firm-level control variables: employment, asset, and outsourcing cost. Moreover, four fixed effects (firm, region, industry, and year) and two linear time trends (region and industry) were adopted to control heterogeneous trends by region, industry, and year. Finally, I transformed the dependent and the control variables into natural logarithm form. Since production inputs such as labor and capital were controlled, the variable “parent” captures the impact of parent companies’ shared technological knowledge, management know-how, and so on.

Table 3.2 shows the effects of having a parent company on the revenue of its subsidiary. FE_full model does not show significant effect of having a parent company on its subsidiary. However, two split models tell different stories. FE_foreign model, which samples are limited to ones with foreign parent companies, shows the firms with foreign parent companies have on average 4% higher revenue, compared to firms without parent companies. By contrast, domestic parent companies (FE_domesitc) do not show any significant impact on their subsidiaries’ performance. This result is aligned with the above-mentioned literature. In this regard, the main question can be “what conditions allow firms with domestic parent companies to enjoy benefits from parents’ knowledge sharing?”

Table 3.2. Comparison of benefits from parent companies by nationality

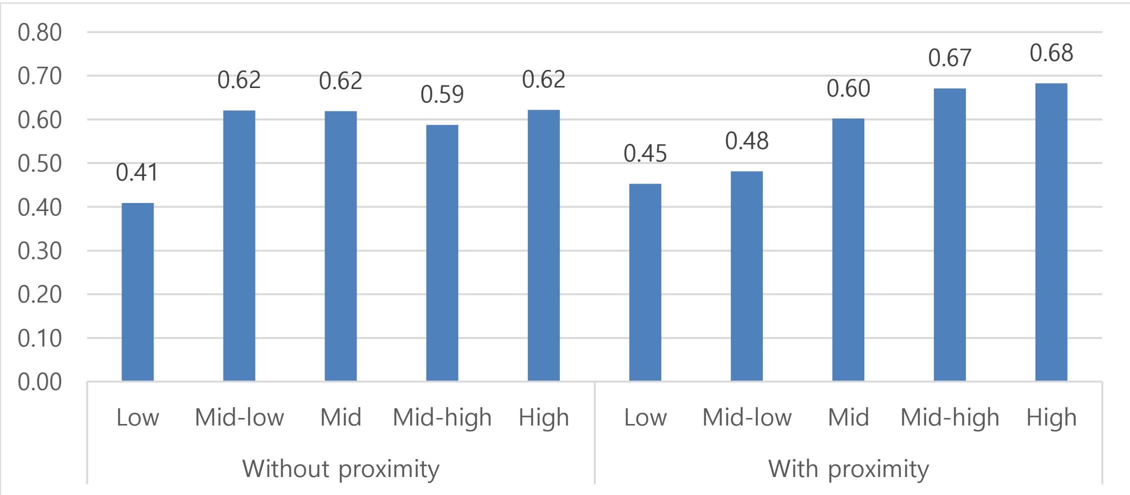
	FE_full	**FE_domestic**	**FE_foreign**
Parent	-0.01 (0.01)	-0.01 (0.01)	0.04** (0.02)
Log (employment)	0.35*** (0.03)	0.35*** (0.03)	0.33*** (0.04)
Log (asset)	0.54*** (0.03)	0.52*** (0.03)	0.60*** (0.06)
Log (outsourcing cost)	0.02*** (0.01)	0.02*** (0.01)	0.01*** (0.01)
Constant	416.15 (199.99)	416.18 (201.16)	257.37 (167.00)
R-squared	0.46	0.45	0.53
Observations (Firms)	21,028 (2,159)	17,138 (1,776)	3,890 (383)

Note: All regressions include, but do not report, four fixed effects (firm, region, industry, and year) and two linear time trends (region and industry).
* Significant at 10%, ** at 5%, *** at 1%.

Figure 3.1 shows the correlation between asset and revenue per employ depending on subsidiaries’ absorptive capacity and geographical proximity between parents and subsidiaries. The same BAPS data was used. This correlation contains revenue (firms’ output) and production inputs (labor and capital), and implies the relationship between output and input. If the correlation is high, it may suggest inputs transformed into output effectively, which may mean greater TFP.

Firms without geographical proximity (left side in the figure) do not show any trend as the absorptive capacity becomes greater. On the other hand, firms with geographical proximity (right side in the figure) show an increasing pattern as the absorptive capacity gets greater. Among some theoretical possibilities, a plausible hypothesis could be deduced on whether geographical proximity and absorptive capacity have a positive impact on the TFP of subsidiaries.

Figure 3.1. Correlations between asset and revenue per employ



Note: The numbers are Pearson correlation coefficients, which range from -1 to 1.

These preliminary checks suggest plausible differential effects. In more detail, if a subsidiary has high absorptive capacity and is located closely to its parent company, the impact from the knowledge transfer could be greater. To put it differently, these firms have greater TFP than others.

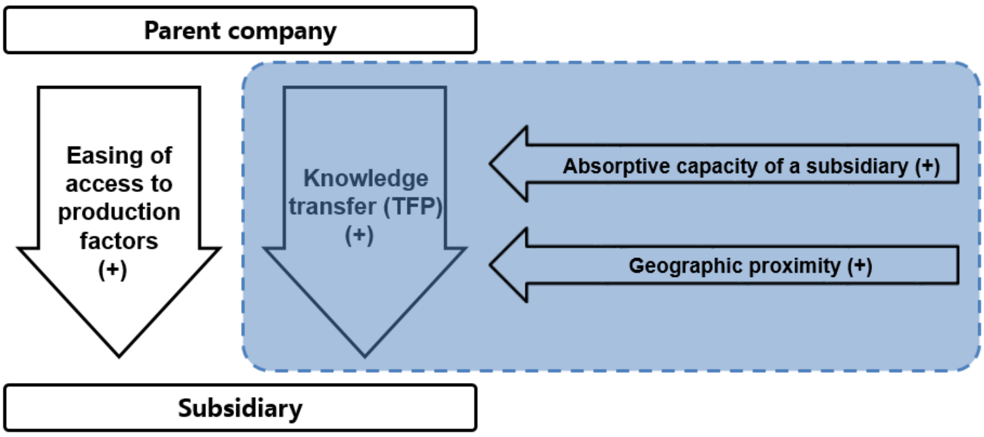
3.4. Research question and hypothesis

This study aims to investigate the differential effects of having a parent company on its subsidiary, depending on the absorptive capacity of the subsidiary as well as the geographical proximity between the parent and the subsidiary.

Based on the literature review and preliminary checks, I hypothesize the following:

Hypothesis: Knowledge transfer from a parent company brings greater effects on its subsidiary's performance if the subsidiary has high absorptive capacity and is located closely to the parent company.

Figure 3.2. Theorization based on prior studies



3.5. Description of the dataset

This study used the Business Activities Panel Survey (BAPS) from Korean Statistics Agency. It provides information for business structures (e.g. parent companies, subsidiaries, and foreign control), activities (e.g. exporting/importing, strategic alliance, and R&D), and financial situation (e.g., revenues, employment, and assets). It collects data from all firms with fifty regular employees or above and greater than KRW 300 million in capital. This panel covers from 2006 to 2018 and amounts to 20,403 firms and 148,790 observations (Korean Statistics Agency, 2018).

