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Industrial Agglomeration and Regional Growth in Korea: Focusing on the Software and ICT Service Sector

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1. INTRODUCTION

Japan and its followers, the NIEs and ASEAN, are known for their highly manufacturing-based economies. With help from government industrial policies including building export processing zones (EPZ) and preferential treatment to investors, Southeast Asia succeeded in inviting foreign direct investment (FDI) from developed countries or in promoting intra-regional FDI. As a result, the region became the cornerstone of global production networks especially for electrical home appliances, computers and peripherals.

However this international division of labor is changing as Mainland China is emerging as a global manufacturing base. China's plentiful supply of cheap labor and giant market potential attracts FDI from all over the world. As Ueki [2001] expected, companies have begun restructuring their production networks. Japanese companies relocated or plan to relocate 22 bases from ASEAN5 (Indonesia, Malaysia, Philippines, Singapore, and Thailand) to China since 2001 (*Nihon Keizai Shimbun,* July 25, 2002).

This phenomenon has forced countries in the region to explore new avenues to establish vital and high-growth economies. Seeing expansion of new frontiers such as information and communications technology (ICT) and biotechnology, which are often called 'knowledge-based industries,' most of the Asian countries began shifting their policy priorities. Generally speaking, these industries greatly depend on cutting edge technologies. In addition, speed of technological innovation and cycle is so rapid and competition is so intensive that it is very difficult for innovators to retain a technological edge unless they can keep innovative. So it has become a top priority mission for industrial policymakers to build an environment suitable to stimulate innovation and entrepreneurship.

One of the radical and ideal models for ICT development can be found in Silicon Valley. Many countries have learned lessons from Silicon Valley's experience that is based on relationships between governments, universities, venture businesses, venture capital firms and public/private supportive/coordination bodies. Anther successful case, which is the envy especially of developing countries, is Bangalore in India, where the software cluster is based on a system of international division of labor between the US and India. In this case, Indian universities played an important role mainly as the sources of knowledge workers.

Observing common characteristics of the two locations, it is seen that universities play a critical role in the formation and development of the industrial clusters, and indeed it has been recognized that proximity of excellent engineering universities are indispensable to development of an ICT cluster in a region. As a consequence, many governments have begun planning and implementing policies for promotion of knowledge transfers from universities and/or research institutions.

But is it correct to simply apply a university-/research institution-centered model in order to develop knowledge-based industries? The answer to this question may not be derived without analyzing factors that will affect formations of industrial clusters and intercity/intra-regional/international division of labor.

The aim of this paper is to contribute to the debate on the questions above mentioned. I focus on an industrial agglomeration, specifically software industry, in Korea and use regional data in order to analyze the change in number of employees by industry and by region. The reason for focusing on Korea was the country's rapid recovery from financial crisis in 1997. It is noteworthy that Korea emerged as a frontrunner in broadband dissemination and changed its economic structure to a more Internet-based economy in the process of recovery from the crisis (Ueki [2002]).

This paper is organized as follows: section 2 observes regional distribution of industries; and section 3 summarizes systematic characteristics of knowledge-based economy and policies for R&D and business promotion. In section 4 and 5, very simple econometric analyses are implemented to gain preliminary results: section 4 analyzes regional growth; and section 5 focuses on the characteristics of the ICT sector. Section 6 concludes.

2. INDUSTRIAL ORGANIZATION AND THE ICT INDUSTRY

2.1. Distribution of Industries by Region

According to data from regional statistics reports issued by the Korean government, business activities are highly concentrated in the capital sphere, which consists of Seoul and its peripherals. Table 7.1, which arranges data on the total number of 43 industries, indicates the dominant position of Seoul. About one-quarter of all companies and workers are located in Seoul. By adding Gyonggi, neighboring Seoul, more than 40% of them were represented by the two areas.

