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The Regional Innovation System in China: Regional comparison of technology, venture financing, and human capital focusing on Shenzhen

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The Regional Innovation System in China: Regional comparison of technology, venture financing, and human capital focusing on Shenzhen[1]

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(Abstract)

Shenzhen has become a hot spot of innovation in China. In this paper, we characterize Shenzhen's innovation by comparing it with that of Beijing and Shanghai using patent and venture investment data.

First, the role of universities and public research institutions is small in Shenzhen's innovation system as compared to Beijing and Shanghai. In contrast, private high-tech firms, such as Huawei, ZTE, and Tencent, are leading the innovation scene in Shenzhen.

Second, we find that high-tech start-ups are geographically concentrated in the Nanshan district, particularly Yuehai Jiedao, where national-level high-tech zones are located. Recently, the number of start-ups has been increasing, and local, big firms, such as ZTE, are providing the human resources for such start-up firms.

Third, inventor-disambiguated information based on patent data allows us to look at interorganizational talent movements. We find that such movements tend to occur within short distances, such as within the same district (e.g., Nanshan district).

To sum up, Shenzhen has truly become a hot spot of high-tech entrepreneurship and innovation, but the dynamics are very much regionally bound. Therefore, it is important to become a local player in order to take advantage of innovation movements in Shenzhen by means of minority investment by corporate venture capital into local start-up firms.

[1] This paper is based on the project "Empirical Analysis of Innovation Ecosystems in Advancement of the Internet of Things (IoT)" by RIETI (Research Institute of Economy, Trade and Industry). In addition, financial support from the JETRO Hong Kong Office on the "Shenzhen and China Innovation Survey" is acknowledged. However, the views expressed in this paper are the author's and not those of these organizations.

Keywords: Regional innovation system, China, Shenzhen, Patent data

1. Introduction

There is growing attention on Shenzhen as an innovation hub in China. Shenzhen has developed as the production backyard of Hong Kong, which plays the role of the gateway to China for foreign investments in the electronics industry. In addition, domestic high-tech giants, such as Huawei and ZTE (both telecommunications equipment producers), as well as BYD, which has grown from a battery manufacturer into an automotive producer, have their headquarters there. Therefore, Shenzhen has been ranked as a top city in China in terms of patent applications and research and development (R&D) investments even since the 1990s.

However, it has only been from a few years ago that Shenzhen has been called as a high-tech mecca by attracting huge amounts of venture funding for high-tech entrepreneurship. One of the factors behind such movements has been the advancement of information technology, such as the Internet of Things (IoT) and artificial intelligence (AI), which has opened up substantial business opportunities. In China, the expansion of internet businesses has created new three big giants, Baidu, Alibaba, and Tencent (known as BAT). Tencent is based in Shenzhen and makes substantial contributions to local entrepreneurship activities as a source of human and financial capital. In addition, production facilities concentrated in Shenzhen, or the Pearl River Delta area, can be connected by the internet as IoT technologies advance, which creates new business opportunities in the area. In addition, the diffusion of the smartphone platform has made entrepreneurship activities easier through the emergence of the business-to-consumer platform (Kimura, 2016).

There has also been a strong policy push. The growth rate of China’s economy has slowed recently, and the Chinese government has changed its economic policy targets from investment-led, high-speed growth to the quality improvement of growth, such as through innovation and entrepreneurship promotion by taking care of energy and environmental sustainability. Among these measures, the premier, Li Keqiang, announced the policy of “Dazhong Chuanuyue, Wanzhong Chuanxin (Entrepreneurship and Innovation for Everybody)”. For example, the government introduced venture capital (VC) funding promotion policies, such as co-financing for private VC funds from local government funds (Fujita, 2017). Furthermore, internet companies, such as BAT, are actively inventing through their corporate venture capital. As a result, there are some data showing that the size of VC investments in China has reached $100 billion, comparable to the figure in the United States. [2]

There is no question that the booming high-entrepreneurship in China and Shenzhen plays an important role. However, there is no statistical evidence to show what is going on. This paper fills this gap by comparing the innovation activities of Shenzhen with those of Beijing and Shanghai. I focus on the three factors of technology, funding, and human capital, which are important for understanding the regional innovation ecosystem. Specifically, the state of technological development can be captured by a patent database. The patent database can be used for analyzing high-tech talents since inventor records help us to understand the invention process at the individual engineer level. VC financing is analyzed using another dataset, called IT Juzi, the information platform of venture firms, VCs, and entrepreneurs.

The structure of this paper is as follows. The next section provides information on State Intellectual Property Office (SIPO) patent database and a general description of technological development in China. The body section of this paper then compares Shenzhen with Beijing and Shanghai by using the patent database as well as VC financing information. Finally, the paper concludes with a summary and policy implications.

2. Innovation Activities in China and the Patent Database

2-1. Measuring innovation by patent data

Patent databases are extensively used in empirical studies on innovation, and the development of databases has spread all over the world. Motohashi (2008) describes the use of the SIPO database for measuring technological development in China. In this paper's analysis, the dataset is extended to patents published by December 2016. The following items are available from the patent publication information:

- Date of application (reflects the timing of invention).
- Title of the invention and technology classes by International Patent Classification code.
- Name of the applicant (name of firm, university, etc. as the applicant of the invention; this information allows us to aggregate patent statistics by the type of

[2] "VC Investment in China close to 10 trillion yen! Where is it from?", 21 July 2017, JBPRESS.

applicant, such as firm patents versus university ones).

- Address of the applicant (allows us to aggregate patent statistics by location, such as from Beijing or Shenzhen).
- Name of the inventor.

The patent statics reflect the state of innovation activities in detail, but there are some drawbacks as well (Nagaoka et al., 2012). First, not all inventions are patented. Under the patent system, information on patent applications is published within 18 months of application. Therefore, there are some strategic reasons for which a firm might not file a patent for its invention and keeps it as a trade secret. In general, product innovations are more likely to be patented compared to process innovations since inventions embodied in new products can be more easily imitated by reverse engineering than process innovations, where the invention can be kept secret easily. In addition, it has been found that patent rights are effective for protecting inventions of some particular products, such as drugs, but this is not always the case for others (NISTEP, 2004).

In addition, it should be noted that there is great heterogeneity in the quality of patents. For example, when we compare two firms with the same R&D investment size from the pharmaceutical and electronics industries, the number of patent applications will have a one or even two-digit order of difference (in general, electronics firms have greater numbers of patents). The number of very high-quality patents may also be very small even within the same firm (Nagaoka et al., 2012). Therefore, the simple patent counts may not represent innovation performance very well, and the numbers must be weighted by patent quality, typically the number of forward citations.

2-2. Trend of patenting in China

Unfortunately, citation information does not exist in the SIPO patent database, so we use the simple patent counts in this paper.