This study used the BAPS data that are relevant for this topic as following: i) primary industries (agriculture, forestry and fishing) and firms with foreign parent companies were excluded; ii) firms having a parent company without high technology intensity (i.e. low, mid-low, and mid intensity) were dropped as this study needed to limit the parent companies that have better technological knowledge for their subsidiaries; after this, 12,906 firms and 103,840 observations remained.

The sample description by parent company possession is as follows. 93.3% of firms (12,046 firms, 96,629 observations) did not have parent companies, which means they have always been independent companies. In contrast, 2.9% of firms (371 firms, 2,528 observations) had their parent companies for the whole period. 3.8 % of firms (489 firms, 4,683 observations) had their parent companies occasionally, which indicates that they have been under their parent companies for some periods; however, they are independent companies for other periods. Among the firms, 287 firms and their parent companies were located in the same city or province whereas 202 firms and their parent companies resided in different cities or provinces (Table 3.3). Firms with parent companies occasionally had variations for the fixed effect estimation as their parent company possession was on and off.

Absorptive capacity was calculated based on the R&D expenditure by firm as Cohen and Levinthal (1990) argue that a firm's absorptive capacity is a function of its R&D investment. Based on the R&D expenditure, each firm was classified to one of the five categories as low, mid-low, mid, mid-high, and high.

Table 3.3. Sample description by parent company possession

Parent company possession	Location of a parent and its subsidiary	Absorptive capacity	
Firms without parent companies all the time (12,046 firms, 96,629 observations)	-	Low	4,505 firms, 30,813 observations
		Mid-low	888 firms, 8,418 observations
		Mid	2,288 firms, 18,967 observations
		Mid-high	2,311 firms, 19,390 observations
		High	2,054 firms, 19,041 observations
Firms with parent companies occasionally (489 firms, 4,683 observations)	Same city/province (287 firms, 2,682 observations)	Low	71 firms, 507 observations
		Mid-low	25 firms, 253 observations
		Mid	73 firms, 718 observations
		Mid-high	49 firms, 501 observations
		High	69 firms, 703 observations
	Different city/province (202 firms, 2,001 observations)	Low	30 firms, 206 observations
		Mid-low	18 firms, 176 observations
		Mid	51 firms, 529 observations
		Mid-high	51 firms, 538 observations
		High	52 firms, 552 observations

Firms with parent companies all the time (371 firms, 2,528 observations)	-	Low	152 firms, 930 observations
		Mid-low	27 firms, 235 observations
		Mid	75 firms, 564 observations
		Mid-high	48 firms, 329 observations
		High	69 firms, 470 observations

3.6. Methodology and Models

3.6.1. Methodology: Firm-level fixed effect estimation

The purpose of this study is to check if parent companies have differential effects on their subsidiaries' performance, depending on the absorptive capacity of the subsidiaries and the geographical proximity between the parents and the subsidiaries. For this purpose, firm-level fixed effects estimation was used. By adding region- and industry-level fixed effects, it controlled both time-invariant characteristics of each firm and heterogeneous time, industry, and region effects. It is reasonable to expect the impact of parent companies varies across firms, industries, and regions; thus, it is important to control these heterogeneous characteristics. In this sense, fixed effects estimation is an effective tool to measure the impact of parent companies at the firm level.

Fixed effect is more appropriate than random effect because unobserved characteristics of establishments can be associated with regressors. In addition, since fixed effect allows any correlations between unobserved characteristics of establishments and independent variables, it is a more convincing estimation (Wooldridge, 2009). Moreover, I used clustered standard error at the firm level to minimize the heteroscedasticity issue.

3.6.2. Estimation model

For the estimation model, FE was adopted. The estimation model was modified from Autor (2003) as follows:

$Revenue_{it}$ = *F (*$Parent_{it}$*,* *Absorptive* $capacity_i$*,* $Proximity_i$*) + time-varying control variables (employment, asset, and outsourcing cost) +four fixed effects (firm, region, industry, and year) + two linear time trends (region and industry).*

where *i* denotes firm, and *t* denotes time.

The dependent variable is annual revenue by firm. As information on profit is not available in BAPS, revenue is the best candidate to measure a firm's performance.

The independent variables are parent company possession, absorptive capacity of a subsidiary, and geographical proximity between a parent and its subsidiary. First, parent company possession means if a firm has its parent company or not at a given year. As this study aims to explore the effects from domestic parent companies, the parent companies are limited to domestic ones. Second, absorptive capacity is measure by the degree of R&D expenditure, as explained in the literature review section. A firm is classified to one of five level of absorptive capacity, based on its average R&D expenditure. Third, in terms of geographical proximity, a firms is regarded it has proximity if the firms and its parent company are located in a same city or province. It is ideal to use real geographic distance between them. However, BAPS has only administrative locations of firms, thus the information of administrative location is used as proxy of the geographical proximity.

In addition, I used several firm-level control variables: employment, asset, and outsourcing cost. Moreover, four fixed effects (firm, region, industry, and year) and two linear time trends (region and industry) were adopted to control heterogeneous trends by region, industry, and year. Finally, I transformed the dependent and the control variables into natural logarithm form.

As the samples were split by absorptive capacity and geographical proximity in the estimations, the coefficients of the parent variable in the estimations captured the effect of having a parent company, depending on the level of the absorptive capacity. Comparing the coefficients of the parent variable can identify if parent companies have differential effects on their subsidiaries depending on the absorptive capacity and geographical proximity. Moreover, by adding labor and capital variables as the control variables, the parent coefficient measured the impact of knowledge transfer (i.e. impact on TFP) from parent companies, excluding the effects from easing the access to the production factors.

Here, I present the expected signs of the variables. Studies on economics and labor economics suggest positive signs of control variable (i.e. employment, asset, and outsourcing cost). Revenue is closely related to consumption of labor and capital. In addition, if a firm outsources its production related activities, a firms is likely to have greater revenue, as it means the firms consumes more labor and capital.

Table 3.4. Variable definitions

Variable	Definition
Revenue (KRW mil.)	Total revenue by $firm_{it}$
Parent	Parent = 1 if a firm has a parent company, otherwise 0
Absorptive capacity (5 categories)	Category variable (1-5) based on average R&D expenditure by firm
Proximity	Proximity = 1 if a parent and its subsidiary are in the same city/province
Employment (person)	Total employment by $firm_{it}$
Asset (KRW mil.)	Total asset by $firm_{it}$
Outsourcing cost (KRW mil.)	Total outsourcing cost by $firm_{it}$
Region (17 categories)	Head office location by $firm_{i}$
Industry sector (69 categories)	2 digit classification (KSIC)

Note: BAPS defines a parent company when the company has more than 50% shares of its subsidiary. Joint-venture and the other types of vertical relationship are not defined as a parent company in the survey. See the appendix 3.2 for the industry sectors.

3.7. Results

The results of fixed-effects (FE) estimations are presented in Table 3.5. Six FE models were used. The FE-full model used all samples whereas the other five (FE_1~FE_5) used sub-samples split by absorptive capacity levels of subsidiaries. All models used observations with the geographical proximity between parents and their subsidiaries.

First, the parent coefficient of the FE_full model was positive but insignificant. All control variables were positive and significant as expected. Among the split models, only FE_5, which means that subsidiaries have the highest level of absorptive capacity, shows a positive and significant effect of having a parent company. The coefficient suggests if a firm with high absorptive capacity has the parent company within the same city/province, they have about 6% higher revenues on average than the firm without a parent company. To put it differently, it implies that having a parent company is not enough to enjoy the benefits from knowledge transfer. When subsidiaries have absorptive capacity with geographical proximity facilitating the transfer by easing face-to-face communication and other interactions, they can actualize the benefits from knowledge transfer.

