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Communication Externalities on the Knowledge-based Firms in Metropolitan Areas: Case Study of China and Korea

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Abstract

This paper provides some evidence on communication style that serves as the contact tool and its related external economies to knowledge-intensive production and innovation within the emerging high-technology based industrial clusters in metropolitan areas of China and Korea. Our unique data-set from questionnaire survey enables us to examine the firms' behavior of communication regarding the choice of communication mode, how often, with whom, and for what purpose. Such analysis provides insights about actual relationships among business partners of industry-university-government in each cluster of Zhongguancun Area (Beijing), Seoul Digital Complex and Daedeok Valley (Daejeon). Our studies demonstrate that 1) with suppliers firms contact with high frequency but with less face-to-face meeting opportunities, 2) with customers and banks/investors but more with face-to-face contact, as common characteristic, 3) and that firms' long-term experience in the market is helpful to construct such meaningful communication network in Seoul Digital Complex. However, we could not show fully that communication externalities generated by the face-to-face contact influence the innovative output of firms.

JEL classification: O32, R11, O40

Keywords: Communication externalities, Geographical proximity, Zhongguancun, Seoul Digital Complex, Daedeok Valley

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1. Introduction

This paper tries to provide some evidence on communication style that serves as the contact tool and its related external economies to knowledge-intensive production and innovation within the emerging high-technology based industrial clusters in metropolitan areas of China and Korea.

After decades-long extraordinary export-led growth, Korea has found its place as an exporter of technology intensive goods in the world comparative advantage ladder. At the same time, it became one of major policy goals in the post- 1997 economic crisis structural reform to foster non-conglomerate, high-technology, small and medium business, which are more agile, flexible, and entrepreneurial. China, in turn, has shown remarkable economic development taking full advantage of labor intensive manufacturing exports driven by foreign direct investment. As long-term strategy, however, the need for strengthening "own technology" based progress is keenly recognized.

Observing the location pattern of such new business, it is notable that firms are being created in large metropolitan areas. If we recall that assembling factories had sprawled out toward the countryside searching for cheaper labor, this is a new trend. The locational advantages of urban centers can be considered as the following: the existence of larger market for new technology products both for selling own products and purchasing inputs; availability of highly educated workforce; and access to the scientific knowledge created in best universities. Of course, such advantages of market, talent, and knowledge are, in principle, accessible from other areas, by paying more transport cost. Suppose, however, there is "bonus" information attached to these transactions, including some hints about the products of the next generation, introduction to friends of friends, and rumors about unpublished research results. They are naturally very important in an industry where technology standard change with rapidly. Then, assume the quality of such information tend to decay quite badly distance, number of intermediary people, and time. Given such conditions, it is natural for firms to want to be located in metropolitan centers which enable face-to-face communication with key persons. For example, some businessmen of the telecommunication equipment sector in Beijing replied to our interview: "It's only in Beijing that we can meet informally with high-rank officials and university scientists. All the technological standard of the next generation is decided here. We try to take any information which might help us to determine our firm's strategy." Then, a certain type of tacit knowledge like this information would lead many firms to gather in a specific region like Beijing. This is exactly like "bonus" from information.

Following the recent studies such as Charlot and Duanton (2004, 2005) and Arita, Fujita and Kameyama (2005), our analysis uses the unique data-set obtained from questionnaire survey. Our data-set was collected in Zhongguancun Area (Beijing), Seoul Digital Complex and Daedeok Valley (Daejeon) about firms' behavior of communication: how often, with whom, and for what purpose. It intends to identify what kind of communication externalities can explain the formation of the successful IT clusters in China and Korea. This data-set allows us to examine the existence of actual interaction at firm level and to study the actual effects of communication externalities.

In the survey, we put special focus on information technology related firms. The progress of economic globalization over the last ten years promoted international division of labor. Part of this is attributable to the modern telecommunication technology, the Internet in particular, which reduced substantially the necessity of face-to-face communication in knowledge-creating activities. The emergence of IT industry clusters in developing countries such as Zhongguancun, Bangalore (India), Penang (Malaysia), and Singapore have grown on the basis of vertical integration (subcontracting and outsourcing) with the US firms, especially of Silicon Valley (Okuno, 1999; Sanwa Research Institute, 2001). The cost-advantage-seeking objective of the spread of IT industry is rather straightforward. Still, it is interesting to note that the spread has occurred only to a few limited numbers of places in the world where local agglomeration economies are in motion. Like the US IT clusters, in Zhongguancun and Bangalore local government, universities and research institutes played a pivotal role in providing technological environment to create information about technology and human resource network. Thus, while direct access to the most advanced innovation center was essential to explain the spread of IT industry toward developing countries, the intensity of local communication should have high explanatory power to answer the question where such industry have landed.

The rest of the paper is organized as follows: Section 2 summarizes the related literature. Section 3 presents the nature of each industrial cluster studied in this paper (i.e. Zhongguancun, Seoul Digital Complex and Daedeok Valley) with using data description of questionnaire survey. Section 4 describes the empirical model and shows the estimation results of several specifications. And, Section 5 concludes the paper.

2. Theoretical Background

The literature on industrial localization based on knowledge spillover is not new. In his seminal work, Marshall (1890) stated that technology spillover and formation of specialized skilled labor pool are creating “something in the air” in a location specialized in particular type of industry. Later, Jacobs (1969) emphasized the importance of the diversity of specialized talents rather than specialization at local level as a factor promoting the creation of new types of activities. In Jacob’s words, “In cities with many organizations supplying so many bits and pieces of work, it is possible to start a new exporting organization while depending upon others for many of the goods and services one needs (Jacobs, 1969, p.181).” Using the U.S. city/industry data, Glaeser, Kallal, Scheinkman and Shleifer (1992) studied the contrasting view of “specialization vs. diversification” to find supportive evidence on Jacob’s externalities. This result was further elaborated by Henderson, Kuncoro and Turner (1995) who found that Marshallian view applies for mature industries while the new industries should develop on the basis of Jacobian externalities. These studies suggest that the early stage of the development typically occurs by specializing in mature industry taking advantage of within-industry knowledge spillover, but the long-run urban growth should be driven by urbanization economies with diversified economic activities.

In either case, it is widely accepted by economists that firms benefit from knowledge spillover which gives rise to aggregate increasing returns to scale due to non-excludability and non-rivalry of knowledge. Romer (1986) was one of the first to model knowledge spillover as a source of endogenous growth. Provided that the benefit of knowledge spillover is sensitive to distance, especially when the knowledge is tacit in nature, it can be seen as a source of agglomeration economies.

Yet, the stylized models of new economic geography (Fujita, Krugman and Venables, 1999) have deliberately avoided incorporation of knowledge spillover because knowledge flows “are invisible; they leave no paper trail by which they may be measured and tracked, and there is nothing to prevent the theorist from assuming anything about them that she likes (Krugman, 1991, p.53).” It is recognized as a challenge for anybody seeking any relevant spatial economic model of knowledge spillover to be able to address: “not only that knowledge spills over but also why those spillovers decay as they move across geographic space (Audretsch and Feldman, 2004).”

In this regard, a pioneer study by Jaffe, Trajtenberg and Henderson (1993) considered patent citations as a visible paper trail of knowledge flows and found that patent citation is 5 to 10 times more likely to occur within the same city suggesting the effect of distance. Later, in studying industry-university cooperation, Mansfield (1995) demonstrated that firms attach more importance to the quality of a researcher to work with than to accessibility to him in the basic research phase, while exhibiting the opposite preference in the applied research phase due to the sensitivity to time and cost in the competitive stage.

Recently, the literature such as Audretsch and Feldman (1996), Varga (1998) and Acs (2002) investigated the geography of innovation focusing on the role of university and R&D institutions. Audretsch and Feldman (1996) found evidence that even after controlling the degree of geographical concentration of production, knowledge created by university research results in greater innovation in firms. The results of their estimation also suggest that the propensity of innovative activities to cluster is more attributable to knowledge spillovers than mere locational advantage in production. Varga (1998) identified that channels of the university knowledge transfer are: R&D cooperation between academia and industry; university seminars; scholarly journal publications; faculty consulting; industrial associates programs; industrial parks; spin-offs (faculty and students); technology licensing; the local labor market of scientists and engineers; and local professional associations of scientists. Acs (2002) further detailed that importance of spillover from universities are particularly relevant to small firms and sector-specific (strong effect on electronics industry and almost none on chemical and machinery). Following these studies, the literature identifying knowledge spillover from university research to corporate R&D has been expanding, as reviewed extensively by Audretsch and Feldman (2004).

However, as Fujita and Thisse (2001) correctly observed, existing knowledge spillover model has the weakness of leaving vague the sources of external economies, and the underlying mechanism of the local interaction is not clearly defined. Those previous studies have not considered explicitly what kind of interaction of firms and people can generate the externalities of communication and technological exchange. They usually assume that the increase in the number of locally participating agents may increase interaction, keeping the actual interaction in the black box. Although there are excellent descriptive works such as Saxenian (1994), considerable work of theoretical nature remains to be done incorporating geographical proximity and innovation.