Figure 2-1 compares the number of patent applications for domestic applicants and foreign applicants. The number of applications from foreign applicants, mainly foreign firms, dominated until 2005, but the number of domestic applicants surpassed foreign applicants on that year and increased rapidly after 2010.[3] It should be noted that the

[3] It should be noted that the decrease in 2016 occurs because of data truncation. Since the publication of application information takes place within 18 months after the

number of domestic patent applications can be explained by the local government policy to subsidize patenting activities since the 2000s. Dang and Motohashi (2015) analyze such policies and find that the impacts are estimated to increase patent applications by 30%. Therefore, even if there had not been such a policy, the application number in 2014 would have still been over 500,000 (767,000/1.3). Therefore, the increase in domestic patent applications reflects the improvement of technological capability in China. On the other hand, the number of foreign applications is stable after 2006. Since large firms in developed countries carefully select the inventions to be patented worldwide, a stable number of patent applications from such big players may explain the trend of foreign applications in China.

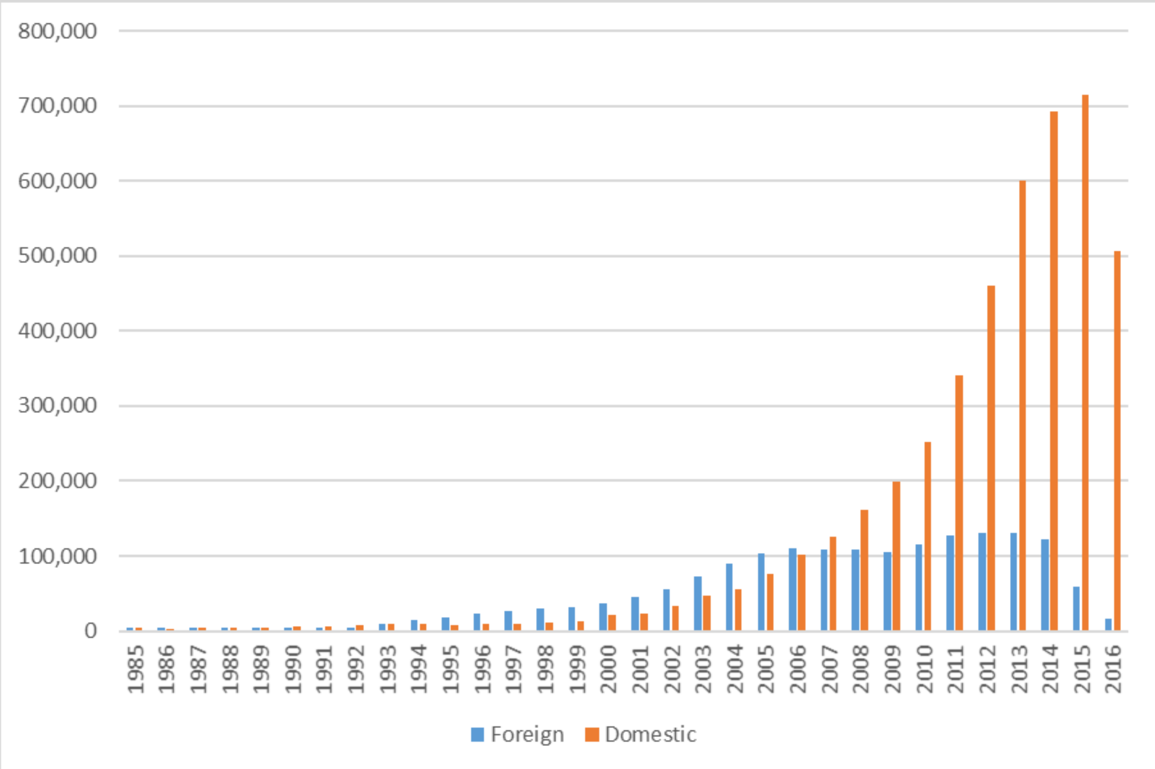

Figure 2-1: Number of patent applications by applicant type (domestic versus foreign)

Figure 2-2 shows the share of patent applications by applicant type (individuals, firms, universities, and PRIs) for domestic applications. Until 2000, individual inventors dominated over institutional ones, such as firms and universities, but the number of firm

application date, the data published until the end of 2016 contain all applications by June 2015 but not all patents applied after that.

applications increased in these 10 years. The increase in institutional applicants over individual ones can be explained by the diffusion of the employee invention system. In terms of the comparison between private (firm) and public (university and PRI) patents, private ones outnumbered those of public ones in 2005 by 1.5 times (31,562 and 19,366, respectively), but the ratio increased to 3 in 2015 (432,334 and 152,836, respectively). Therefore, the role of private firms has become important in the development of China's innovation system.

However, it should be noted that the role of the public sector, such as universities and PRIs, is large compared with other developed nations. For example, the number of public sector applications in Japan comprises about 1% of total applications. In addition, the share of patent applications by both firms and universities (joint applications) in China was 1.7% in 2014, which was significantly larger than in other countries. Therefore, universities and PRIs still play a relatively large role in China's technology development.

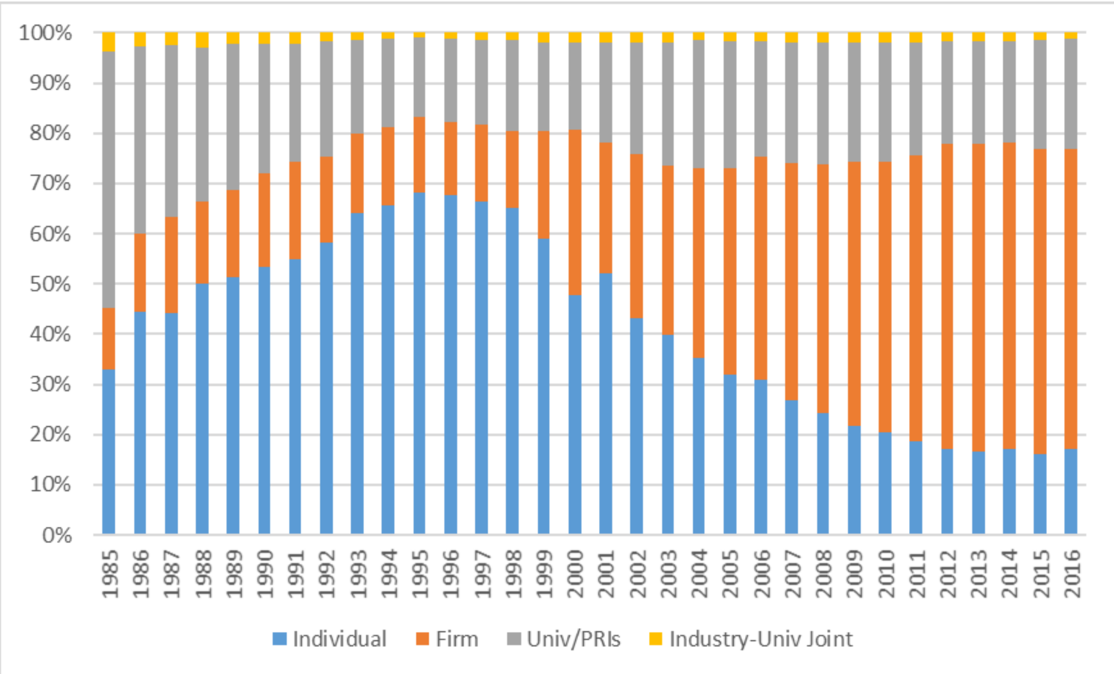

Figure 2-2: Share of patent applications by type (domestic applicants only)

Finally, Figure 2-3 shows the geographical distribution of patent applications. Here the most detailed level of administrative distinction (district level for cities with districts and city level for others, about 4,000 districts and cities) is used, and the size of the circles reflects the number of patent applications.