Table 3.5. FE estimation results (with geographical proximity)

	FE_full	FE_1	FE_2	FE_3	FE_4	FE_5
Parent	0.01 (0.03)	0.05 (0.05)	-0.06 (0.05)	-0.03 (0.08)	-0.04 (0.15)	0.06* (0.04)
Log (employment)	0.31*** (0.05)	0.21*** (0.05)	0.22*** (0.06)	0.35*** (0.094)	0.43*** (0.15)	0.27*** (0.06)
Log (asset)	0.52*** (0.07)	0.65*** (0.14)	0.74*** (0.16)	0.32*** (0.10)	0.54*** (0.18)	0.63*** (0.07)
Log (outsourcing cost)	0.01*** (0.01)	0.01** (0.01)	0.01* (0.01)	0.02** (0.01)	0.03* (0.02)	0.01** (0.01)
Constant	1461.85 (110.63)	1283.59 (171.51)	108.55 (153.76)	54.95 (109.58)	79.64 (308.47)	-76.68 (136.87)
R-squared	0.46	0.51	0.68	0.44	0.40	0.67
Observations (Firms)	4,090 (500)	1,105 (167)	301 (31)	1,050 (117)	650 (79)	984 (106)

Note: All regressions include, but do not report, four fixed effect (firm, region, industry, and year) and two linear time trends (region and industry).
* Significant at 10%, ** at 5%, *** at 1%.

Second, same estimations were conducted by using the sample without geographical proximity between parents and their subsidiaries (Table 3.6). All models did not have any positive and significant coefficients of the parent variable. On the contrary to the results in table 3.5, the FE_full model showed negative and significant coefficient of the parent variable. It also implies that geographical proximity matters to actualize the benefits from parent companies.

Table 3.6. FE estimation results (without geographical proximity)

	FE_full	FE_1	FE_2	FE_3	FE_4	FE_5
Parent	-0.10** (0.05)	-0.35 (0.22)	-0.02 (0.07)	-0.03 (0.04)	-0.07 (0.05)	-0.05 (0.05)
Log (employment)	0.33*** (0.06)	0.09 (0.09)	0.51*** (0.12)	0.46*** (0.08)	0.50*** (0.08)	0.31*** (0.06)
Log (asset)	0.51*** (0.05)	0.48*** (0.11)	0.39*** (0.12)	0.33*** (0.08)	0.41*** (0.07)	0.61*** (0.07)
Log	0.02**	0.02	0.02*	0.01	0.01	0.02***

(outsourcing cost)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)
Constant	-66.87* (36.66)	-656.75** (261.57)	203.21*** (52.56)	-19.33 (74.73)	-40.09 (121.17)	-41.25 (38.79)
R-squared	0.46	0.62	0.72	0.65	0.62	0.74
Observations (Firms)	3,121 (360)	538 (86)	147 (16)	794 (82)	773 (80)	869 (96)

Note: All regressions include, but do not report, four fixed effect (firm, region, industry, and year) and two linear time trends (region and industry).
* Significant at 10%, ** at 5%, *** at 1%.

3.8. Robustness check

This section provides another estimation for robustness check. FE is a good tool to tackle to measure the differential effects of the parents companies. FE can also use the variations along each firm as it is the firm-level FE estimation. In other words, FE uses variations when a firm changes its status along the time-series on whether it has a parent company or not. It has virtue of controlling time-invariant firm characteristics. However, it was unable to compare the firm performance between firms with parent companies and ones without. Considering the fact that more than 93% of firms did not have a parent company at all in the BAPS dataset, this comparison provides another evidence on identifying whether there are differential effects of parent companies, depending on the absorptive capacity and geographical proximity.

3.8.1. Methodology: propensity score matching (PSM) + difference-in-differences (DID)

Difference-in-differences (DID) combined with propensity score matching (PSM) was adopted. PSM + DID allows to compare the firm performance between firms with parent companies and ones without. Moreover, this study added one additional variable and its interaction terms to the traditional DID model. It is useful to capture a different trend which could influence differently a treatment group and a control group in the DID estimator. DID is also useful to deal with time-invariant endogeneity issues. However, this approach was only valid when the critical assumption - parallel trends between the treated and control groups before the treatment – was met. PSM was useful to secure the parallel trends by matching a firm in the treated group with a firm having similar characteristics in the control group (Bentivogli & Mirenda, 2017).

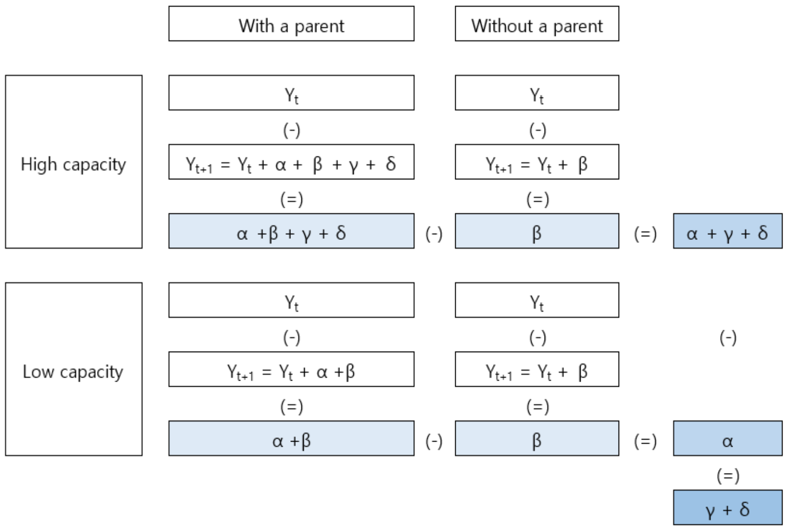
This robustness check also uses the same BAPS data with a little different setting. Samples were used as follows: i) the period of 2009-2015 was used as the treated group was the firms that were subject to their parent companies at first in 2011[11]; ii) firms with seven-year (09-15) observations were analyzed; iii) primary industries (i.e. agriculture, forestry, and fishing) and firms with foreign parent companies were excluded; iv) firms having parent companies with low technology intensity (low and mid-low) were dropped; v) revenue outliers (higher than top 99% or lower than bottom 1%) were dropped as the analysis with the limited number of treated/control firms may not be robust to the outliers. After this, 5,683 firms (39,781 observations) remained.

Figure 3.3 shows how DID was used in this study. When outcomes were compared before and after the treatment (i.e. having a parent company in 2011) from firms with high absorptive capacity and which were located in a same city or province with their parent companies, four factors could be measured: i) benefits from knowledge transfer, which does not require any absorptive capacity of a subsidiary (α), ii) natural growth over time (β), iii) additional benefits from knowledge transfer, only when a subsidiary has high absorptive capacity (δ), and iv) additional benefits from knowledge transfer, only when a parent and a subsidiary locate closely (γ). If I conducted the same comparison with firms with high absorptive capacity and no parent company, it would capture only natural growth over time (β). The difference of the first and second comparisons, which is the DID estimator, is $\alpha+\delta+\gamma$. When I conducted the same comparison with firms with low absorptive capacity, the DID estimator measured only α. By contracting these two estimators, the size of $\delta+\gamma$ was finally measured, which is the additional benefits from knowledge transfer only when a subsidiary has high absorptive capacity and geographical proximity with their parent companies.