Table 7.1: Number of Establishments and Workers by Administrative Units

	Establishments				Workers			
	1998	(%)	2000	(%)	1998	(%)	2000	(%)
Seoul	610,363	23.8	647,609	24.0	2,923,458	26.4	3,143,416	25.9
Busan	231,247	9.0	234,255	8.7	913,888	8.2	950,743	7.8
Daegu	146,936	5.7	151,937	5.6	559,318	5.0	591,768	4.9
Incheon	117,398	4.6	127,625	4.7	543,739	4.9	605,334	5.0
Gwangju	74,520	2.9	79,301	2.9	306,742	2.8	344,859	2.8
Daejeon	75,924	3.0	78,768	2.9	308,325	2.8	325,088	2.7
Ulsan	50,230	2.0	52,941	2.0	274,581	2.5	310,920	2.6
Gyeonggi	390,677	15.2	434,566	16.1	1,861,998	16.8	2,208,717	18.2
Gangwon	98,075	3.8	100,648	3.7	341,179	3.1	357,422	2.9
Chungbuk	82,681	3.2	85,583	3.2	341,884	3.1	379,731	3.1
Chungnam	103,906	4.0	105,937	3.9	409,572	3.7	449,549	3.7
Jeonbuk	108,298	4.2	108,483	4.0	399,853	3.6	418,237	3.4
Jeonnam	117,610	4.6	118,395	4.4	414,816	3.7	436,593	3.6
Gyeongbuk	154,551	6.0	158,621	5.9	632,240	5.7	673,902	5.6
Gyeongnam	171,601	6.7	177,906	6.6	737,180	6.6	813,409	6.7
Jeju	32,708	1.3	35,498	1.3	118,069	1.1	128,822	1.1
Total	2,566,725	100.0	2,698,073	100.0	11,086,842	100.0	12,138,510	100.0

Source: *Report on Mining and Manufacturing Survey*, Statistical Office, Korea.

The concentration of geographical distribution by companies and workers enhanced between 1998 and 2000. This can be observed from the Herschmann=Herfindahl Index (HHI),[1] which is a measure of the degree of concentration. Higher HHI indicates more intensive concentration. HHI calculated on the number of establishments increased slightly from 0.112 in 1998 to 0.114 in 2000. HHI on workers also upped from 0.125 to 0.127.

2.2. ICT, R&D and the Education Sector

The ICT industry consists of hardware and software and ICT service. According to the industrial classification listed in Table A-1 in the Annex, it seems to be acceptable to define that the hardware sector corresponds to computer/office machinery of ID No. 19, and software and ICT service (hereafter software) is computer and related activities (No. 37).

As observed from Table 7.2, only 0.4 percent of Korean workers are engaged in the hardware sector. During the two years between 1998 and 2000, the number of both establishments and workers for the hardware sector grew so that the sector grabbed a larger slice of the share of Korean industry. But it was with software that the most dynamic changes happened in this period. The number of establishments increased from 4,428 to 8,145 and the number of workers more than doubled from 57,531 to 124,984. As a result, the number of workers employed in the software sector has reached more than double the number for the hardware sector

The R&D and education sectors, which are often seen as sectors with close relationships to developments in the ICT sector, also increased their numbers and share of establishments and workers.

The uneven geographical distribution by location of establishments and workers observed from the data of the 43 industries can be observed concerning four knowledge-based industries in Table 7.3. The most intensive concentration is seen in software. Seoul grabbed more than 80% of the software workers in 1998 and enhanced to 84% in 2000. The hardware sector forms industrial agglomerations in Gyeonggi with more than 55% of total workers and Gyeongbuk with about 20%. Except for the R&D sector, every administrative unit with 10%-plus workers increased its share. In the R&D sector, Seoul deprived Gyeonggi and Daejeon of their shares. On the whole, concentration by location of these sectors to Seoul has progressed during the period.

Table 7.2: Number of Establishments and Workers by Industries

ID	Establishment				Workers			
	1998	(%)	2000	(%)	1998	(%)	2000	(%)
3	2,111	0.1	2,066	0.1	23,962	0.2	21,406	0.2
4-5	5,839	0.2	6,434	0.2	173,320	1.6	180,827	1.5
6-8	17,170	0.7	20,929	0.8	391,019	3.5	437,573	3.6
9-10	3,974	0.2	4,596	0.2	76,900	0.7	82,907	0.7
11	3,962	0.2	4,841	0.2	71,474	0.6	87,455	0.7
12-14	7,883	0.3	10,065	0.4	271,485	2.4	307,201	2.5
15-17	13,322	0.5	16,151	0.6	339,176	3.1	371,744	3.1
18	10,281	0.4	12,984	0.5	234,768	2.1	279,844	2.3
19	568	0.0	819	0.0	41,635	0.4	50,064	0.4
20	3,852	0.2	5,008	0.2	112,164	1.0	139,722	1.2
21	2,851	0.1	3,961	0.1	218,995	2.0	279,642	2.3
22	1,709	0.1	2,229	0.1	39,974	0.4	46,486	0.4
23	2,589	0.1	3,200	0.1	184,449	1.7	203,952	1.7
24	938	0.0	1,044	0.0	89,520	0.8	94,392	0.8
25-26	4,607	0.2	5,849	0.2	79,023	0.7	90,781	0.7
27	1,318	0.1	1,420	0.1	52,713	0.5	56,629	0.5
28	63,186	2.5	66,621	2.5	711,225	6.4	640,755	5.3
29-31	963,162	37.5	916,685	34.0	2,433,235	21.9	2,493,217	20.5
32	578,175	22.5	607,718	22.5	1,335,601	12.0	1,555,985	12.8
33	218,395	8.5	273,283	10.1	811,297	7.3	896,131	7.4
34-36	127,352	5.0	130,447	4.8	969,562	8.7	943,466	7.8
37	4,428	0.2	8,145	0.3	57,531	0.5	124,984	1.0
38	1,095	0.0	1,604	0.1	45,631	0.4	55,188	0.5
39	52,551	2.0	59,992	2.2	419,820	3.8	438,835	3.6
40	94,935	3.7	102,802	3.8	779,622	7.0	921,158	7.6
41	53,979	2.1	65,944	2.4	395,855	3.6	487,902	4.0
42	99,121	3.9	120,517	4.5	248,769	2.2	318,409	2.6
43	1,752	0.1	2,360	0.1	22,090	0.2	28,340	0.2
44-45	225,620	8.8	240,359	8.9	456,027	4.1	503,515	4.1
0	2,566,725	100.0	2,698,073	100.0	11,086,842	100.0	12,138,510	100.0