There are three big clusters found in the coastal area i.e., Beijing (Zhongancun, centered around the Haidian district), the Shanghai/Yangze River Delta including Suzhou and Hangzhou, and the Shenzhen/Pearl River Delta including Guangzhou. In addition, some other clustering areas are found in-land, such as in Chengdu, Chongqing, Xian, and Wuhan, but the sizes are relatively small compared to the large three coastal clusters.

Figure 2-3: Regional distribution of patent applications

3. The Regional Innovation Ecosystem: Beijing, Shanghai, and Shenzhen

3-1. Concept of the regional innovation ecosystem

The innovation ecosystem is a hot topic in innovation studies. IoT technology diffuses in the market, business fields become interconnected with one another, and the focus of open innovation is shifting from one-to-one collaboration in a particular business to the creation of an ecosystem involving multiple players across various industry fields. For example, the traditional business structure of the automotive industry is a hierarchal one where a car manufacturer is located at the top, and a number of parts companies are found in the downstream. However, as car sharing systems, such as Uber, become popular, car manufacturers become incorporated as part of a system of components in a larger transportation service system. In order to respond to such competitive forces outside the car industry, an automotive firm needs to create its own ecosystem of transportation services with other complementary service providers, such as parking services and even railway transportation service providers, to create seamless transportation services over a long distance. In addition, autonomous driving technology is an essential technology component in such services. Therefore, it is also important to create collaborative networks with start-up firms that are strong in particular technologies, such as sensor and image recognition by using artificial intelligence. The innovation ecosystem is such that firm networks involve various players, and the participants have mutually beneficial relationships (Keidanren, 2017).

Then, can such ecosystems, or networks of players, be effectively formed in a regionally bounded area? The answer is obviously yes, since business interactions are easily made within short distances as compared to parties separated by long distances. Formally, there are some economic externalities in the agglomeration of innovative activities. The previous literature discusses two types of externalities (Fujita, 2009). The first one is the Marshall, Arrow, and Romer type, which suggests that homogeneous types of management resources, such as talents and technologies, contribute to positive externalities in agglomeration. For example, the co-location of firms within the same industry attracts human resources for the specific industry from outside. In addition, knowledge spillovers can occur more easily among the same types of industry (Jaffe, 1986) and where geographical distances are smaller (Jaffe, Trajtenberg, and Henderson, 1993). Therefore, a firm has greater incentive to locate in a place where a large number of firms with the same type of technology are located. As a consequence, economic externalities by technology spillovers are generated by homogeneous technology and industry agglomeration.

On the other hand, there is another school that stresses clusters of diverse knowledge for agglomeration externalities. This is called the Jacobs type, named from the seminal work by Jacobs (1969). According to Schumpeter, innovation occurs in new combinations of different ideas. Therefore, diversity in terms of technology, industry, and talents in a particular area can be a source of economic externality in agglomeration. One example of this is Florida's (2007) concept of "creative capital". Florida argues that creative ideas and innovation are generated in the urban environment, which attracts "creative class" people from outside. Therefore, one of the important factors for cities to be innovative is to allow diversity, such as through the social acceptance of different cultures, ethnicities, or LGBT people (Florida, 2007).

It should be noted that the MAR externality and the Jacobs one do not contradict each other, and both types can be found at the same time empirically (Beaudry and Schiffauerova, 2009). In general, MAR externalities are observed at the macro level, while Jacobs externalities are relevant at the micro level. In addition, it has been found that MAR externalities are important in the short term, but Jacobs externalities appear in the long term. For example, Silicon Valley attracts many of the same types of firms in the computer and software industries at the macro level. However, a micro look reveals that quite diverse people in terms of ethnicity are working there. In addition, a diverse mix of firms has allowed a flexible evolution from the semiconductor industry to an internet technology cluster in the long-term perspective.

Moreover, the MAR type of externality tends to be discussed in the context of an uncompetitive economic environment where a large firm dominates the market, while the Jacobs type fits a competitive environment activated by entrepreneurial dynamics. But, reality reflects both types of mechanism of market development. Again, in Silicon Valley, a major driver of innovation is, of course, entrepreneurship activities. At the same time, we cannot deny the importance of anchor companies, such as Intel and HP in the computer era, and, more recently, Google and Apple in playing an important role for driving innovative entrepreneurship in the region.

It is obvious that economic and innovation activities are geographically concentrated. In China, we have already seen that inventions are clustered around three big coastal areas, Beijing, Shanghai, and Shenzhen. Therefore, the next question is how such innovation agglomeration is formed. Particularly, we analyze the existence of agglomeration externalities by looking at technology, human resources, and VC finance. These three factors are important for understanding the regional ecosystem, that is, the state of interactions among various innovation system players, such as big firms, start-up firms, universities, high-tech talents, and venture capitals, within a certain geographical boundary (Asheim and Coenen, 2006). In this section, we focus on three cities, Beijing, Shanghai, and Shenzhen, to understand the mechanism of innovation agglomeration and the differences between them.

3-2. Comparison of Beijing, Shanghai, and Shenzhen using patent data

First, we use the patent data to show the structural characteristics of technological development in Beijing, Shanghai, and Shenzhen. We extract the patents where the applicants are located in the three cities. In total, about 1 million patents (Beijing:

448,452; Shanghai: 287,092; and Shenzhen: 261,992) out of 6.2 million are used.

Beijing can be characterized as the center of China's public research organizations, where Beijing University, Tsinghua University, and numerous Chinese Academy of Science (CAS) Research Institutes are located. Therefore, the presence of publicly funded research is supposed to be large. In addition, a lot of foreign multinationals have research centers in the city.

Shanghai is a center of commercial activities, and large domestic firms as well as multinationals are actively engaged in business activities in the city. Shanghai's city government promotes the policy for a "Global Innovation Hub", with a package of incentives for foreign firms to set up research centers in the Pudong area, where a concentration of life science and electronics research activities can be found. Not only private firms but also universities and public research institutes are active in this area. Shanghai Jiaotong University and Zhejiang University are competing at the top rank in terms of university patent applications.

In Shenzhen, however, there are almost no public research organizations. Therefore, top universities outside this area, such as Beijing University and Tsinghua University, have set up their branch schools in the city. In contrast, Shenzhen can be characterized as having a concentration of big, high-tech firms. Actually, all of the top three patent applicants in China (Huawei, ZTE, and Foxconn) are located in Shenzhen. In addition, high-tech entrepreneurship has become quite active recently, as will be shown in detail later.

Figure 3-1 shows the shares of patent applications by applicant type. In Beijing and Shanghai, the share of firm applicants is around 70%, while that of Shenzhen is 95%. The share of university applicants is relatively large in Beijing, while the presence of public research institutes is greater in Shanghai.