[11] The year of 2011 was chosen since the greatest number of firms had their parent companies in 2011.

Later in this section, I also checked the DID estimator by using only firms without geographical proximity to their parent companies. The estimator captured the size of δ. If δ+γ was statistically significant, δ would not be significant, and it may suggest that geographical proximity matters for knowledge transfer between a parent-subsidiary relationship.

Figure 3.3. Concept of Difference-in-Differences (DID) with differential effects



Note: α: benefits from knowledge transfer, which does not require any absorptive capacity of a subsidiary; β: natural growth over time; δ: additional benefits from knowledge transfer, only when a subsidiary has high absorptive capacity; γ: additional benefits from knowledge transfer, only when a parent and a subsidiary locate closely.
Source: This figure is modified from Woo & Chang (2018).

3.8.2. Estimation model

DID model was adopted. As the samples were limited to firms that were located in the same city/province where their parent companies were located, β7 has captured the differential effects of having a parent company, depending on the level of the absorptive capacity. Moreover, by adding labor and capital variables as the control variables, the estimator has measured the impact of knowledge transfer from the parent companies, excluding the effects of easing the access to the production factors. The estimation model is as follows:

Revenue = β_0 + β_1*Treated* + β_2*Post* + β_3*High capacity* + β_4*Treated*Post* + β_5*Post*High capacity* + β_6*Treated*High capacity* + β_7*Treated*Post*High capacity* + *time-varying control variables (employment, asset, outsourcing cost, strategic alliance, and subsidiary) + three fixed effects (region, industry, and year) + two linear time trends (region and industry).*

where Treated = 1 if a firm has a parent company in 2011, otherwise 0, Post = 1 if year $\geq$ 2011 otherwise 0, and High capacity = 1 if a firm's R&D intensity is mid-high or high, otherwise 0.

The dependent variable is revenue by firm. In addition, I used several firm-level control variables: employment, asset, and outsourcing cost. Moreover, three fixed effects (region, industry, and year) and two linear time trends (region and industry) were adopted to control heterogeneous trends by region, industry, and year. Finally, I transformed the dependent and the control variables into natural logarithm form.

Table 3.7. Variable definitions

Variable	Definition
Revenue (KRW mil)	Total revenue by $firm_{it}$
Treated	Treated = 1 if a firm has a parent company in 2011, otherwise 0
Post	Post = 1 if year $\geq$ 2011, otherwise 0
High capacity	High capacity = 1 if a firm's R&D intensity is mid-high or high, otherwise 0.
Employment (person)	Total employment by $firm_{it}$
Asset (KRW mil)	Total asset by $firm_{it}$
Outsourcing cost (KRW mil)	Total outsourcing cost by $firm_{it}$
Region (7 categories)	Head office location by $firm_i$
Industry sector (6 sectors)	Manufacturing; Producer services; Consumer services; Distribution services; Public and non-profit; Others (see appendix 3)

3.8.3. Matching strategy

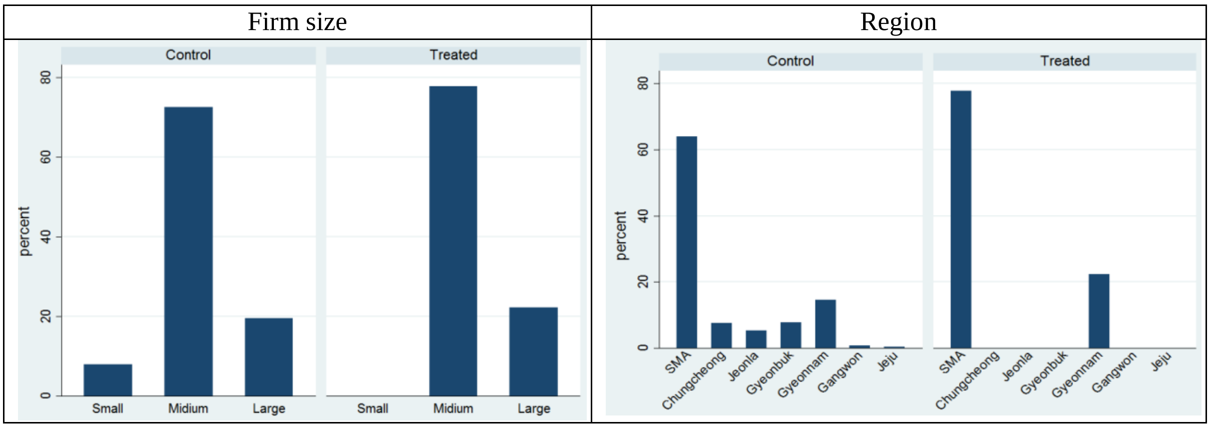
The treatment group candidates were the firms which had the parent companies occasionally and were located in the same city/province where the parent companies resided. The year 2011 was chosen as the treated year since it allows for securing the greatest number of firms from the treatment group candidate firms. As a result, for the treated group, firms with the following features were identified: i) firms which had parent companies in 2011 for the first time; ii) firms that had their parent companies for the rest years during the period 2011-2015; iii) firms which were located in the same city/province where their parent companies resided. The control group was the firms as follows: i) firms which have not had parent companies at all for the period 2009-2015.

Regarding the PSM, logit regression was run to estimate the propensity score to have a parent company for both treated and control groups. Observations before the treatment (i.e. having a parent company in 2011 for the first time) were used for the matching. Observations included revenue, employment, R&D expenditure, asset, outsourcing cost, strategic alliance, and subsidiary. One-to-one matching was used, which means that the nearest neighbor of each firm in the control group was matched to each firm in the treated group. This one-to-one matching can minimize the selection bias by pairing the firms with the closest propensity score.

Prior to the matching, 10 firms (70 observations) for the treated and 5,270 firms (36,890 observations) for the control group were identified. PSM matched 27 firms (189 observations), in particular, 9 firms (63 observations) from the treated group and 18 firms (126 observations) from the control group.

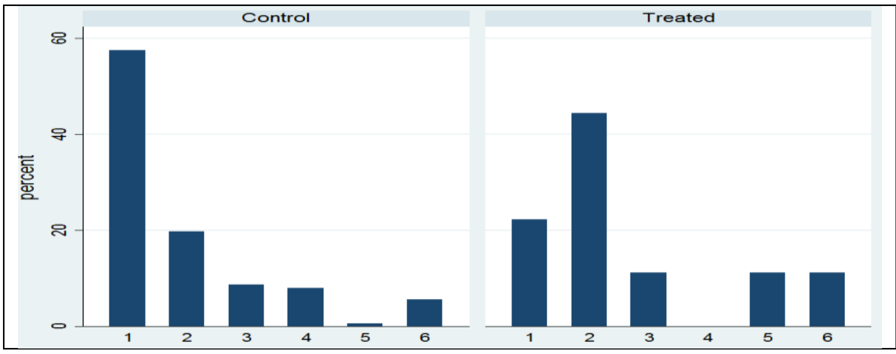
Figure 3.4 and Figure 3.5 compare the two groups by size, region, and industry sector, on average, during the pre-treatment (2009-2010), especially for firms located in a same city or province where their parents are resided. The figures suggest that the groups have a systematic difference. For example, location-wise, the treatment group concentrated on two regions (the Seoul Metropolitan Area and Gyeongnam) whereas the control group firms were located in 7 different regions. In addition, the industry sectors of the treatment group had more shares in producer services while the manufacturing industry had the greatest share in the control group.