One promising direction was shown by Aydogan and Lyon (2004). Their paper argues that technological complementarities will increase the benefit of cooperation in R&D. Exchange of ideas can be done conveniently at a central place meeting such as academic congress but the fear of being cheated, by someone who just attend the meeting without contributing with his own idea, makes bilateral traveling preferable. In such a case, agglomeration of technologically complementary firms will be beneficial in order to save on traveling cost.

The empirical studies in this vein should face the difficulty of lack of data and ambiguous concepts of measurement of “innovation”, “knowledge”, and “proximity”. As done by Jaffe, Trajtenberg and Henderson (1993), it is common to consider that output of innovation is represented by patent, which is also convenient because patent data is relatively easily accessible. Yet patent may not be perfectly good proxy of innovation, because all innovative output are not necessarily patented, and all patent will not lead to innovation. Alternatively, Charlot and Duranton (2004) prefer to measure the effect of communication externalities by earned wage, while Anselin, Varga, and Acs (2000) use the U.S. small Business Administration Innovation Database (BAID), which measures innovation by the number of new product announcements in trade and technical journals. In turn, knowledge is treated as a sort of firm capital stock to produce innovation. Its measurement is also a subject of debate in constructing a meaningful index synthesizing R&D investment, employment of knowledgeable talent and evaluation of stock reflecting a depreciation of the past accumulation. Regarding the proximity, we should take into account the concept of distance, traveling time (including the means of transportation), and the use of telecommunication (because face-to-face communication and telecommunication is sometimes complementary with each other, rather than substitute).

Since almost all of the previous studies use census data to investigate the evidence of external economies without taking actual relationships among firms and/or industries, we can hardly expect that any usable data-set is readily available. In general, when we measure the effects of spillovers or externalities from industrial agglomeration we assume implicitly existence of spillovers or externalities even if an actual interaction exists or it doesn’t exist. For this reason, it is unavoidable to conduct questionnaire sample survey to investigate actual relationships about firms’ behavior of communication: how often, with whom, and for what purpose. In fact, recent studies such as Charlot and Duanton (2004, 2005) and Arita, Fujita and Kameyama (2005) have examined the effects of communication externalities using questionnaire survey after specifying the existence of actual interaction (Note 1).

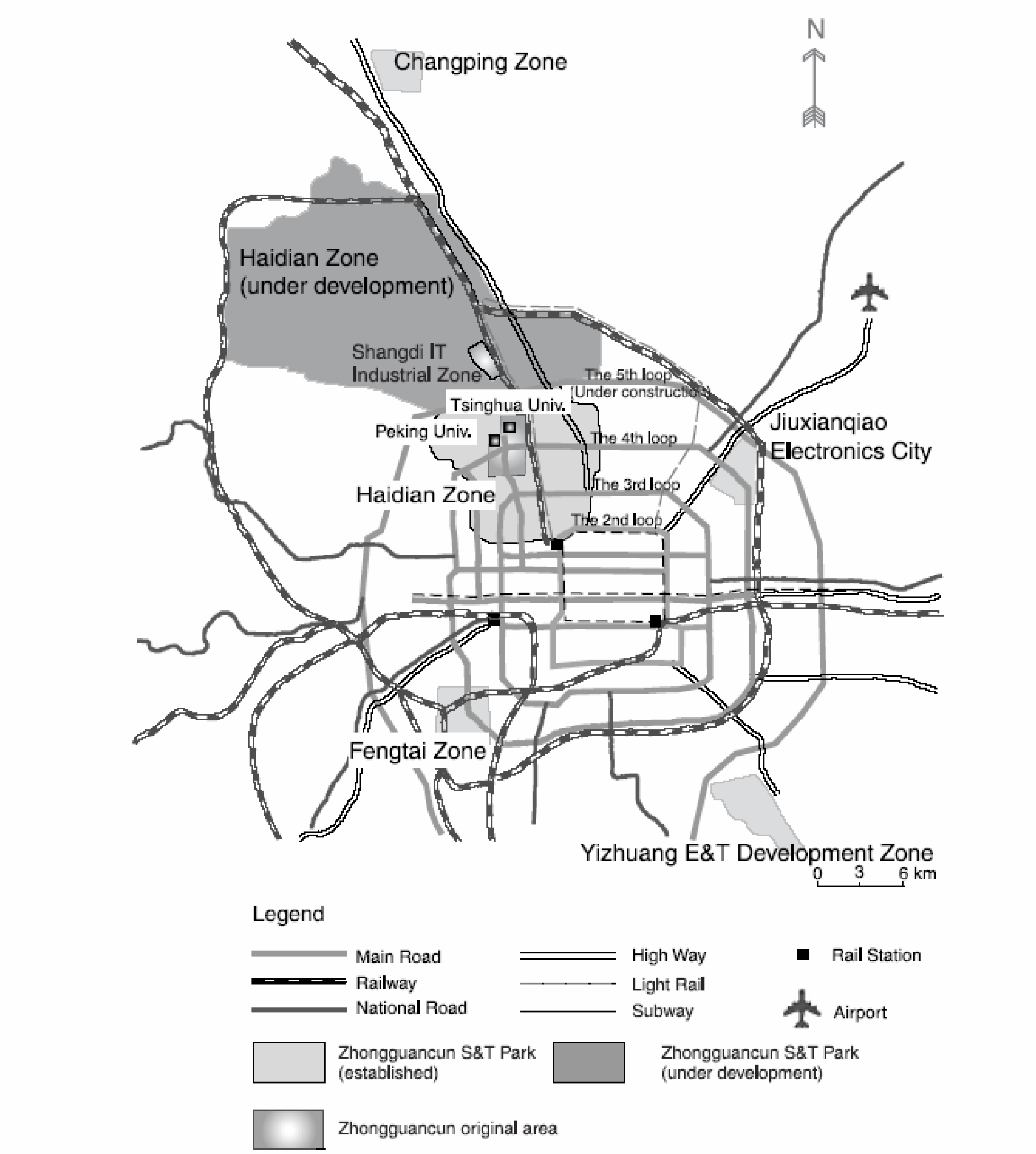
3. The Development of Industrial Clusters in Metropolitan Areas; Beijing, Seoul and Daejeon

In this section, we make a survey of the nature of industrial clusters, Zhongguancun, Seoul Digital Complex and Daedeok Valley from the view of trajectory of development and state.

3.1. Zhongguancun Science Park (ZSP)

The city of Beijing has increased its layers of urban area as the outer loop turnpikes were constructed further from the city center for rapidly increasing through traffic. While the 3rd Ring Road completed in 1994 has 48 km total length, the newest 6th Ring Road finished ten years later has 130 km. The core area of ZSP, the "Silicon Valley of China", occupies the layers between 3rd and 5th Ring in the city's northwest corner Haidian-qu (district). This area was largely agricultural until early 1980s but already included most prestigious Chinese universities such as Tsuinghua University and Peking University as well as the Chinese Academy of Science (CAS), which actually is a conglomerate of 99 research institutes across China, among which 37 are located in Beijing (see Figure 1).

Figure 1: Map of Beijing



(Source) Zhou and Xin (2003), Figure 1.

In the 1980s, Zhongguancun came to be known as an "electronics street" appreciated by shoppers who seek cheap clone computers and parts. Various authors reported that about 40 companies were already established by 1984. Many of them were spin-offs of engineers from academic institutions in the area. Some of these early startups later grew into big business groups such as Lenovo (established in 1984) and Stone (established in 1984) from the CAS, Founder (established in 1986) from Peking University, Tsinghua Unisplendour (established in 1988) from Tsinghua University.

The first systematic survey of ZSP conducted in 1987 identified 400 high-tech firms. Since late 1980s when the first experimental science park was setup, thousands of firms mushroomed through application of scientific outcomes originating in these academic institutions into business. Encouraged by strong potential of growth, Beijing Municipal Government established Beijing Experimental Zone for New Technology Industries in the Haidian district and issued Beijing Municipal Government Temporal Rule. Among other benefits are: (1) Income tax reduction to 10-15%, depending on the company's export performance; (2) preferential tariff rate on imported materials and machineries; (3) finance from the city's Technology Innovation Fund; (4) university professors and research institute scientists were allowed to have part time job; (5) eligible workers were granted the resident card of Beijing. National government also joined force by constructing the first incubator system, Shangdi Information Industry Base, to the north of the Haidian district in 1991, followed by science parks in Fengtai and Changpin in 1992, the Oversea Students Pioneer Park in 1997. These industrial parks were integrated into a single entity Zhongguancun Science Park in 1999.