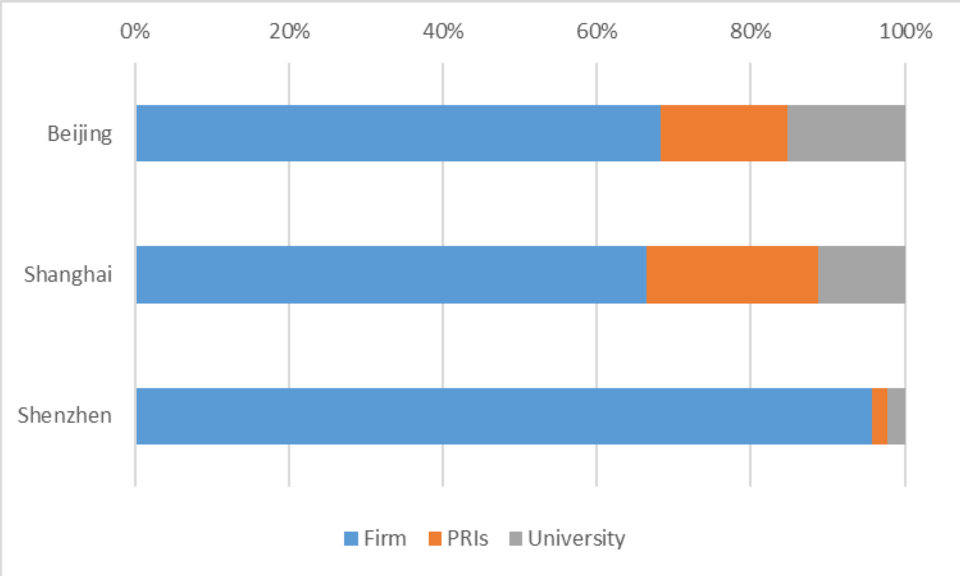

Figure 3-1: Share of patents by applicant type (individual applicants excluded)

Figure 3-2 shows the composition of technology in patent applications. In Beijing, the share of electronics and information technology is large, but there are also a substantial number of chemical patents. The pattern is more diversified for Shanghai, where large numbers of drug/medical and machinery patents are also found. In contrast, patent applications in Shenzhen are quite focused on electronics and information technology.

The Appendix table shows the index of revealed comparative advantage (RCA, the ratio of the share by technology class in each city to the same share for all of China) by mode detail technology classification (WIPO base 33 classes). In Beijing, the RCA index is high for “clock, controlling, computer (2.15)”, “nuclear physics (1.81)”, “electronics circuit, communication tech. (1.66)”, and “measurement, optics, photography (1.58)”. In Shanghai, the comparative advantage is found not only in such electronics fields but also in the life science field, such as “genetic engineering (2.21)”, “organic chemistry, pesticides (1.56)”, and “biotechnology, beer, fermentation (1.41)”. In Shenzhen, the RCA index for “electronics circuit, communication tech.” and “nuclear physics” is very high (more than 4), and that of “clock, controlling, computer” is over 2. But the advantage is quite concentrated in these small number of fields.[4]

[4] A high RCA for nuclear physics is explained by the existence of the China General Nuclear Power Group in Shenzhen, which operates nuclear power plants all over China.

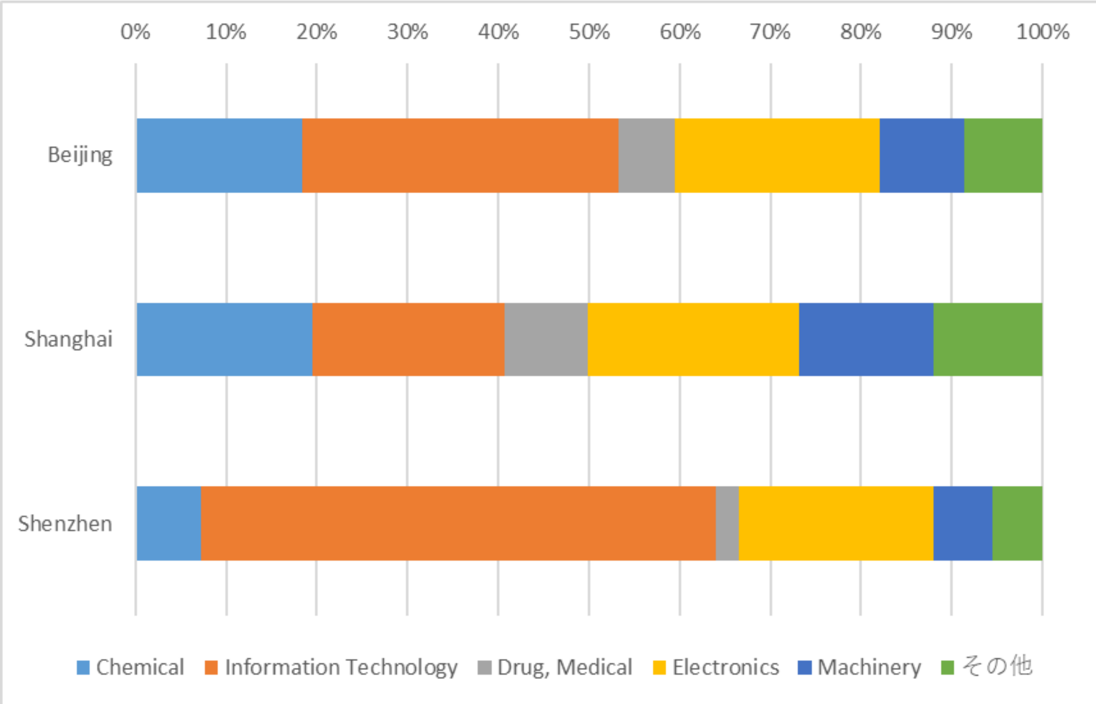

Figure 3-2: Share of patents by technology field

The pattern of electronics concentration in Shenzhen can be explained by the large patent applicants, such as Huawei and ZTE, but it is found that such a pattern does not change very much even if the two firms are excluded from the sample. Then, how about the presence of small applicants? Figure 3-3 shows the share of patent applications by small applicants (less than 1,000 applications in total). In all three cities, the share is increasing, showing that the presence of small applicants or high-tech SMEs is becoming greater. But the increase in speed is highest in Shenzhen. This reflects the fact that high-tech entrepreneurship has become active in the city.