Figure 3.4. Comparison by firm size and region before PSM



Note: see the appendix 3.3 for the detail of firm size classification.

Figure 3.5. Comparison by firm sector before PSM



1	Manufacturing
2	Producer services
3	Consumer services
4	Distribution services
5	Public and non-profit
6	Others

Note: see the appendix 3.4 for the detail of industry sectors.

Other characteristics, including employment, R&D expenditure, total asset, outsource cost, strategic alliance, and subsidiary, were adopted as the outcome and the control variables. Table 3.8 presents the difference between the two groups before the treatment. On average, the treated group showed smaller levels in the revenue. The treatment group showed higher levels of labor inputs and outsourcing whereas the control group presented higher levels of capital inputs and R&D expenditure. All variables here were used to match the treated and control groups by conducting the propensity-score matching (PSM) method.

Table 3.8. Comparison by other control variables (09-10)

	Control		Treated	
	Mean	**S.D**	**Mean**	**S.D**
Revenue (KRW mil)	92,253.69	269,807.00	63,535.67	58,070.67
Employment	263.12	521.44	327.56	333.36
Total asset (KRW mil)	133,694.40	829,663.10	60,857.94	68,640.55
Outsourcing (KRW mil)	7,874.86	44,589.44	12,235.78	24,739.96
R&D (KRW mil)	1,133.87	5,970.34	444.22	716.38
strategic alliance (Y/N)	0.10	0.30	0.22	0.43
Subsidiary (Y/N)	0.43	0.50	0.56	0.51

Note: S.D stands for standard deviation.

Logit regression was used to estimate the propensity score. After the propensity score matching, the treated group had 9 firms and 63 observations, and the control group had 18 firms and 126 observations. T-test was conducted for a balance test in order to check whether the mean values of the variables from both groups before the treatment (i.e., 2009-2010) were systematically different or not. Table 3.9 shows the mean values from the both groups after PSM. The t-test results suggest that both groups were well-balanced as all p-values from the t-test were not statistically significant.

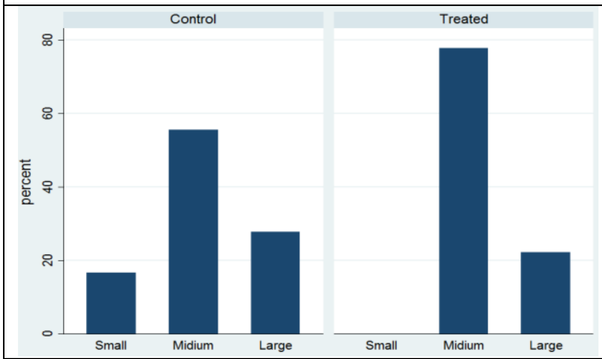
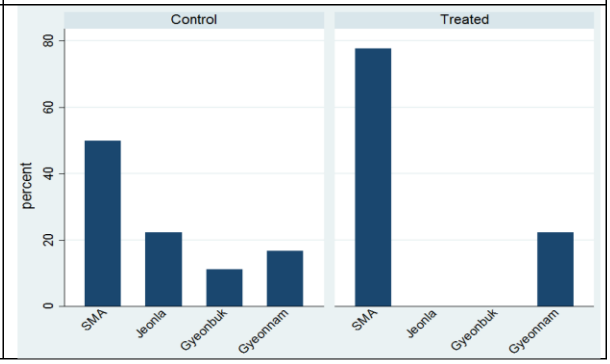
Table 3.9. Mean comparison between the treated and control group (2007-2009)

Variable	Control	Treated	Difference	P-value (T-test)
Log(employment)	5.02	5.37	-0.35	0.18
Log(asset)	9.71	10.34	-0.63	0.19
Log(outsourcing cost)	3.28	4.51	-1.23	0.36
Log(R&D expenditure)	2.10	2.92	-0.81	0.37
Strategic alliance (Y/N)	0.19	0.22	-0.03	0.82
Subsidiary (Y/N)	0.36	0.56	-0.19	0.18

Figure 3.6 and Figure 3.7 compared the two groups by size, region, and industry sector before the treatment (i.e., 2009-2010) after PSM. As the sample size was smaller than the previous sample size, it was more difficult to make comparable groups in all aspects. Even if the factors that can affect revenue

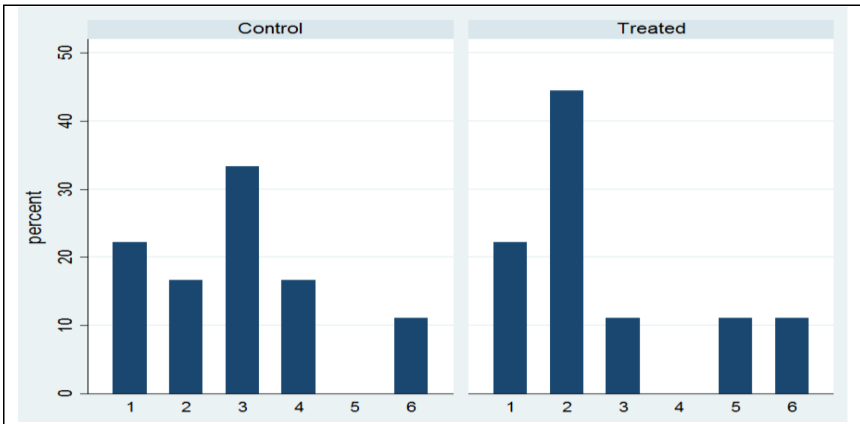
(e.g. employment, asset, outsourcing cost etc) were well matched, firms would not be perfectly matched in terms of region and industry sectors. Thus, three fixed effects (region, industry, and year) + two linear time trends (region and industry) were added to the estimation model as it was necessary to minimize their influence on the estimation models.

Figure 3.6. Comparison by firm size and region (2009) after PSM

Firm size	Region
	

Note: see the appendix 3.3 for the detail of firm size classification.

Figure 3.7. Comparison by firm sector (2009) after PSM



1	Manufacturing
2	Producer services
3	Consumer services
4	Distribution services
5	Public and non-profit
6	Others

Note: see the appendix 3.4 for the detail of industry sectors.

I conducted two fixed effect estimations with linear time trend terms to check if the parallel trend assumption was met. If the treated and control groups had different trajectories prior to the treatment, linear time trend coefficient (β_1) would be significantly different.

The first one is presented below. The estimation shows that the coefficient was insignificant, thus statistically speaking, the two groups did not have different trends before 2011.