Table 1: ZSP's development (unit: million yuan)

Year	Number of firms	Number of employees	Gross revenue	Profit	Government tax income
1988	527	n.a	1.4	n.a	0.1
1989	850	10,100	1.8	0.1	0.1
1990	974	14,929	2.5	0.2	0.1
1991	1,343	30,698	3.7	0.4	0.2
1992	2,442	69,228	6.0	0.5	0.2
1993	3,769	107,768	10.0	0.9	0.4
1994	4,229	112,649	14.2	0.8	0.5
1995	4,438	119,577	20.0	1.3	0.8
1996	4,506	124,835	25.8	1.5	0.9
1997	4,525	135,297	34.1	2.3	1.1
1998	4,546	147,286	45.2	2.9	1.6
1999	4,837	196,139	63.7	4.8	2.0
2000	n.a.	292,772	91.2	10.1	5.6
2001	n.a.	361,272	128.7	11.3	8.9
2002	n.a	405,668	148.5	11.2	10.0
2003	n.a	488,561	160.8	18.0	12.0

(Source) Zhou and Xin (2003) Table 1 and Zhongguancun Administrative Government homepage. (http://www.ZSP.gov.cn)

Today, ZSP has expanded to other districts such as Fengtai, Changping, the Electronic City Zone and Yizhuang (a part of the Beijing Economic and Technological Development Zone), Desheng, and Jianxiang. The planned area amounts to almost 400 square kilometers which covers about 2% of the gross area of Beijing. Those 58 universities in the area educate 36% of the graduate students of the entire nation.

Table 1 show that there were a couple of stages in the development of ZSP. The number of employees doubled in each three consecutive years of 1991-93. There was a period of relatively slow growth until 1998; the growth accelerated afterwards. Recall that ZSP geographically expanded during 1991-93 by the construction of several science and technology industrial parks, especially by the creation of Shangdi Information Industry Base in which the incubator system was inaugurated. Oversea Students Pioneer Park was created in 1997 which helped spurring of returning students' opening of businesses. Multinational enterprises started to establish their R&D in ZSP by 1997-98 which also partly explains the later high growth of ZSP. Although the total number of firms in ZSP is not reported since 2000, it is largely believed that it has already reached to 7000.

Table 2: ZSP IT firms by sub sectors in 2001

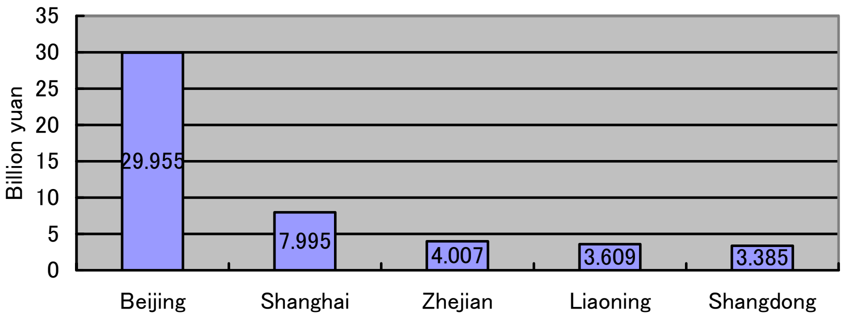
	Percentage of total firms	Percentage of employees	Employment per firm in category
IT SUBSECTORS			
Computer hardware manufacturer	8.8	11	59
Software development/system integrator	31.8	29	44
Internet and e-commerce	12	15.2	61
Microelectronic and IC designer/manufacturer	7.9	12	73
Telecommunication equipment manufacturer	6.6	13.5	98
IT consulting services	7.6	6.4	41
Computer distributor/ retailer	16.2	6.4	19
Computer technical services	9.2	6.5	34
FIRM EMPLOYMENT SIZE			
More than 500	0.9	32.7	1,659
200-500	2	13.8	328
100-200	3.4	10.8	152
50-100	9	14.3	76
20-50	22.5	15.8	34
Less than 20	62.3	12.6	10
TOTAL, FIRMS AND EMPLOYMENT	3,404	162,417	48

(Source) Zhongguancun Administrative Government, Human Resource Survey 2001, cited by Zhou and Xin (2003) Table 4.

ZSP became highly specialized in electronics and information technology. According to accessible data (C-Press, 2002), 915 out of 1582 surveyed Chinese-owned firms and 250 out of 392 foreign firms in ZSP are related to IT. The industry related to this technological field in China was a sellers' market, because of the large population and the market protection with quite limited number of suppliers. Beijing offered ideal locational advantage. There was a huge demand for informatization in the government sector. Because Beijing is the center of all kinds of political decision, information regarding the next generation technological standard is always in the air. The accessibility to the central government was crucial in the rapidly progressing industry. Yan (2004) explains that the early success of ZSP enterprises owed little to either their managing capability or technological strength but it was largely due to early comer's benefit which allowed nearly monopolizing the market. Zhou and Xin (2003) echoes that the success of Legend (i.e. Lenovo) can be credited to its market strategies of massive distribution and service networks across China.

Table 2 presents detailed structure of ZSP-based firms. The largest proportion of firms is engaged in software and system integration. Manufacturing is also quite active in computer, IC chips, and telecommunication equipment. ZSP firms are predominantly small in size. More than 60 percent of firms have less than 20 employees. Firms with employment greater than 500 represent less than 1% of total but they are quite big with 1659 employment on average. Average size of software firms is relatively small.

Figure 2: Total annual turnover of University-owned enterprises in principal provinces



(Source) Ministry of Education

In the Chinese context, it is peculiar that universities remain as the large shareholder of spin-off enterprises. This is because universities' objective is to utilize the profit to finance the operation cost. The annual turnover of the Founder group of the Beijing University, the largest of the university-owned enterprises in China, amounted to 22 billion yuan (US$ 2.8 billion) in 2003 and covered more than 10% of the university annual budget (Waseda Business School Review, 2005). Tsinghua University established Tsinghua Holdings in 2003 which controls 39 enterprises and has minority stakes in several others. The annual turnover of the group amounts to 15 billion yuan (US$ 1.8 billion). Beijing stands out as the location of university-owned enterprise business. (see Figure 2).

The presence of multinational enterprises is increasing in ZSP. It is no mystery why many multinational firms are also attracted to ZSP to establish R&D facilities.

Such firms include IBM, Sun, Nokia, Matsushita, Fujitsu, Microsoft, P&G, Novo Nordisk, Lucent, Nortel, Motorola, Intel, HP, GE, Oracle, and Symantec. The multinational research-intensive R&D units tend to locate in Beijing mainly because of the academic infrastructure and quicker access to information from standard-setting and decision-shaping government bodies (von Zedtwitz, 2004).

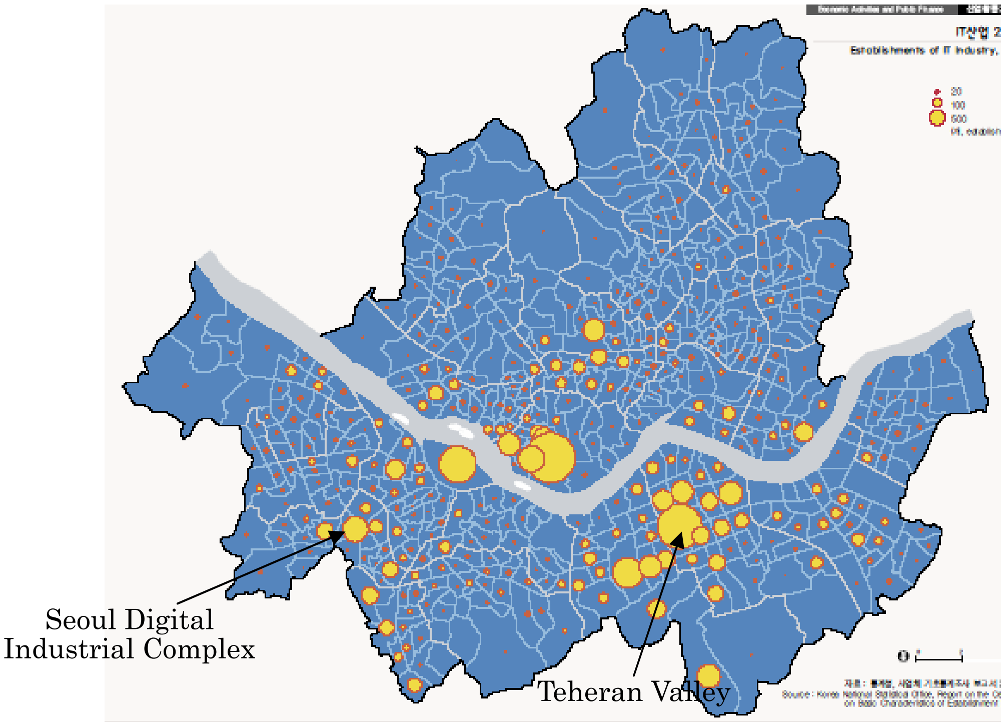
Despite the outstanding growth, there remains certain consensus that ZSP enterprises have not yet shown that they are really technologically innovative. Yan (2004) argues that in reality, small firms are striving to make instant earning which induce them to engage more in marketing and sales producing some phony products rather than investing in innovation. Cao (2004) asserts that "they (high-tech park firms) seem unwilling to bet their long-term and sustainable growth on indigenous innovation at a time when imported technology, a large and growing domestic market, relatively low labor costs, and other advantages could bring them immediate and short-term benefits (p.649)." Lack of regulatory enforcement of the intellectual property protection should seriously discourage the innovation. Furthermore, the lack of trust may constitute important obstacle in current ZSP because it results in decreasing of efficiency of social exchanges and preventing to large extent companies from taking advantage of vicinity. It says ZSP started to construct splendid building to attract the world top 500 enterprises recently but this endeavor raised the market price of the office rent substantially and small firms started to migrate from ZSP. This may have much to do with the financial speculation in the real estate market in view of the 2008 Olympic Game to be taken place in ZSP. Yet, if this problem prevails, the original strength of academia-based innovative dynamic of ZSP will be further lost. This should be a serious concern to the local community. The significance of agglomeration effects and their role in inducing high-tech clusters are still poorly understood. And the design of policies that can give rise to innovative clusters is also very much an art form, even though the workings of the principal ingredients are well known (p.268).