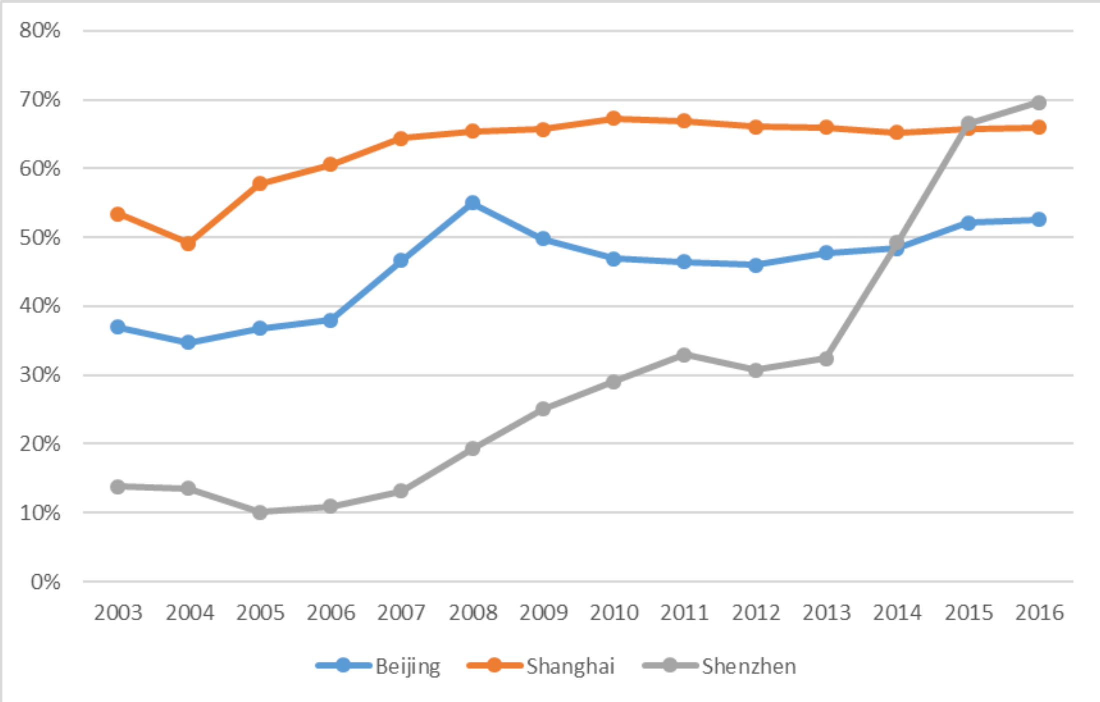

Figure 3-3: Share of small applicants (less than 1,000 applications)

3-3. Comparison of venture investments in Beijing, Shanghai, and Shenzhen

Here we look at the situation of venture investment using IT Juzi data. IT Juzi, is a research company based in Beijing Zhongguancun, providing information on venture investment (e.g., information on investors, investees, the size of investment, and the round stage) from public information. Similar kinds of data can be found in the United States from Crunch Base and Thomson Venture Expert. The dataset used in this section covers all investment deals in China until 2016 (26,823 items of investment data for 8,506 venture companies) available from IT Juzi. The number of venture companies in Beijing, Shanghai, Shenzhen, and other areas in China was 3,405, 1,727, 849, and 2,506, respectively. Figure 3-4 shows the trends in the investment rounds for each region. Most investments were made between 2014 and 2016, and the number of investments in Beijing, Shanghai, and Shenzhen increased until 2015 but went down in 2016.

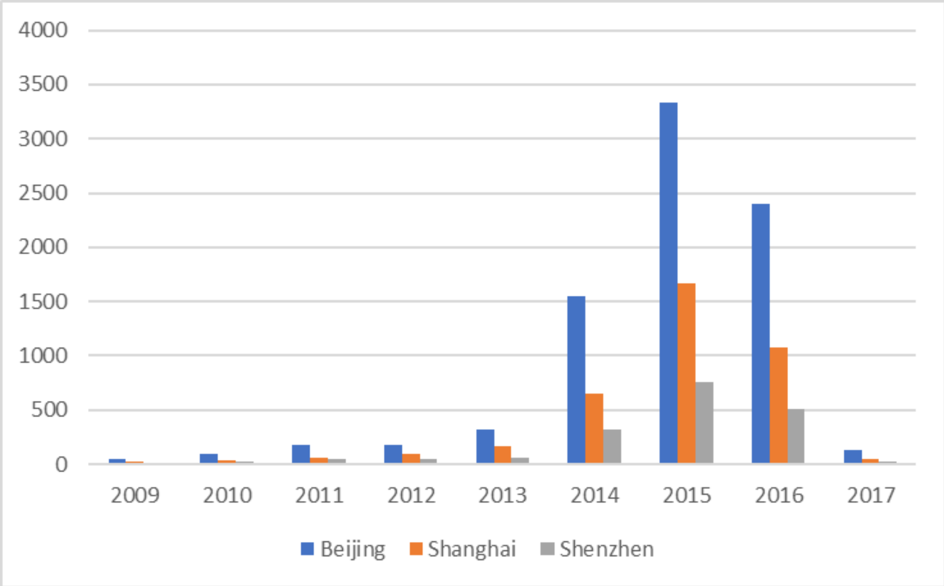

Figure 3-4: Number of VC invents by venture firm location

Next, we look at the differences in investment structure by city. Figure 3-5 shows the shares of each investment round. Angel investment and the A round of investment account for the majority when looking at the number of times for each investment round. The share for angel investment is highest in Beijing, followed by Shanghai, Shenzhen, and others. Since the geographical proximity to the investee company is relatively more important for such early-stage investment, the availability of angel investments is higher in the three big cities compared to the rest of China.

We also find that the share of A round investments is high in Shenzhen. Since IT Juzi provides categorical information on investment size, we can see that the relative investment size for Shenzhen is smaller compared to that for Beijing and Shanghai.

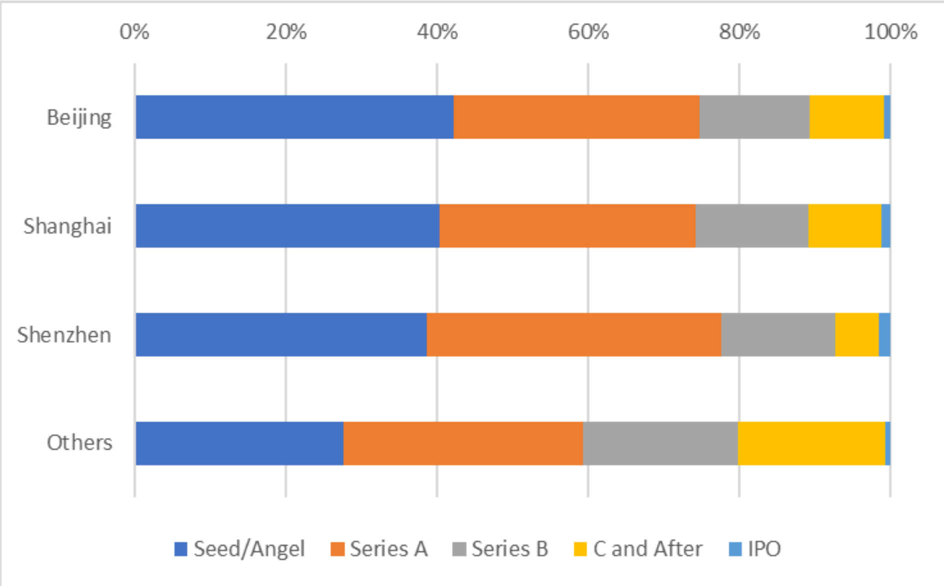

Figure 3-5: Number of investments by VC round

Next, we linked the roughly 8,500 companies covered by IT Juzi with the patent data by applicant name. About 20% of the enterprises were linked. The companies that could not be linked were supposed to be the ones that did not file patent applications. Looking at this by city, the ratio of patent application companies among Shenzhen venture companies was highest, at 30.5% (Figure 3-6). Meanwhile, the proportion of patent applications by Beijing and Shanghai venture companies was about 17%. This is because many of Shenzhen's venture companies are electronics hardware related ones. On the other hand, in Beijing and Shanghai, a relatively large number of companies based on business model innovation, such as sharing services by Didi Chuxing and Mobike.