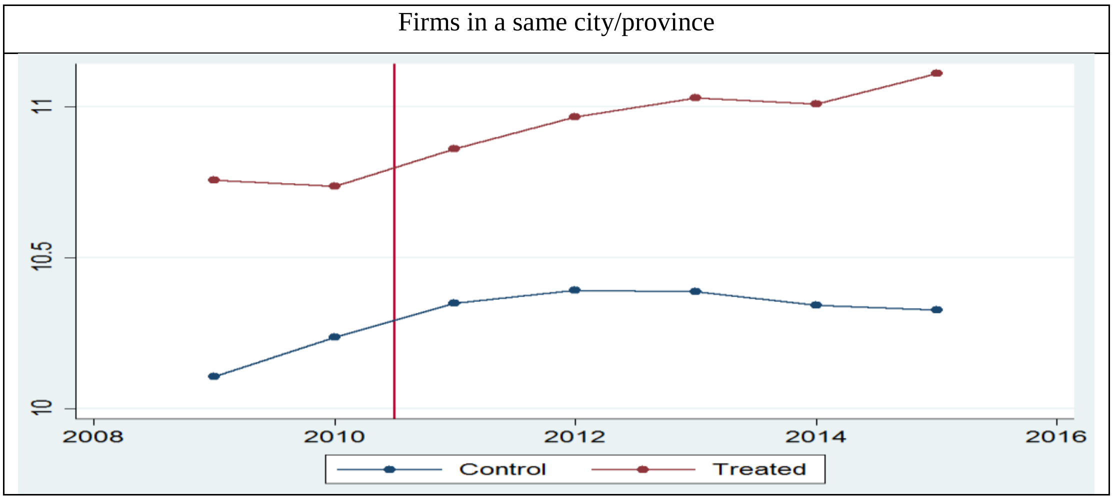
Revenue = β_0 + β_1*Treated*Year + time-varying control variables (employment, size, R&D expenditure, asset, outsourcing cost, strategic alliance, and subsidiary) + three fixed effects (region, industry, and year)*

where Treated = 1 if a firm has a parent company in 2011, otherwise 0, and year 〈 2011.

Second, I conducted the same fixed effect estimation, after replacing "Treated" by "High capacity", in order to check the parallel trend assumption in terms of absorptive capacity. Likewise, the estimation showed that the coefficient of the linear time trend term was insignificant, thus statistically, the two groups did not have different trends before 2011.

Figure 3.8 shows the trend of the average revenue by the two groups: firms with high absorptive capacity and firms with low capacity. This trend also does not suggest serious violation of the parallel trend assumption before 2011.

Figure 3.8. Average revenue by the group



3.8.4. Results

First, DID with proximity model showed a positive and significant effect of having a parent company when firms had high absorptive capacity and geographical proximity to their parent companies. The coefficient suggests that if firms with high absorptive capacity have the parent company within the same city/province, they would have about 80% higher revenues on average than firms with low capacity under the same proximity condition with their parent companies. To put it differently, it implies that having a parent company is not enough to enjoy the benefits from knowledge transfer. When subsidiaries have absorptive capacity with geographical proximity facilitating the transfer by easing face-to-face communication and other interactions, they can actualize the benefits from knowledge transfer.

Second, I conducted a placebo test during the period of 2009-2010 (i.e. before the treatment) to test if the two groups had the common trends. Table 3.10 shows that the coefficient of Treated*Post*High in the DID_placebo model was not significant. This means that the two groups had parallel trends before the treatment.

Third, I conducted the same DID estimation with firms without geographical proximity to their parent companies. Here, the treatment group had the same condition as the treatment group in the main model. The only difference was that the firms were located in a different city/province where their parent companies were located. The control group was as same as the control group in the main model; firms which have not had parent companies at all for the period 2009-2015. When the balance of the two groups and the parallel trend assumption were checked, they were balanced, and no serious violation of the parallel trend assumption was found. DID without the proximity model showed that the effect of having a parent company was not significant. It suggests that high absorptive capacity is not enough to enjoy the benefits from knowledge transfer. Overall, it was deduced that geographical proximity is an important factor for subsidiaries to enjoy the benefits of knowledge transfer.

Table 3.10. DID estimation results

	DID with proximity	DID_placebo	DID w/o proximity
Treated	0.45 (0.29)	0.28 (0.41)	-0.24** (0.11)
Post	-0.15 (0.54)	-1.04** (0.47)	0.20 (0.37)
High	1.89*** (0.37)	1.90*** (0.65)	-0.12 (0.14)
Treated*Post	-0.27 (0.29)	-0.06 (0.47)	-0.43** (0.22)
Post*High	-0.22 (0.21)	0.52 (0.42)	-0.02 (0.15)
Treated*High	-1.79*** (0.37)	-1.72*** (0.52)	0.19 (0.19)
Treated*Post*High	0.80** (0.35)	-0.25 (0.48)	0.13 (0.27)
Log (employment)	0.25*** (0.07)	-0.01 (0.18)	0.66*** (0.05)
Log (asset)	0.86*** (0.05)	0.97*** (0.14)	0.52*** (0.04)
Log (outsourcing cost)	-0.04*** (0.01)	-0.01 (0.03)	-0.01 (0.01)
Constant	-66.02 (216.67)	-2829.06*** (815.99)	19.09 (127.36)
R-squared	0.95	0.97	0.87
Observations	182	52	189

Note: All regressions include, but do not report, three fixed effect (region, industry, and year) and two linear time trends (region and industry).

* Significant at 10%, ** at 5%, *** at 1%.

3.9. Conclusion

3.9.1. Policy Implication

Policy implication from this study centers on the role of geographical proximity over other proximities. Proximity in urban studies usually means geographical proximity; however, other types of proximity exist, for example, organizational, social, and cognitive proximities (Hansen, 2015). Boschma (2005) defines the following: organizational proximity means the extent of control through inter-organizational relationships; social proximity is associated with social relationships, such as friendship and working relationship; and cognitive proximity is related to similarities in capabilities of economic agents (Hansen, 2015). Knoben and Oerlemans (2006) rearranged this proximity framework in terms of inter-organizational collaboration and combined non-geographical proximities to the organizational proximity as the other proximities were basically based on the concept of communities of practice, which means groups of people who share interests for what they do and for how they perform better.

Some prior studies argue that geographical proximity can be substituted by other proximities as they also can bring similar benefits, such as less transaction cost, lesser effort for knowledge absorption, and higher trust (Darr & Kurtzberg, 2000). However, this study implies that geographical proximity can be a catalyst of knowledge transfer between entities that have close organizational proximity. In other words, this study shows that geographical proximity is still critical when organizational proximity is obtained. Thus, as far as policies for knowledge transfer are concerned, geographical proximity should be considered as a crucial factor to boost the policy influence.

3.9.2. Future Study

One limitation of this study was arisen by the sample size used in this study. Although BAPS has more than 20,000 firms, 860 firms were used in the FE estimation, and only 27 firms were used in the DID estimation. It seems to be a hard-to-avoidable limitation as a lot of firms stayed as independent firms. However, this indicates that it becomes necessary to explore a way to secure more samples to improve the accuracy of analyses in future studies.

Appendix 3.1. Technology intensity classification at a two-digit level (ISIC ver4)

	Manufacturing	Non-manufacturing
High	21: Pharmaceuticals 26: Computer, electronic and optical products	72: Scientific research and development
Medium high	30: Other transport equipment 29: Motor vehicles, trailers and semi-trailers 28: Machinery and equipment n.e.c. 20: Chemicals and chemical products 27: Electrical equipment	58: Publishing activities 62-63: IT and other information services
Medium	22: Rubber and plastic products 32: Other manufacturing 23: Other non-metallic mineral products 24: Basic metals 33: Repair and installation of machinery	
Medium low	13: Textiles 25: Fabricated metal products, except machinery 15: Leather and related products 17: Paper and paper products 10-12: Food products, beverages and tobacco 14: Wearing apparel 19: Coke and refined petroleum products 31: Furniture 16: Wood and products of wood and cork 18: Printing and reproduction of recorded media	69-75: Professional, scientific and technical activities except scientific R&D (ISIC 69 to 75 except 72) 61: Telecommunications 05-09: Mining and quarrying
Low		64-66: Financial and insurance activities 35-39: Electricity, gas, water supply, waste mgt 59-60: Audiovisual and broadcasting activities 45-47: Wholesale and retail trade 01-03: Agriculture, forestry and fishing 41-43: Construction 77-82: Administrative and support service activities 90-99: Arts, entertainment, repair of household goods 49-53: Transportation and storage 55-56: Accommodation and food service activities 68: Real estate activities

Source: Galindo-Rueda & Verger (2016).