3.2. Seoul Digital Industrial Complex

It is worth remembering that Korean IT related venture companies first mushroomed in southeastern part of Seoul, especially in the area around Teheran Street of Gangnam-gu (district) which came to be known as Teheran Valley as a symbol of the new industrialization in Seoul (Shin and Byeon, 2001). It is said that the Teheran Valley was a self-organized organic creature gathering skilled workers who lost their jobs in conglomerate business groups (chaebols) during the financial crisis of 1997. This even led to the phenomena of KOSDAQ market IT venture capital boom. The area also started to offer wide varieties of restaurants and shopping amenities. Such unorganized growth, however, provoked congestions and office rental price hike in recent years.

Seoul Digital Industrial Complex and Daedeok Valley emerged as alternative for companies seeking lower cost location and for new startups seeking government support program.

Figure 3: Seoul: Establishment of IT industry locations, 2000



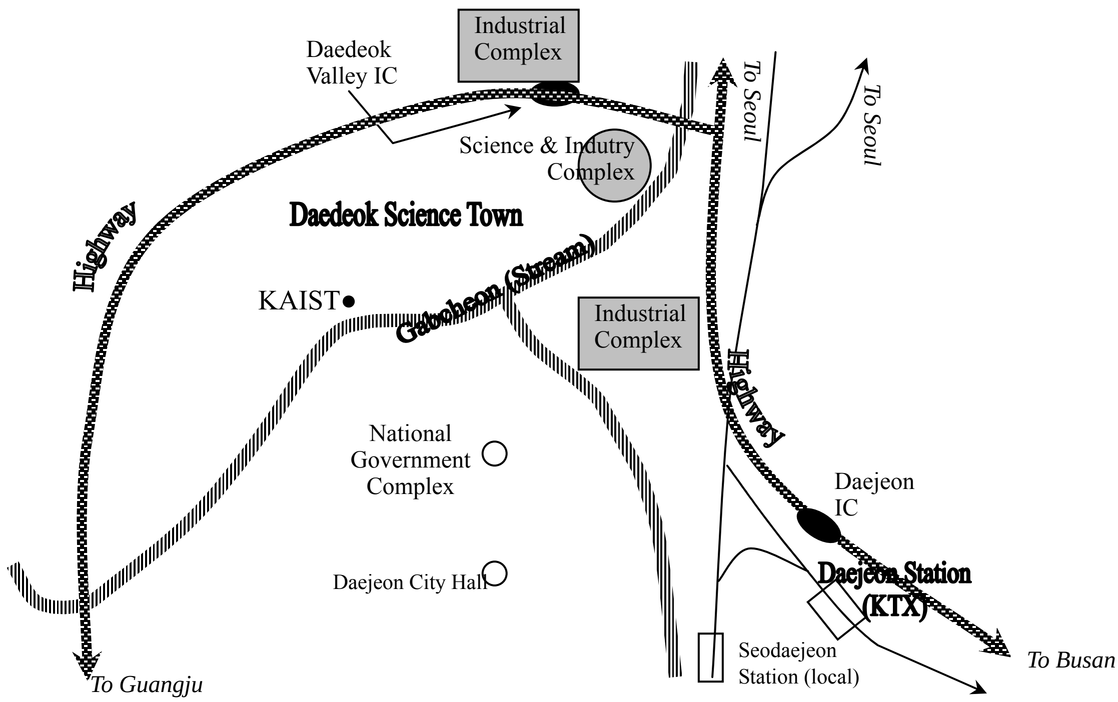
(Source) Seoul Development Institute, Thematic Maps of Seoul

The Seoul Digital Industrial Complex is located at the southwestern part of Seoul Metropolitan City, Guro-gu (district). It was planned as the revitalization of the Guro Industrial Complex which, since the 1960s, had been regarded as the national symbol of Korea’s export industry specializing in traditional manufacturing such as textile and apparel. Having lost its competitiveness to countries with cheaper-labor cost, the area was reformed into high rise buildings by a government body Korea Industrial Complex Corporation (KICOX) to accommodate high technology based venture companies and was renamed in 2000. As of December 2003, the Seoul Digital Industrial Complex is a home to 2,206 firms, among which 1,834 are already in operational phase, generating employment for 41,580 workers (see Figure 3).

3.3. Daedeok Valley

Daedeok Valley is in Yusong-gu (district), Daejeon Metropolitan City. The core of Daedeok Valley is Daedeok Science Park (DSP). DSP was established in 1973 modeled after Japan's Tsukuba Science Town. Daejeon was chosen for DSP because of availability of ample cheap land and its convenient location at the geographic center, which is geographical gravity point and have the role of hub point of transportation system reachable from Seoul in about one hour and from Busan and Kwangju in about two hours using Korean high speed express train (KTX: Korea Train Express). Currently, there are 15,899 researchers in DSP: including 6,473 in 18 government-sponsored institutions; 3,297 in 27 private corporate R&D laboratories; 2,452 in public enterprise R&D laboratories; 2,319 in 4 higher education institution; 899 in 44 venture companies; 422 in 9 public institutions; and 37 in 4 supporting institutions. Among them 4,455 hold Ph.D. degree (see Figure 4).

Figure 4: Map of Daedeok Valley



DSP can count on two most prestigious government-owned scientific institutions: Electronics and Telecommunication Research Institute (ETRI) and Korean Advanced Institute of Science and Technology (KAIST). ETRI's most notable scientific harvest includes CDMA mobile telecommunication technology which was adapted into Korean cellular phone manufacturing to make international success. On the other hand, KAIST's major function is the higher education. There is 394 faculty staff, 2,978 students in the Bachelor of Science program, 1,971 students in Master of Science program, and 2,357 students in the Ph.D. program (see Table 3). According to the record of the 2004 gradates, more than a half of the undergraduate degree earners chose to study in the internal graduate program. In case of the MS degree earners, about one-third of them continue advancing to the Ph.D. Program (mostly internally), and another one-third chose to work in companies or research units affiliated to chaebols. Regarding the Ph.D. program graduates, about one-third is employed by chaebol groups and another one-third usually choose to work for government-sponsored research institutes or educational institutions. We can observe strong orientation of the graduate students to seek job in big companies and government-sponsored research institutions. Yet, it is notable that more than 10% of the Ph.D. students work in venture companies.

Table 3: Human resource from KAIST according to 2004 graduates

After graduation career choice		BS	MS	Ph.D.
Advanced studies	KAIST	216	234	-
	Other graduate school	66	29	-
	Post-doctoral programs abroad	-	-	9
Private sector	Chaebols (conglomerates)	15	260	75
	SMEs/Venture	23	21	24
	Other Private business	5	45	3
Public sector	Government-sponsored research institute	-	32	59
	Government	-	4	-
	Education	-	5	12
	Reinvestment organs	-	14	3
	Degree linkage program	-	17	-
	Other public services	-	4	-
Others	Military service	22	2	-
	Not decided	41	21	17
Total		388	688	203

In the initial phase of construction of DSP, the government transferred government sponsored research institutes and higher education from Seoul. Any productive activities were not allowed to locate in the science park because it was expected that the pollution-free and quite atmosphere would attract knowledgeable people. However, private research institutes affiliated with conglomerate business groups (chaebols) were reluctant to move to DSP because the location was considered as countryside where decent educational, cultural, or commercial infrastructure was not yet available (Shin, 2001). It took a while such obstacles were mitigated, owing partly to the Daejeon Science Expo in 1993.

Yusuf (2003) evaluated that Daedeok has not developed into full-fledged innovative cluster due to the lack of the following aspects: cultural and social amenity; easy access to financial and commercial center; start-up culture and diversified producer services to support it; and market realities which stimulate applied and development research. Shin (2001) also criticized that the DPS has created few networks among the research institutes within the park. By looking for synergetic application of technology, business firms may be able to play a catalyst role.

It is expected that DSP research resource should be utilized more in business. The government announced the plan to transform the area surrounding DSP to a high-tech venture cluster named as Daedeok Valley. The plan is being carried out as a part the post-1997 crisis structural reform to reduce the dominance by the conglomerates through the promotion of small and medium enterprises, and at the same time enhancing the consolidation of Korea's comparative advantage structure based on scientific knowledge intensive activities. Such problems as pointed out by Yusuf (2003) needed to be addressed.