	# of firms	Patent firm	Share	# of patents
Beijing	3,405	611	17.9%	26,751
Shanghai	1,727	299	17.3%	4,704
Shenzhen	849	259	30.5%	15,296
Others	2,506	604	24.1%	19,987
Total	8,487	1,773	20.9%	66,738

Figure 3-6: Results of linking IT Juzi and patent data

3-4. Mobility of high-tech talents

It is important to look at the mobility of human resources in considering the interactions between large companies and start-ups to understand agglomeration externalities. Particularly, for the establishment and growth of high-tech ventures, how to secure talented people with technology is important, and the large company must be a major supplier of such people. Huawei, for example, attracts excellent students from all over China, and excellent talent is attracted to Shenzhen. Once the personnel have gathered in Shenzhen, if spinning out from Huawei and waking up a venture company, the probability of establishing in Shenzhen is high. Networks cultivated through business are considered to have high local characteristics. In this section, we analyze the state of researcher talent migration using the result of the inventor identification from the patent information (matching foreigners and inventors with the same name and for multiple patents; that is, whether the inventors are the same person) (Yin and Motohashi, 2017).

Figure 3-7 shows the state of inventor mobility at the province level. It shows the net number of inventors moving into an area, i.e., the number of those moving in minus those moving out. Red shading indicates the provinces where the number of researchers increased (inflow exceeded the outflow), while the blue shading denotes the provinces where researchers decreased (outflow exceeded the inflow). In general, researchers tended to move from the provinces (cities) where the patenting activities are concentrated, such as Beijing, Shanghai, and Guangdong, to the surrounding provinces, especially East Chain areas such as Jiangsu province and Zhejiang province. Some inland provinces in the south, such as Sichuan, gained inventors. In contrast, outflows of inventors dominated inflows in northeastern provinces such as Liaoning, Jilin, and Heilongjiang.

In terms of the inflows and outflows of researchers (inventors) in Beijing, Shanghai, Shenzhen, a detailed look at the mobility patterns shows that people in Beijing are gathering from all over China. Shanghai is strongly connected with its surrounding areas, such as Jiangsu province and Zhejiang province. The fact that Shanghai is overflowing is due to the fact that the ecosystem of innovation has spread to other parts of the Yangtze River Delta. Finally, for Shenzhen, there are a substantial number of inflows from Beijing, but a large number of outflows can be observed to the surrounding cities of the Pearl River Delta.

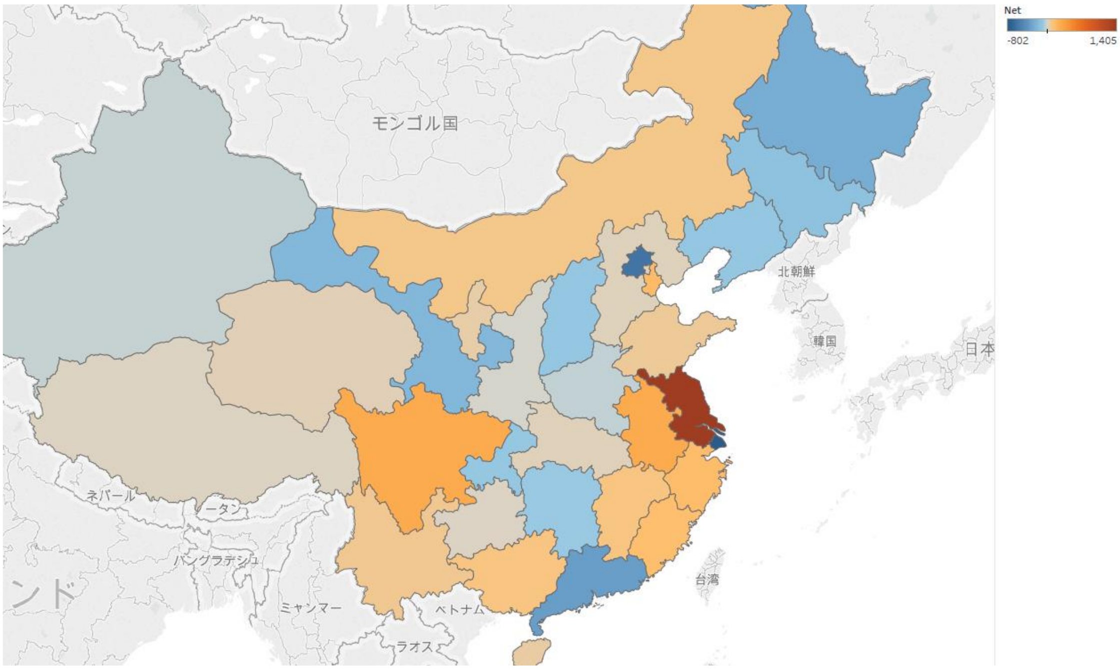

Figure 3-7: Inventor mobility at the province level

4. The Start-up Ecosystem in Shenzhen

In this section, we look at Shenzhen in more detail, focusing on inventor mobility and its relationship with the formation of the start-up ecosystem in the city. First, Figure 4-1 shows the regional distribution of patenting in Shenzhen (each circle corresponds to the address of a patent applicant, with the size proportional to the number of patent applications). While the area of Shenzhen is not large for the average city size of China, there are some clusters of patent applications within Shenzhen. First, the concentration of patents is found in the Nanshan district, centered around ZTE and Ocean King Lightning (海洋王). Second, Longgnag district, where Huawei has its headquarter, attracts a number of patent applicants, too. Third, there is a cluster of patenting close to the border with Hong Kong.

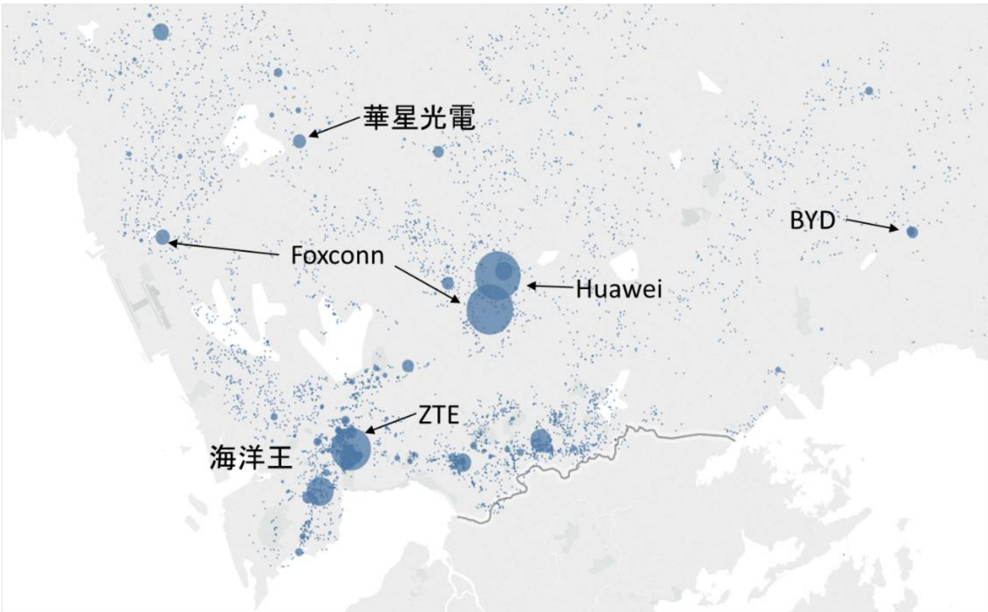

Figure 4-1: Geographical distribution of patent applicants in Shenzhen

Next, let us take a look at patenting activities by start-up firms. Here, we define a start-up firm as a firm that started a patent application in 2010 or after. Of these 44,274 patents, the numbers for the two large districts, Nanshan and Baoan, are 17,973 and 16,111, respectively. Therefore, we can see that high-tech start-up activities are concentrated in these two districts.