Appendix 3.2. Industry sectors in KSIC (9th revision)

KSIC	Industry sector
01	Agriculture
02	Forestry
03	Fishing
05	Mining of Coal, Crude Petroleum and Natural Gas
06	Mining of Metal Ores
07	Mining of Non-metallic Minerals, Except Fuel
08	Mining support service activities
10	Manufacture of Food Products
11	Manufacture of Beverages
12	Manufacture of Tobacco Products
13	Manufacture of Textiles, Except Apparel
14	Manufacture of wearing apparel, Clothing Accessories and Fur Articles
15	Tanning and Dressing of Leather , Manufacture of Luggage and Footwear
16	Manufacture of Wood Products of Wood and Cork ; Except Furniture
17	Manufacture of Pulp, Paper and Paper Products
18	Printing and Reproduction of Recorded Media
19	Manufacture of Coke, hard-coal and lignite fuel briquettes and Refined Petroleum Products
20	Manufacture of chemicals and chemical products except pharmaceuticals, medicinal chemicals
21	Manufacture of chemicals and chemical products except pharmaceuticals, medicinal chemicals
22	Manufacture of Rubber and Plastic Products
23	Manufacture of Other Non-metallic Mineral Products
24	Manufacture of Basic Metal Products
25	Manufacture of Fabricated Metal Products, Except Machinery and Furniture
26	Manufacture of Electronic Components, Computer, Radio, Television and Communication Equipment and Apparatuses
27	Manufacture of Medical, Precision and Optical Instruments, Watches and Clocks
28	Manufacture of electrical equipment
29	Manufacture of Other Machinery and Equipment
30	Manufacture of Motor Vehicles, Trailers and Semitrailers
31	Manufacture of Other Transport Equipment
32	Manufacture of Furniture
33	Other manufacturing
35	Electricity, gas, steam and air conditioning supply
36	Water Supply
37	Sewage, Wastewater and Human Waste Treatment Services
38	Waste Collection, Disposal and Materials Recovery
39	Remediation activities and other waste management services
41	General Construction
42	Special Trade Construction
45	Sale of Motor Vehicles and Parts
46	Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles

47	Retail Trade, Except Motor Vehicles and Motorcycles
49	Land Transport ; Transport Via Pipelines
50	Water Transport
51	Air Transport
52	Storage and support activities for transportation
55	Accommodation
56	Food and beverage service activities
58	Publishing activities
59	Motion picture, video and television program production, sound recording and music publishing
60	Broadcasting
61	Telecommunications
62	Computer programming, consultancy and related activities
63	Information service activities
64	Financial Institutions, Except Insurance and Pension Funding
65	Insurance and Pension Funding
66	Activities Auxiliary to Financial Service and Insurance Activities
68	Real Estate Activities
69	Renting and leasing; except real estate
70	Research and Development
71	Professional Services
72	Architectural, Engineering and Other Scientific Technical Services
73	Professional, Scientific and Technical Services, n.e.c.
74	Business Facilities Management and Landscape Services
75	Business Support Services
84	Public Administration and Defence ; Compulsory Social Security
85	Education
86	Human Health
87	Social Work Activities
90	Creative, Arts and Recreation Related Services
91	Sports activities and amusement activities
94	Membership Organizations
95	Maintenance and Repair Services
96	Other Personal Services Activities

Appendix 3.3. Small and medium firm criteria table (As of 2015)

Average revenue of recent three years was less than each standard, and each firm was classified as either medium-sized or small-sized.

(Unit: KRW million)

Industry	Section	Division	Medium-sized	Small-sized
Agriculture, forestry and fishing	A	-	100000	8000
Mining and quarrying	B	-	100000	8000
Manufacture of Food Products	C	10	100000	12000
Manufacture of Beverages	C	11	80000	12000
Manufacture of Tobacco Products	C	12	100000	8000
Manufacture of Textiles, Except Apparel	C	13	100000	8000
Manufacture of wearing apparel, Clothing Accessories and Fur Articles	C	14	150000	12000
Tanning and Dressing of Leather , Manufacture of Luggage and Footwear	C	15	150000	12000
Manufacture of Wood Products of Wood and Cork ; Except Furniture	C	16	100000	8000
Manufacture of Pulp, Paper and Paper Products	C	17	150000	8000
Printing and Reproduction of Recorded Media	C	18	80000	8000
Manufacture of Coke, hard-coal and lignite fuel briquettes and Refined Petroleum Products	C	19	100000	12000
Manufacture of chemicals and chemical products except pharmaceuticals, medicinal chemicals	C	20	100000	12000
Manufacture of Pharmaceuticals, Medicinal Chemicals and Botanical Products	C	21	80000	12000
Manufacture of Rubber and Plastic Products	C	22	100000	8000
Manufacture of Other Non-metallic Mineral Products	C	23	80000	12000
Manufacture of Basic Metal Products	C	24	150000	12000
Manufacture of Fabricated Metal Products, Except Machinery and Furniture	C	25	100000	12000
Manufacture of Electronic Components, Computer, Radio, Television and Communication Equipment and Apparatuses	C	26	100000	12000
Manufacture of Medical, Precision and Optical Instruments, Watches and Clocks	C	27	80000	8000
Manufacture of electrical equipment	C	28	150000	12000
Manufacture of Other Machinery and Equipment	C	29	100000	12000
Manufacture of Motor Vehicles, Trailers and Semitrailers	C	30	100000	12000
Manufacture of Other Transport Equipment	C	31	100000	8000
Manufacture of Furniture	C	32	150000	12000
Other manufacturing	C	33	80000	8000
Electricity, gas, steam and water supply	D	-	100000	12000
Sewerage, waste management, materials recovery and remediation activities	E	-	80000	3000
Construction	F	-	100000	8000
Wholesale and retail trade	G	-	100000	5000
Transportation	H	-	80000	8000
Accommodation and food service activities	I	-	40000	1000
Information and communications	J	-	80000	5000
Financial and insurance activities	K	-	40000	8000
Real estate activities and renting and leasing	L	-	40000	3000
Professional, scientific and technical activities	M	-	60000	3000
Business facilities management and business support services	N	-	60000	3000
Education	P	-	40000	1000
Human health and social work activities	Q	-	60000	1000
Arts, sports and recreation related services	R	-	60000	3000
Membership organizations, repair and other personal services	S	-	60000	1000

Appendix 3.4. Industry taxonomy

Industry sector	Industry (KSIC 9^{th}, 1 digit)
Manufacturing	Manufacturing (C)
Producer services	Financial and insurance activities (K) Real estate activities and renting and leasing (L) Professional, scientific and technical activities (M) Business facilities management and business support services (N) Membership organizations, repair and other personal services (S) Information and communications (J)
Consumer services	Arts, sports and recreation related services (R) Accommodation and food service activities (I) Wholesale and retail trade (G)
Distribution services	Transportation (H) Electricity, gas, steam and water supply (D)
Public and non-profit	Public administration and defense ; compulsory social security (O) Education (P) Human health and social work activities (Q)
Others	Sewerage, waste management, materials recovery and remediation activities (E) Construction (F)

Reference list

Agrawal, A., & Cockburn, I. (2003). The anchor tenant hypothesis: exploring the role of large, local, R&D-intensive firms in regional innovation systems. *International journal of industrial organization, 21*(9), 1227-1253.