Along with this policy guideline, public institutions for research and higher education in the region launched projects to support high-tech venture firm startup. ETRI established ITEC (IT Technology Transfer & Evaluation Center) and started to offer a "shared service" which supports the shared use of the development equipment and test and authentication facilities that small and medium companies have difficulty in purchasing. Shared service includes: testing, certification, test-bed (applying the developed product to the relevant environment and providing the test environment), equipment support, technical assistance, facility support, production support (proto type). Technology evaluation is a series of actions which identify certain technologies' commercial value. Technology transfer implies dissemination of the ETRI scientific products. According to ETRI (2005), ETRI has 264 spin-offs including 16 KOSDAQ listed companies. Similarly, KAIST established the High Technology Venture Center (HTVC) in 1997 and as of November 2005, 77 firms are accommodated (HTVC's homepage, November 12, 2005 checked.).

Secondly, having been criticized that DSP is managed by the national government without linkage with the local government, a private Hanwha group and Daejeon Metropolitan City made a consortium to construct the Daedeok Techno Valley near DSP in 2001. There are already about 100 firms hosted there. The Techno Valley intends not only to host spin-offs from the DSP but also to setup the industrial park exclusively for foreign investors.

Thirdly, as mentioned above, the problem of distance from the commercial center of Seoul was mitigated by the start of KTX connecting Daejeon to Seoul in less than one hour.

3.4. The characteristics of three industrial clusters

In summary, characteristics of our three sample regions can be descried as follows. Table 4 shows the nature of each three clusters plus one cluster (Teheran Valley) from the views of location, emergence, government support and academic institute. Both Zhongguancun and Seoul Digital Industrial Complex are located in suburb of the capital city enjoying proximity to the market, but the location cost is not as expensive as in CBD. Daedeok Valley is a bit far from the market but enjoys lower cost. Emergence of the agglomeration was natural in Zhongguancun as it was in Teheran Valley, while Seoul Digital Industrial Complex and Daedeok Valley are artificial creatures. The government later joined with strong support in Zhongguancun, while the disorganized growth already exhibit diseconomies of agglomeration in Teheran Valley. The strong presence of academic institutions is common to Zhongguancun and Daedeok Valley.

Table 4: Comparison of Sample Region Characteristics

	Zhongguancun Science Park	Seoul Digital Ind. Complex	Daedeok Valley	Teheran Valley (reference)
Location	Suburb-Capital	Suburb - Capital	Local City	CBD-Capital
Emergence	Natural	Government Planning	Government Planning	Natural
Governmen	Strong	Strong	Strong	Weak
Academic	Strong	No	Strong	No

(Source) Author's own

4. Data Description

4.1. Data collection

Our data-set is constructed from *Survey Questionnaires on International Comparison of Industrial Clusters in East Asia,* conducted in March-April 2005 as a part of the research project on *the Urban and Industrial Agglomeration in East Asia*, organized by The International Centre for the Study of East Asian Development (ICSEAD). For the purpose of comparison, we restricted the respondents to firms related to information technology and asked them the same questions in Zhongguancun Science Park in China; Seoul Digital Complex and Daedeok Valley in Korea; Kitakyushu, Sendai and Nagano in Japan (Note 2). The questionnaire was designed to figure out in what form, on what purpose, and how often firms make contact with business partners such as suppliers, customers, research institutes and universities, local supporting agencies, and financial institutions (investors and banks), and how geographical distance affects such interactions. The details of the questionnaire is provided in Appendix A.

With regard to Zhongguancun in China, we selected firms registered by Zhongguancun Science Park and asked the questions either by telephone or on direct visits (Note 3). The number of effective replies is 207. In Korea, the questionnaire survey was conducted for the firms registered in the Korea Industrial Complex Corporation (KICOX) and Daedeok Valley Venture Association (DDVA). The number of effective replies is 50 in Seoul Digital Complex and 50 in Daedeok Valley. Thus, the total number of samples in Korea is 100.

4.2. Description of the data

According to our data, the main industries of Zhongguancun are “electronic parts and devices” as manufacturing, and “package software” and “information processing” as services, and those of Seoul Digital Complex and Daedeok Valley are machinery & equipment as manufacturing and “information processing” and “producer services” as services. Among the latter, firms in Seoul Digital Complex specialize relatively in service industry and those in Daedeok Valley specialize relatively in manufacturing. The summary statistics are shown in Table 5 about “year of establishment”, “sales value”, “R&D share relative to sales”, “number of patent”, “number of product item”, “employment”, and number of employee engaged in R&D”.

Table 5: Summary Statistics for Average Firm

5-1. Zhongguancun

						Obs.=199
	Measure	Mean	STDDV	C.V.	Maximum	Minimum
Firm Age1	Year	5.62	6.55	1.17	49.00	0.00
Firm Age2 (located in this cluster)	Year	5.13	6.27	1.22	49.00	0.00
Sales Amount, 1998	10,000 $	35.51	154.48	4.35	1449.28	0.00
Sales Amount, 2001	10,000 $	75.32	223.98	2.97	1811.59	0.00
Sales Amount, 2004	10,000 $	184.17	479.44	2.60	3623.19	0.00
Expenditure of R&D, 1998	10,000 $	6.07	29.52	4.86	284.78	0.00
Expenditure of R&D, 2001	10,000 $	16.62	56.68	3.41	438.41	0.00
Expenditure of R&D, 2004	10,000 $	45.78	141.16	3.08	1043.48	0.00
R&D share in Sales Amount, 1998	%	6.81	17.93	2.63	100.00	0.00
R&D share in Sales Amount, 2001	%	13.34	22.02	1.65	80.00	0.00
R&D share in Sales Amount, 2004	%	26.33	28.48	1.08	160.00	0.00
Average Growth Rate (Sales Amount, 2001-04)	%	1.94	2.36	1.22	12.42	-3.89
Average Growth Rate (Expenditure of R&D, 2001-04)	%	0.55	1.81	3.26	7.98	-2.76
# of Employment	Person	57.86	102.82	1.78	850.00	2.00
# of Resaerchers	Person	19.22	36.02	1.87	260.00	0.00
Resaerchers share in Employment	%	0.39	0.32	0.82	1.00	0.00
# of Patent		3.23	5.70	1.76	50.00	0.00
# of Production Item		10.49	71.72	6.84	1000.00	0.00

(Note) Not including the firms that hired over 1,000 person

5-2. Seoul Digital Complex

						Obs.=50
	Measure	Mean	STDDV	C.V.	Maximum	Minimum
Firm Age1	Year	6.80	5.58	0.82	32.00	1.00
Firm Age2 (located in this cluster)	Year	3.58	4.91	1.37	32.00	1.00
Sales Amount, 1998	10,000 $	-	-	-	-	-
Sales Amount, 2001	10,000 $	525.17	1476.45	2.81	8534.30	0.00
Sales Amount, 2004	10,000 $	502.61	907.45	1.81	4284.19	17.49
Expenditure of R&D, 1998	10,000 $	-	-	-	-	-
Expenditure of R&D, 2001	10,000 $	7556.42	38413.18	5.08	195892.48	0.00
Expenditure of R&D, 2004	10,000 $	48.38	67.38	1.39	393.45	0.00
R&D share in Sales Amount, 1998	%	-	-	-	-	-
R&D share in Sales Amount, 2001	%	114.09	455.59	3.99	2295.35	0.00
R&D share in Sales Amount, 2004	%	19.77	19.31	0.98	80.00	0.00
Average Growth Rate (Sales Amount, 2001-04)	%	2.31	5.88	2.55	10.72	-21.36
Average Growth Rate (Expenditure of R&D, 2001-04)	%	-1.28	11.96	-9.35	6.33	-59.08
# of Employment	Person	22.98	29.42	1.28	180.00	2.00
# of Resaerchers	Person	6.60	6.08	0.92	24.00	0.00
Resaerchers share in Employment	%	0.38	0.29	0.76	1.00	0.00
# of Patent		8.48	10.97	1.29	44.00	1.00
# of Production Item		22.73	104.99	4.62	700.00	0.00

5-2. Daedeok Valley

	Measure	Mean	STDDV	C.V.	Maximum	Minimum
						Obs.=50
Firm Age1	Year	6.72	3.02	0.45	15.00	0.00
Firm Age2 (located in this cluster)	Year	6.02	3.13	0.52	15.00	0.00
Sales Amount, 1998	10,000 $	-	-	-	-	-
Sales Amount, 2001	10,000 $	136.57	168.04	1.23	635.17	0.00
Sales Amount, 2004	10,000 $	318.60	491.90	1.54	3156.31	0.00
Expenditure of R&D, 1998	10,000 $	-	-	-	-	-
Expenditure of R&D, 2001	10,000 $	22.87	24.55	1.07	114.33	0.00
Expenditure of R&D, 2004	10,000 $	49.17	60.90	1.24	331.94	0.00
R&D share in Sales Amount, 1998	%	-	-	-	-	-
R&D share in Sales Amount, 2001	%	76.32	316.91	4.15	2000.00	0.00
R&D share in Sales Amount, 2004	%	22.78	17.97	0.79	80.00	0.00
Average Growth Rate (Sales Amount, 2001-04)	%	2.83	3.82	1.35	12.82	-6.87
Average Growth Rate (Expenditure of R&D, 2001-04)	%	0.97	2.32	2.39	5.92	-3.97
# of Employment	Person	30.36	27.21	0.90	126.00	2.00
# of Resaerchers	Person	10.18	8.15	0.80	35.00	0.00
Resaerchers share in Employment	%	0.42	0.25	0.59	1.00	0.00
# of Patent		11.10	11.14	1.00	60.00	0.00
# of Production Item		11.21	41.33	3.69	290.00	0.00