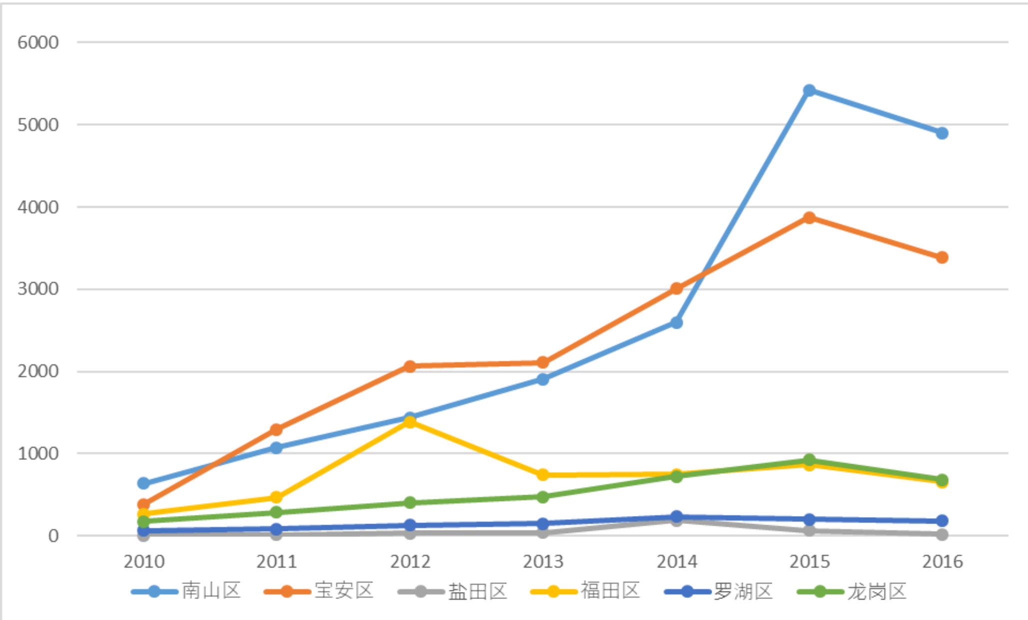

Figure 4-2: Number of start-up patent applications by district

Nanshan district, particularly YueHai Jiedao, is covered with national-level high-tech parks and can be called the center of the start-up ecosystem in Shenzhen. ZTE and Tencent have their headquarters in this area, and public research organizations, such as Shenzhen University, and research centers of major universities from all over China are located there as well. Foxconn has its headquarters in the Baoan district, and Shenzhen airport is also located there. It should be noted that the Guangming district is now separated from Baoan (since 2007), so a more detailed investigation is needed to understand the start of the start-up ecosystem there.

Next, we look at the mobility of inventors in Shenzhen. Here we focus on those who moved to Shenzhen to see where they came from. Such cases totaled 11,537 observations in the patent data. Figure 4-3 classifies all samples into two-by-two categories, i.e., by type of firm, whether a venture firm or other firm (called a large firm), and whether being before or after moving. For example, venture–venture shows those who moved from a venture firm to another venture firm. For each category, the share by the original location is presented. For the cases of moving from a large firm to a venture firm, the geographical proximity is the highest (about 80% of moves occur within Shenzhen). In such cases, local business contacts are important for inventors to start up their own firms. In contrast, for the case where the former position is a venture company, the inventor may already have certain business relationships for her/his business already, so it is easier to break away from the geographical restrictions. On the other hand, for the case of an inventor moving to a large firm, the location initiation comes from a firm in Shenzhen instead of from the inventor. Therefore, the original location should be diverse. In addition, the case of moving from a large firm to a large firm may be an intra-firm transfer, such as moving from a Huawei research institute in Beijing to the Huawei headquarters in Shenzhen.

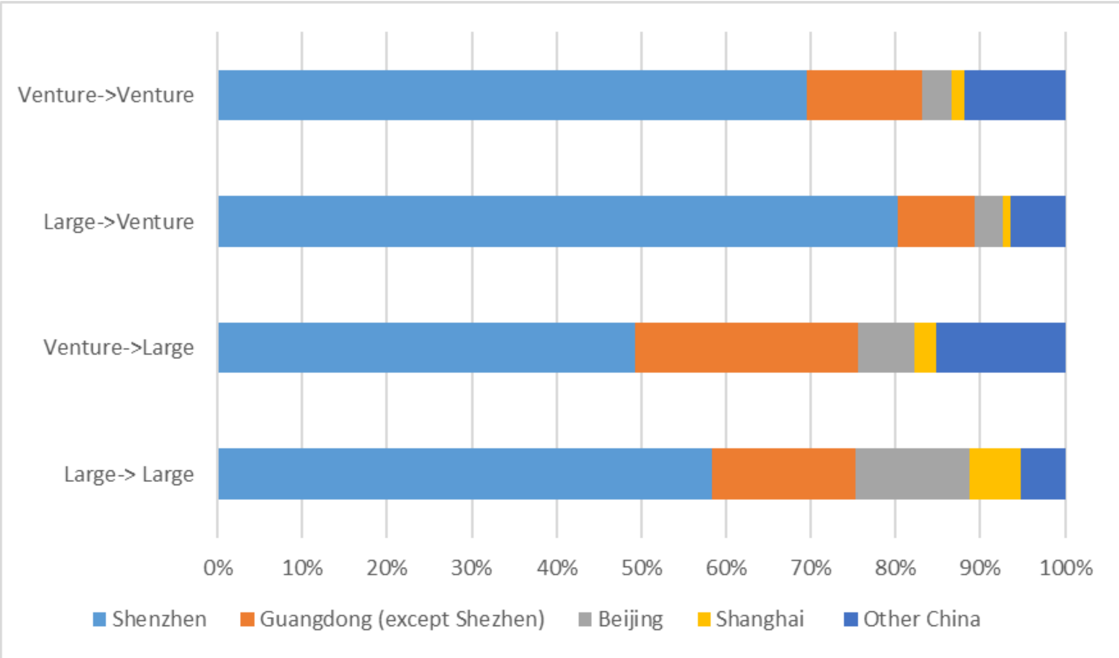

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Figure 4-3: Original locations and movements of inventors by type of mobility

Finally, we look at the geographical proximity of the venture ecosystem in more detail. Figure 4-4 shows the original locations of inventors moving to venture firms in Shenzhen at the district level. For example, about 65% of engineers who moved to a venture firm in the Nanshan district came from within the same Nanshan district. For the similar case for the Baoan district, the share is even higher at around 80%. Therefore, we find that human mobility associated with high-tech entrepreneurship is very geographically bound, so the venture ecosystem must be investigated within a narrow area.