Arnold, M,. & Javorcik, S. (2009). Gifted kids or pushy parents? Foreign direct investment and plant productivity in Indonesia. *Journal of International Economics, 79*(1), 42-53.

Audretsch, D., & Feldman, M. (2004). Knowledge spillovers and the geography of innovation. *Handbook of Regional and Urban Economics, 4,* 2713-2739.

Autor, D. (2003). Outsourcing at will: The contribution of unjust dismissal doctrine to the growth of employment outsourcing. *Journal of Labor Economics*, *21*(1), 1-42.

Bentivogli, C., & Mirenda, L. (2017). Foreign ownership and performance: Evidence from Italian firms. *International Journal of the Economics of Business, 24*(3), 251-273, doi: 10.1080/13571516.2017.1343542.

Bertrand, O., & Zitouna, H. (2005). *Domestic versus cross-border acquisitions: Which impact on the target firms' performance?* (Working Paper No. 647). The Research Institute of Industrial Economics.

Boschma, A. (2005). Proximity and innovation: A critical assessment. *Regional Studies, 39*, 61–74.

Campbell, A., Goold, M., & Alexander, M. (1995). The value of the parent company. *California Management Review,* V0l 38.

Chang-Deok, K. (2017). Measuring effects of job accessibility in industry sectors on land prices in Seoul, Korea. *Seoul Studies, 18*(1), 139-160.

Cho, D. (2016). *Recent increasing share of business groups and its macroeconomic implications* (KDI Economic Outlook, Fall edition). Retrieved from http://www.kdi.re.kr/forecast/forecasts_outlook.jsp?pub_no=15003

Cohen, W. M., &Levinthal, D. A. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly, 35*(1), 128-152.

Conyon, M., Girma, S., Thompson, S., & Wright, P. (2002). The productivity and wage effects of foreign acquisitions in the United Kingdom. *Journal of Industrial Economics*, *50*, 85-102.

Darr, E. & Kurtzberg, T. (2000). An investigation of partner similarity dimensions on knowledge transfer. *Organizational Behavior and Human Decision Processes*, *82*(1), 28–44.

EC (2019). Cluster programmes in Europe and beyond.

Fang, Y., Wade, M., Delios, A., &Beamish, P. (2007). International diversification, subsidiary performance, and the mobility of knowledge resources. *Strategic Management Journal*, *28*(10), 1053-1064.

Fang, Y., Jiang, G., Makino, S., & Beamish, P. (2010). Multinational firm knowledge, use of expatriates, and foreign subsidiary performance. *Journal of Management Studies*, *47*(1).

Fukao, K., Keiko, I., & Miho, T. (2006). *Cross-border acquisitions and target firms' erformance: Evidence from Japanese firm-level data* (NBER Working Paper No. 12422).

Galindo-Rueda, F., & Verger, F. (2016). *OECD taxonomy of economic activities based on R&D Intensity* (OECD Science, Technology and Industry Working Papers). Paris: OECD Publishing.

Gao, H., Yang, J., Yin, H., & Ma, Z. (2017). The impact of partner similarity on alliance management capability, stability and performance. *International Journal of Physical Distribution and Logistics Management*, *47*(9), 906-926.

Girma, S., & Gorg H. (2007). Evaluating the foreign ownership wage premium using a difference-in-differences matching approach. *Journal of International Economics*, *72*, 97-112.

Giuliani, E. (2007). The selective nature of knowledge networks in clusters: Evidence from the wine industry. *Journal of Economic Geography, 7*, 139–168.

Griffith, R., Redding, S., & Van Reenen, J. (2003). R&D and absorptive capacity: theory and empirical evidence. Scandinavian journal of Economics, 105(1), 99-118.

Guadalupe, M., Kuzmina, O., & Thomas, C. (2012). Innovation and foreign ownership. *American Economic Review, 102*(7), 3594-3627.

Gupta, A., & Govindarajan, V. (2000). Knowledge flows within multinational corporations. *Strategic Management Journal*, *21*, 473–496.

Hansen, T. (2015). Substitution or overlap? The relations between geographical and non-spatial proximity dimensions in collaborative innovation projects. *Regional Studies*, *49*(10), 1672–1684. http://dx.doi.org/10.1080/00343404.2013.873120.

Henderson, V., Lee, T., & Lee, J. (2001). Scale externalities in Korea. *Journal of Urban Economics*, *49*(3), 479-504.

Kim, C. (2011). Long-term performance of group affiliated firms. *Yonsei Business Review, 48*(2), 133-163

Kim, K. (2010). The effects of industrial specialization and diversity on regional employment growth and income inequality: With a special reference to the wage-earners in the manufacturing sector. Ph.D thesis. Dankuk University.

Kim, K., & Ko, S. (2009). The effects of agglomeration economy on regional employment growth. *Journal of Korea Planning Association*, *44*(7).

Kim , M., &Lee, Y. (2007). Decentralization of urban industries and urban scale economies in Korea. *The Korea Spatial Planning Review, 2007*(6).

Knoben, J., & Oerlemans, L. (2006). Proximity and inter-organizational collaboration: A literature review. *International Journal of Management Reviews*, *8*(2), 71–89.

Korean Statistics Agency. (2018). *Business Activities Panel Survey*. Retrieved from http://kostat.go.kr/portal/korea/kor_nw/1/9/4/index.board

McDonald, J. F., & McMillen, D. P. (2011). Urban economics and real estate: Theory and policy. Hoboken, NJ: John Wiley & Sons.

OECD. (2019). *OECD SME and entrepreneurship outlook 2019*. Paris: OECD Publishing. https://doi.org/10.1787/34907e9c-en

Park, K. & Jung, C. (2011). Tunneling or propping: Functions of business groups under spin-offs. *Korean Journal of Financial Studies*, *40*(3), 461-499.

Parkhe, A. (1991). Interfirm diversity, organizational learning, and longevity in global strategic alliances. *Journal of International Business Studies*, *22*(4), 579-601.

Phaal, R., Farrukh, C., & Probert, D. (2001). *A framework for supporting the management of technological innovation*. *Proceedings of the Conference on the Future of Innovation Study, the Netherlands*, 20-23.

Toussaint-Comeau, M., Newberger, R., & Augustine, D. (2016). Inclusive cluster-based development strategies for inner cities: A conference summary. *Economic Development Quarterly*, *30*(2), 171–184.

Wang, P., Tong, T., & Koh, C. (2004). An integrated model of knowledge transfer from MNC parent to China subsidiary. *Journal of World Business*, *39*(2), 168-182.

Woo, S., & Chang, W. (2018). Straw effect?: the negative side-effects of public funding for subcontractor SMEs. *Journal of Korean Economic Analysis*, *24*(1), 53-105.

Yan Zhang, Y., Li, H., Hitt, M, & Cui, G. (2007). R&D intensity and international joint venture performance in an emerging market: Moderating effects of market focus and ownership structure. *Journal of International Business Studies*, *38*(6), 944-960.