As shown in Table 5, the average age of firms in three industrial clusters is almost the same, a little more than six years. It reflects a boom of venture enterprises in China and Korea in the late 1990s and the early 2000. It is also common to all three clusters that firm sales revenue grew 2 to 3 percent on annual average during 2001-2004. These are still small enterprises in terms of the average employment, with a size of about 58 in Zhongguancun, 23 in Seoul Digital Complex, and 30 in Daedeok Valley. The firm size in Zhongguancun is the largest among the three clusters. They appeared to be highly R&D oriented as shown by 40% of the total employee being the research staff engaged in R&D. The lower proportion of R&D expenditure against the total sales revenue in Zhongguancun (13 percent in 2001 and 26 percent in 2004) may indicate the labor-intensiveness of R&D in China compared to those figures in Seoul Digital Complex and Daedeok Valley. The number of patent right is 4 in Zhongguancun, 8 in Seoul Digital Complex and 11 in Daedeok Valley. The number of product items, serving as a proxy for the level of product differentiation and responsiveness to the market, is 12 in Zhongguancun, 23 in Seoul Digital Complex and 11 in Daedeok Valley. Larger product variety per firm in Seoul Digital Complex compared to Daedeok Valley is an indication of its closeness to the market. Daedeok Valley is characterized by the proximity to fundamental research.

4.3. The nature of alliance in each metropolitan area

Table 6 shows the overview of alliance with major business partners on R&D stage in Zhongguancun, Seoul Digital Complex and Daedeok Valley. Not surprisingly, it is commonly observed for three clusters that most firms contact with their suppliers and customers with a frequency of more than once per month and even more than once per week, especially in Seoul Digital Complex. Similarly, contact with banks (and other kind of financial institutions) is frequent in three clusters. With regard to the contact with research institutes, firms in Zhongguancun maintain more frequent contact than the Korean counterparts, although more Daedeok Valley firms confirmed more than once per month contact with research institutions than those of the Seoul Digital Complex. This shows that firms in Seoul Digital Complex are relatively more market-oriented and those in Daedeok Valley are more research based. Contacts with the source of human capital (which refers to job search assistance offices of educational institutions) and local supporting agencies are relatively scarce in Korea and more frequent in Zhongguancun.

Table 6: The frequency of contact with business partner (%)

6-1: Zhongguancun

	Supplier	Customer	Research Institute	Source of Human Capital	Industrial Support Agency	Bank or Investor
Several times a year	13.86	7.77	16.41	39.80	27.71	36.71
1–3 times a month	46.53	49.51	46.09	37.76	51.81	34.18
Once a week or more	39.60	42.72	37.50	22.45	20.48	29.11

6-2: Seoul Digital Complex

	Supplier	Customer	Research Institute	Source of Human Capital	Industrial Support Agency	Bank or Investor
Several times a year	12.20	6.52	48.00	80.00	55.17	34.21
1–3 times a month	36.59	34.78	44.00	20.00	37.93	26.32
Once a week or more	51.22	58.70	8.00	0.00	6.90	39.47

6-3: Daedeok Valley

	Supplier	Customer	Research Institute	Source of Human Capital	Industrial Support Agency	Bank or Investor
Several times a year	10.64	6.12	30.95	84.21	68.18	40.00
1–3 times a month	48.94	38.78	57.14	15.79	31.82	37.78
Once a week or more	40.43	55.10	11.90	0.00	0.00	22.22

In Table **7**, we can observe the preferred mode of communication with business partners in each cluster. In general, we consider that by preferring the use of face-to-face communication, firms are exchanging more tacit, intangible, and complicated information with their partners. In three clusters, such relationship is more relevant in their contact with industrial support agencies and financial institutions. This should be because their talks should involve subsidies and credit. Taking the information that firms in Zhongguancun have a relatively higher incidence of contact with supporting agencies suggests a strong influence of incentives offered by public policies in the region. Firms in the Korean clusters value face-to-face contact in relation with customers as well. It is also notable that Daedeok Valley firms engage in more face-to-face contact with research institutions. Although we saw in Table 6 that firms in three regions maintain frequent contact with customers and suppliers equally, Table 7 shows that the relation with suppliers relies less on face-to-face communication than in the case with customers. This may suggest that the relationship with suppliers is market-based, guided mainly by price, but human relationship is more important in sales.

Table 7: The way of communication with business partner (%)

7-1: Zhongguancun

	Supplier	Customer	Research Institute	Source of Human Capital	Industrial Support Agency	Bank or Investor
Face to face communication	27.84	37.00	34.17	37.36	57.14	57.53
Telecommunication	72.16	63.00	65.83	62.64	42.86	42.47

7-2: Seoul Digital Complex

	Supplier	Customer	Research Institute	Source of Human Capital	Industrial Support Agency	Bank or Investor
Face to face communication	36.59	48.89	24.00	20.00	60.71	92.31
Telecommunication	63.41	51.11	76.00	80.00	39.29	7.69

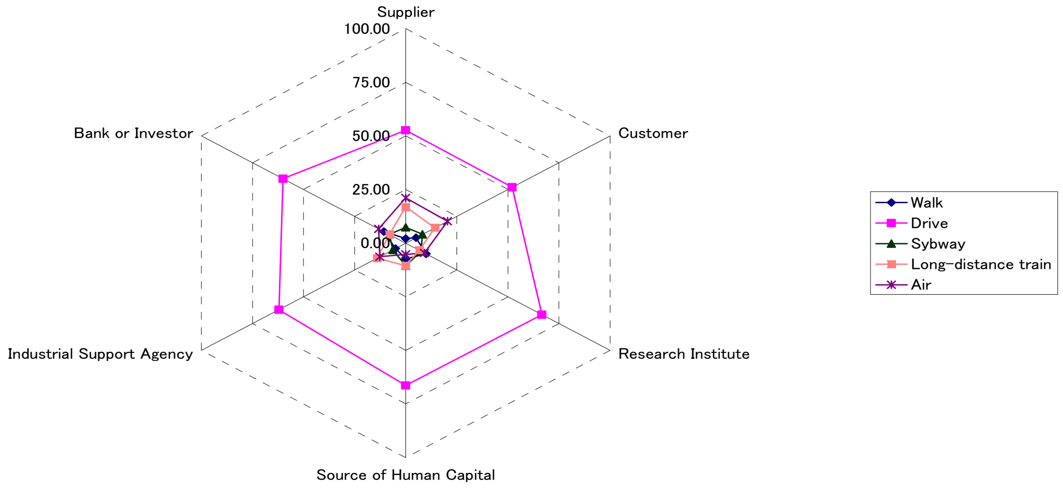
7-3: Daedeok Valley

	Supplier	Customer	Research Institute	Source of Human Capital	Industrial Support Agency	Bank or Investor
Face to face communication	29.79	51.02	54.76	27.03	52.38	77.27
Telecommunication	70.21	48.98	45.24	72.97	47.62	22.73

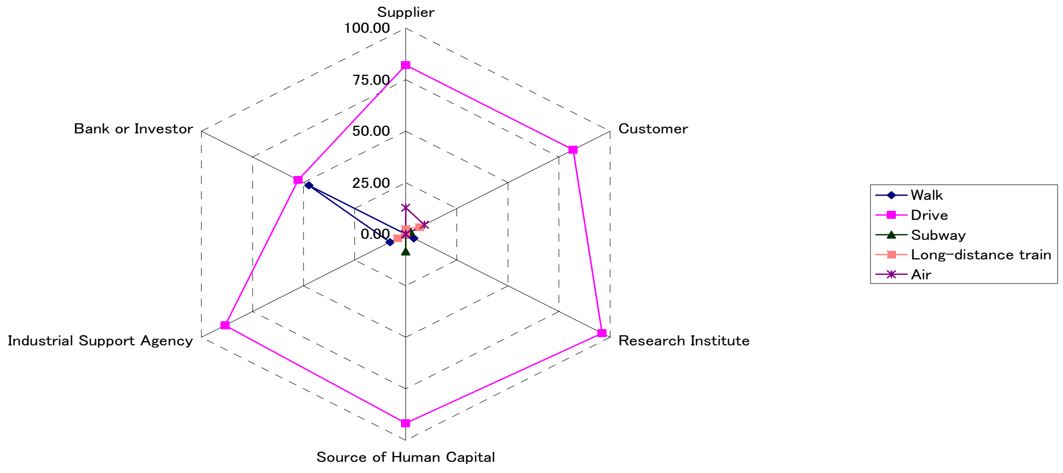
In Figure 5, we can observe what mode of transportation is used for visiting business partners in each industrial cluster. We regard “walk”, “drive”, and “subway” as intra-regional trip, and “long-distance train” and “air” as inter-regional transportation system. The intra-regional trip, especially driving a car, is the most frequently used option in each region. For firms in Zhongguancun “research institute”, “source of human capital", "supporting agencies", and "banks/investors" are more likely found within the same region while there is greater chance to travel to other regions for contacting with customers and suppliers. For firms in Seoul Digital Complex and in Daedeok Valley almost anything can be settled within the same region, either by driving a car or by foot (in relation with financial institutions in Seoul Digital Complex), although some firms responded that their main suppliers or customers are outside the region.