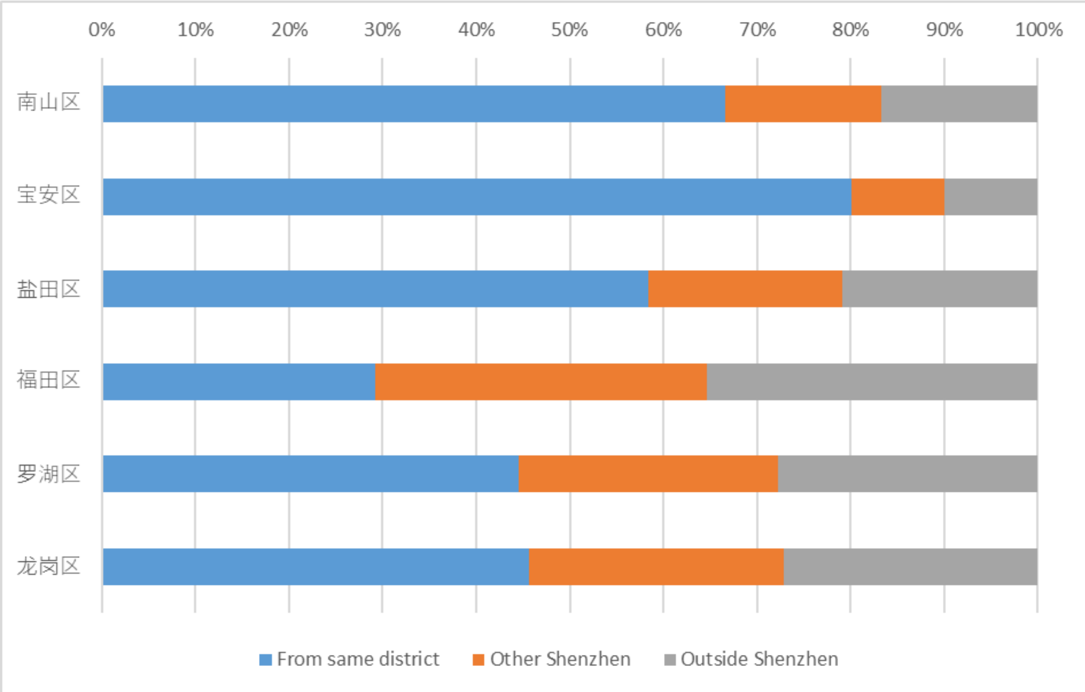

Fig 4-4: Original locations of inventors and movements at the district level

5. Conclusion

In this paper, we compared the regional innovation systems of Beijing, Shanghai, and Shenzhen using patent data and venture investment data. Unlike in Beijing and Shanghai, the presence of universities and public research institutions is small in Shenzhen. Meanwhile, large communication equipment makers such as Huawei and ZTE, and IT companies such as Tencent, actively engage in R&D activities. Therefore, Shenzhen can be characterized by a private firm centered innovation system. In Shenzhen City, R&D venture companies are concentrated in the Nanshan district, particularly in Yuehai Jiedao, where the national-grade, high-tech zone is located. These high-tech ventures have grown rapidly in recent years, and large local companies such as ZTE and Tencent play a major role as a source of high-tech talent. Moreover, it is found that the mobility of patent inventors is occurring within a very narrow area.

In addition, VC investments in Shenzhen are relatively small in size compared to in Beijing and Shanghai, and there is a large share of early-stage investment, such as A round investment. This is mainly attributed to the characteristics of innovation in Shenzhen, which is close to the market and puts more emphasis on speed instead of deep and long R&D investment. The role of universities and public research institutes in

Shenzhen's innovation system is small, and the founders of venture companies are also mainly from companies. A comparative study of the science parks of Tsinghua University in Beijing and Shenzhen shows that there are many science-based companies in Beijing (Tsinghua Science Park), while a market-oriented entrepreneurship model is dominant in Shenzhen's Tsinghua University Research Institute (Mao and Motohashi, 2016). Therefore, due to the smaller size of investments, so-called "unicorn companies" with a market capitalization of more than $1 billion, are not started in Shenzhen.

From the analysis of inventor mobility using patent data, we find that inventors' movements to venture firms are regionally bounded, and more than half of such cases occur within the district level. In the Nanshan district, where venture companies are concentrated, local high-tech companies, such as ZTE and Tencent, are important suppliers of human resources.

Thus, in Shenzhen, both large high-tech firms and the dynamics of high-tech entrepreneurship are important for forming the regional innovation ecosystem. That is, large firms attract high-quality talent from all over China, and the substantial spinoffs from such firms locate their businesses in Shenzhen. However, while this paper contributes to clarifying the pattern of regional agglomeration of innovation, it has not reached the stage of showing the process of such agglomeration. For example, the Yuehai Jiedao in the Nanshan district is an area covered by a national-level high-tech park. As such, it is natural to see many high-tech start-ups located there. Therefore, further study is needed to understand the complementary relationships between large firms and start-ups in more detail.

It is also necessary to consider whether the region's innovation system is open to other regions. This point is important from the perspective of whether multinationals, like Japanese companies, could adopt the innovation dynamism here. In this paper, we found that the entrepreneurship ecosystem is regionally bounded and not so open to the outside world. Therefore, in order to capture the dynamism of innovation in Shenzhen, being an insider is important. As many companies in Silicon Valley do, it seems to be effective to build a network with venture firms by creating corporate venture capitalist in Shenzhen.

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Appendix: Revealed Comparative Advantage (RCA) Index

	Beijing	Shanghai	Shenzhen
Agriculture	0.40	0.50	0.08
Food Stuffs	0.23	0.34	0.11
Personal and Domestic Articles	0.10	0.46	0.22
Health and Amusement	0.44	0.85	0.48
Drugs	0.50	0.62	0.10
Separating, Mixing	1.38	0.97	0.23
Machine tools, Metal working	0.45	0.88	0.33
Casting, Grinding, Layered Product	0.37	0.71	0.49
Printing	0.30	0.55	0.28
Transporting	0.52	0.75	0.32
Packing, Lifting	0.40	0.78	0.38
Non organic chemistry, Fertilizer	1.06	1.10	0.30
Organic chemistry, Pesticides	0.99	1.56	0.25
Organic molecule compounds	0.88	1.27	0.45
Dyes, Petroleum	1.33	0.99	1.11
Biotechnology, Beer, Fermentation	1.01	1.41	0.22
Genetic Engineering	1.30	2.21	0.44
Metallurgy, Coating metals	0.96	1.12	0.40
Textile	0.24	1.12	0.09
Paper	0.30	0.62	0.09
Construction	0.74	1.12	0.24
Mining, Drilling	2.75	0.65	0.07
Engine, Pump	0.48	0.71	0.21
Engineering elements	0.48	0.72	0.32
Lighting, Steam generation, Heating	0.51	0.76	0.93
Weapons, Blasting	1.05	0.35	0.20
Measurement, Optics, Photography	1.58	1.29	1.01
Clock, Controlling, Computer	2.15	1.23	2.09
Display, Information Storage, Instruments	0.87	0.93	1.31
Nuclear physics	1.81	1.47	4.03
Electronics components, semiconductor	0.99	1.29	1.31
Electronics circuit, communication tech.	1.66	1.01	4.09
Others	1.47	2.64	0.65