Figure 5**: The use of transportation to meet business partner (%)**

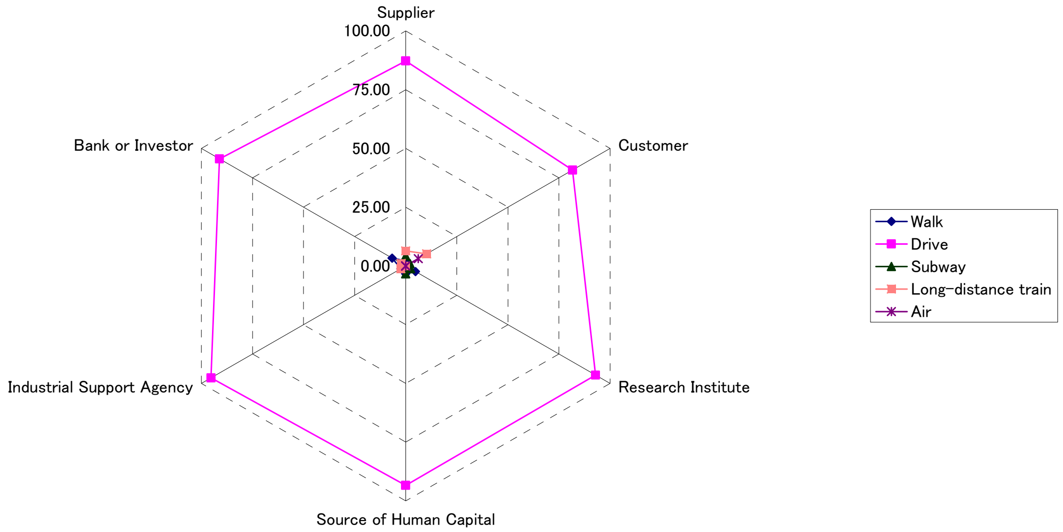
5-1: Zhongguancun



5-2: Seoul Digital Complex



5-3: Daedeok Valley



To sum up, characteristics of information technology related firms in the three clusters according to their use of communication can be illustrated as follows. In terms of the frequency of contacts, we found relatively high intensity with customers, suppliers, and banks in all three regions. Contact with research institutes is the most frequently done in Zhongguancun, followed by Daedeok Valley. Zhongguancun firms contact supporting industries more frequently. Contact with suppliers does not generally involve face-to-face meeting, but to meet face-to-face is considered more effective for communication with customers in Korean two clusters. With local supporting institutions and financial institutions, face-to-face communication is more valued in all three clusters. Communication with local research institutions is mostly held by face-to-face meeting in Daedeok Valley, but Zhongguancun firms use more telecommunication because of the higher frequency. When direct contact is necessary, it is done mostly within the same region, but Zhongguancun firms are more likely to find their suppliers and customers outside the cluster.

In the next section, we shall conduct a statistical analysis of the influence of face-to-face communications on firms' innovative activity. Our basic concern is whether the localized face-to-face contact may generate high-value information flow which is defined as innovation enhancing communication externalities. We test this hypothesis with the data regarding firms' practice of contacts with business partners in the research and development stage in the three clusters.

5. Communication Externalities on the Knowledge-based Firms

5.1. Methodology

Jaffe (1989) provides one of first attempts to model the effect of university research spillover on firms' innovation. His so-called knowledge production function is an analogue of ordinary Cobb-Douglas production function. It stipulates that firm's innovative output is a function of inputs like firm's own R&D investment, university research adjusted by proximity, generally represented as $INN_{ijt} = g(\bullet) + \mu_{ijt}$, where INN_{ijt} is innovative output of an industry i in region j at time t, $g(\bullet)$ is a function of innovative input with the disturbance term μ_t. Subsequent studies, like Jaffe, Trajtenberg and Henderson (1993), Acs, Audretsch and Feldman (1994a, 1994b), Feldman and Florida (1994), Audretsch and Feldman (1996b) and Fischer and Varga (2003) proposed other knowledge production inputs such as presence of related industry and specialized producer services and the population size in the same region. In contrast to these studies, which worked with the industry revel data, we can take advantage of the availability of the firm level data.

In this paper, we modify Jaffe's model for the firm level data and use the number of patents as an innovative output. The basic model form is:

$$\ln \frac{Patent_i}{Emp_i} = \alpha_0 + \alpha_1 \ln \frac{R\&D_i}{Emp_i} + \mu_i ; \qquad (1)$$

where $Patent_i$ is the number of patents created by firm *i*, $R\&D_i$ represents the firm's R&D expenditure, and μ_i is the disturbance. To control the firm size effect on patent, we divide the both side by the firm employment size Emp_i. Notice that, since our data includes only one time period and the analysis with respect to each region is done separately, the subscripts *j* and *t* are omitted from Jaffe's original model.

Because the aim of the present study is to investigate the importance of communication externalities and geographical proximity on the knowledge creation, we shall include the dummy variable DM_i to which we assign 1 when the respondent answered that his firm attaches more importance on face-to-face communication than telecommunication in contacting with business partners, and 0 otherwise. We also consider the effect of the firm age *Age* (experience in the market) on innovation. The model is therefore modified as:

$$\ln \frac{Patent_i}{EMP_i} = \alpha_0 + \alpha_1 \ln \frac{R\&D_i}{EMP_i} + \alpha_2 Age_i + \alpha_3 DM_i + \mu_i \qquad (2)$$

Next, we divide the communication dummy variable for the case of contact with suppliers (DM_1), customers (DM_2), universities (DM_3), and banks (DM_4). We also adds cross-terms multiplying the communication dummies and the firm age to pick up the effect of inclination to face-to-face communication boosted by longer experience in the market. The cross-terms allow us to investigate the hypothesis of firm's experience enhancing local communication network. Finally, we obtain the following model.

$$\ln \frac{Patent_i}{EMP_i} = \alpha_0 + \alpha_1 \ln \frac{R\&D_i}{EMP_i} + \alpha_2 Age_i + \alpha_3 DM_{1i} + \alpha_4 DM_{2i} + \alpha_5 DM_{3i} + \alpha_6 DM_{4i}$$
$$+ \alpha_7 Age_i * DM_{1i} + \alpha_8 Age_i * DM_{2i} + \alpha_9 Age_i * DM_{3i} + \alpha_{10} Age_i * DM_{4i} + \mu_i \qquad (3)$$

We estimate this specification using OLS regression. We expect positive signs for all α_1 through α_{10}.

We run the regression with respect to answers for Question 3 of the questionnaire, shown in Appendix A. In this question, respondents are asked to answer the same query for the three business stages respectively: basic research and development; product development; and marketing/commercialization. For this paper we use only one part of our data-set, regading the basic research and development stage.

5.2. The estimation results

We estimate the equation (3) by using the data on the interaction during the research and development stage from our data-set. This stage should be considered as the phase in which basic idea of the product are created before making concrete design of the product to enter the market.

Table 8 shows the estimation results. Based on the value of R-square, we can see that the model has reasonable explanatory power for Seoul Digital Complex while it fits poorly for Zhongguancun. In the left panel of the table we used the years since establishment of the firm, *Age1*, as the firm age variable, and the years operating in the present location, *Age2*, as the firm age variable in the side panel. The distinction of the two firm age variables may be of interest for the case of Seoul Digital Complex to which many firms relocated from other place. For Zhongguancun and Daedeok Valley, this distinction may have little meaning because firms in these regions are mostly new startups.

First, we observe the estimation results for Zhongguancun in Table 8-1. It shows that only firms' own R&D expenditure has statistically significant effect on innovation. Sign for dummy variables is negative, contrary to our expectation, except for the one related to banks. It is puzzling that face-to-face contact during the research and development stage does not show any effect on patent creation. Whether or not the result indicates that Zhongguancun firms poorly take advantage of agglomeration economies of innovation should be further investigated.

Second, we observe the estimation results for Seoul Digital Complex in Table 8-2. Surprisingly, firms' interction with suppliers utilizing face-to-face communication revealed negative effect on innovation. However, the cross term of the face-to-face dummy with suppliers and firm age since establishment shows positive significant sign, in contrast to the statistically insignificant result for the cross term of face-to-face dummy with suppliers and firms' operating age in the present location as shown in the right side panel. This suggests that firms relocated to newly established Seoul Digital Complex have not established meaningful relationship with suppliers within the complex but firms with longer experiences before coming to the complex were able to establish beneficial face-to-face relationship with suppliers.

Finally, we observe the estimation results for Daedeok Valley in Table 8-3. As was in the case of Zhongguancun, except the effects of R&D expenditure for each firm, there is hardly any significant effects of using the face-to-face communication and having long relation.

These results indicate that face-to-face communications cannot be considered as a source of innovation in the three regions of this study. However, according to our estimation result for the Seoul Digital Complex, the long-term matured relationship with partners may certainly enhance the effects of face-to-face communication and eventually contribute for innovation. This suggests that if may be myopic for policy planners to think that creating a cluster through tax incentives and credit facilities will provide a condition for creative production to take place. It may take long time until such chemistry takes holds..

We could not obtain strong evidence of industry-university-government cooperation in each cluster, especially expected for the case of Zhongguancun and

Daedeok Valley. It is likely that they have not arrived at the stage when the effects of industry-university-government cooperation can be clearly seen. As mentioned by Saxenian (1994) for the case of Silicon Valley, in order to foster sustainable development of industrial clusters, local, horizontal and flexible inter-personal communication and exchange of ideas are generally more important than institutional arrangements. This statement suggests the need for investigation into interaction among technologically talented people in creation of new knowledge, and not into the relation among firms and universities.

Table 8: Regression results about communication externalities and long relation

8-1: Zhongguancun

	Coef.	t-value		Coef.	t-value
R&D	**0.185**	**(1.920)***	R&D	**0.176**	**(1.800)***
Age1	-0.040	(0.430)			
			Age2	0.000	(0.000)
DM-Supplier	-0.475	(0.870)	DM-Supplier	-0.254	(0.570)
DM-Customer	-0.508	(0.670)	DM-Customer	-0.368	(0.600)
DM-University	-0.267	(0.640)	DM-University	-0.207	(0.650)
DM-Bank	0.555	(1.030)	DM-Bank	0.378	(0.940)
cross(Age1*DM-Supp)	0.259	(0.910)	cross(Age2*DM-Supp)	0.167	(0.620)
cross(Age1*DM-Cust)	0.351	(0.840)	cross(Age2*DM-Cust)	0.323	(0.830)
cross(Age1*DM-Univ)	0.080	(0.390)	cross(Age2*DM-Univ)	0.050	(0.290)
cross(Age1*DM-Bank)	-0.297	(1.080)	cross(Age2*DM-Bank)	-0.241	(1.010)
Const.	0.336	(1.400)	Const.	0.279	(1.330)
Adj. R2	0.031		Adj. R2	0.032	
Prob. > F	0.681		Prob. > F	0.693	
* significant at 10% level, ** significant at 5% level					

8-2: Seoul Digital Complex

	Coef.	t-value		Coef.	t-value
R&D	**0.585**	**(5.930)****	R&D	**0.452**	**(4.170)****
Age1	-0.262	(0.500)			
			Age2	0.031	(0.070)
DM-Supplier	**-3.059**	**(4.100)****	DM-Supplier	**-1.288**	**(2.580)****
DM-Customer	-0.296	(0.360)	DM-Customer	0.076	(0.130)
DM-University	2.426	(0.290)	DM-University	0.392	(0.680)
DM-Bank	-0.270	(0.250)	DM-Bank	0.633	(1.020)
cross(Age1*DM-Supp)	**1.095**	**(3.180)****	cross(Age2*DM-Supp)	0.251	(0.790)
cross(Age1*DM-Cust)	0.092	(0.250)	cross(Age2*DM-Cust)	0.157	(0.420)
cross(Age1*DM-Univ)	-1.313	(0.310)	cross(Age2*DM-Univ)	-0.708	(0.940)
cross(Age1*DM-Bank)	0.569	(0.910)	cross(Age2*DM-Bank)	0.039	(0.070)
Const.	-0.639	(0.810)	Const.	-0.749	(1.380)
Adj. R2	0.717		Adj. R2	0.713	
Prob. > F	0.002		Prob. > F	0.038	
* significant at 10% level, ** significant at 5% level					

8-3: Daedeok Valley

	Coef.	t-value			Coef.	t-value
R&D	**0.333**	**(3.310)****		R&D	**0.332**	**(3.320)****
Age1	-0.090	(0.170)				
				Age2	-0.081	(0.230)
DM-Supplier	0.726	(0.280)		DM-Supplier	0.478	(0.250)
DM-Customer	1.432	(0.550)		DM-Customer	1.209	(0.630)
DM-University	0.040	(0.020)		DM-University	0.400	(0.170)
DM-Bank	-1.901	(1.330)		DM-Bank	-1.530	(1.410)
cross(Age1*DM-Supp)	-0.498	(0.410)		cross(Age2*DM-Supp)	-0.409	(0.430)
cross(Age1*DM-Cust)	-0.575	(0.500)		cross(Age2*DM-Cust)	-0.498	(0.550)
cross(Age1*DM-Univ)	0.170	(0.160)		cross(Age2*DM-Univ)	-0.019	(0.010)
cross(Age1*DM-Bank)	0.970	(1.370)		cross(Age2*DM-Bank)	0.853	(1.480)
Const.	0.049	(0.050)		Const.	0.011	(0.020)
R2	0.241			R2	0.239	
Prob. > F	0.075			Prob. > F	0.077	
* significant at 10% level, ** significant at 5% level						

6. Concluding Remarks

In this paper, we use a unique Chinese and Korean data-set obtained from questionnaire survey, including qualitative data on contents and channels of regional cooperation, and some quantitative data gathered in 2005. We examined the importance of communication externalities and geographical proximity on the knowledge-based production as formation factors of such industrial clusters as Zhongguancun, Seoul Digital Complex and Daedeok Valley. We focus on how frequency and the method (face-to-face communication or telecommunication) of contact affect the firm's knowledge-based production.

Some common characteristics were seen for the three clusters. With suppliers firms, contact was with high frequency but with less face-to-face meeting opportunities. Contact with customers and banks/investors is done through more face-to-face meeting. Zhongguancun's firms have unique characteristics of frequent direct meeting with local supporting agencies, and their contact with research institutions are the most frequent among the three. However they rely on telecommunication. This is consistent with the finding of Charlot and Duranton (2005) that industrial cluster fosters communication network and the use of telecommunication, suggesting that the direct meeting and the use of telecommunication is self-reinforcing. Firms in the scientific park environment of Daedeok Valley contact rather less with researchers, but they use face-to-face communication more.

We could not show fully that communication externalities generated by the face-to-face contact influence the innovative output of firms. However, we could identify partial evidence that firms' long-term experience in the market is helpful for construction of such meaningful communication network. This result has a policy implication that the making of innovation-enhancing clusters requires long-term support to facilitate the internal mutual exchanges. Interaction can be enhanced by various opportunities outside of corporate activities, such as: social/cultural amenities; joint activities in basic research, exchanges with different business areas, and with other clusters including of foreign countries. This leads to the discussion of how to induce the inflow or return of knowledgeable workers in developing countries which have been exporters of the precious talent.

These conclusions give us some directions for future task. It is desirable to know more about what really happens when workers communicate in the district of industrial cluster. Also, the analysis in this paper is mostly descriptive, because it does not attempt to explore causality issues. The relationship between the communication externality and intensity of innovation is especially important. We expect that full use of our data set will lead to some effective results. Nonetheless, we need to improve the quality of a questionnaire survey to obtain better measure of innovation because we consider that the patent right data may not reflect the innovativeness, especially for the case of newly industrialized countries like China, where the intellectual property right is not fully guaranteed.

Notes:

1. Arita, Fujita and Kameyama (2005) revealed evidence that 1) the form of intra-regional cooperation have been made by shifting from vertically inter-firm networks to horizontal integrated inter-firm cooperation, 2) the spread of horizontal cooperation is not applied only to inter-firm cooperation but to inter-university and government cooperation in Japanese industrial clusters, 3) the work of inter-university and government cooperation is more effective than that of inter-firm cooperation, contradicting previous studies that stressed only the role of vertically integrated inter-firm linkages in Japan. And, Charlot and Duranton (2005) found that 1) cities foster communication external to the firm and the use of telecommunication, 2) by contrast, the hypothesis of a greater prevalence of face-to-face in cities does not receive much empirical validation, 3) complementarities across media do not lend much support to popular predictions about the forthcoming demise of cities following the replacement of face-to-face communication by telecommunication either.

2. This paper doesn't deal Kitakyushu, Sendai and Nagano. The sample tabulation for Japanese industrial cluster has not finished yet, because the conduct of questionnaire

survey was delayed.

3. The Tsinghua Science Park was established by the funds from Tsinghua University and the firms spin off from Tsinghua University. Because of the process of the establishment, Tsinghua Science Park follows the firms spin off from and related to Tsinghua University. And, sampling was not strictly random in terms of statistical theory, but firms in the population entered the sample if their CEO agreed to cooperate until the number reached intended size. This thing applies in not only Zhongguancun but also Seoul Digital Complex and Daedeok Valley.

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