Note: Industrial classification listed in the Annex.
Source: *Report on Mining and Manufacturing Survey*, Statistical Office, Korea.

The geographical concentration of software companies within Seoul was also observed from the data of the Korea Software Industry Association (KOSA). Among 303 KOSA members, 53.2% of the software companies were located in local research complexes in Kangnam district in the city of Seoul in 1997 when 87.4% of the software companies were located in Seoul (http://english.sw.or.kr/rns_aoc.asp#3).

In fact, over 1,500 ICT companies concentrated around the so-called ' Teheran Volley,' which is the Korean Silicon Valley located in the southern

Table 7.3: Number of Workers of ICT, R&D and Education (Percent Share of Total by Administrative Units)

	Hard (No. 19)		Soft (No. 37)		R&D (No. 38)		Education (No. 40)	
	1998	2000	1998	2000	1998	2000	1998	2000
Seoul	8.0	10.9	80.7	84.1	17.1	26.1	20.8	21.2
Busan	0.3	0.3	3.3	2.8	1.1	1.4	7.9	7.8
Daegu	0.5	0.2	2.2	1.3	0.4	1.0	4.9	4.9
Incheon	5.0	4.7	1.2	1.0	3.1	4.3	4.5	4.5
Gwangju	0.1	0.0	1.2	1.4	0.7	0.6	3.3	3.4
Daejeon	0.3	0.4	1.9	1.8	26.3	22.4	3.4	3.3
Ulsan	0.1	0.0	0.2	0.3	0.1	0.2	2.1	2.2
Gyeonggi	56.2	57.1	5.3	4.5	41.0	35.2	16.4	18.3
Gangwon	1.5	0.0	0.3	0.3	0.7	0.8	4.0	3.6
Chungbuk	4.1	2.0	0.3	0.3	1.1	0.6	3.6	3.5
Chungnam	2.0	1.4	0.1	0.1	1.4	1.3	4.6	4.3
Jeonbuk	0.9	1.1	0.4	0.4	1.1	0.8	5.0	4.6
Jeonnam	0.0	0.0	0.6	0.4	0.6	0.5	5.0	4.5
Gyeongbuk	18.9	19.2	1.1	0.6	2.5	2.4	6.5	6.0
Gyeongnam	2.1	2.4	1.0	0.6	2.3	2.0	6.7	6.5
Jeju	0.0	0.0	0.1	0.1	0.5	0.5	1.3	1.2

Source: *Report on Mining and Manufacturing Survey*, Statistical Office, Korea.

area of Seoul along Teheran Street. In addition, Teheran Volley is a representative venture town. About 900 venture companies of 7,000 venture companies nationwide and of 2,900 venture companies in Seoul located around the area (MIC [2002b]).

3. GROWTH FACTORS OF KNOWLEDGE-BASED INDUSTRIES

Why has the software sector grown so rapidly? Why have agglomerations of especially the ICT, R&D and education sector happened? These questions are the main concerns of this paper. Efficient creation, acquisition, transmission and usage of information and knowledge may have close relations with these phenomena. From this section, the analyses will be done in order to consider factors that promote the growth of the software sector and industrial agglomeration.

3.1. Knowledge-based Economy

The ICT industry is often categorized as knowledge- or 'k-based industry, although there is no precise definition. The definition of knowledge-based economy by Dahkman and Andersson [2000] is helpful in understanding its image. They defined it as *one where knowledge (codified and tacit) is created, acquired, transmitted and used more effectively by enterprises, organizations, individuals and communities for greater economic and social development. It calls for: an economic and institutional regime that provides incentives for the efficient use of existing knowledge, for the creation of new knowledge, for the dismantling of obsolete activities and for the start-up of more efficient new ones; an educated and entrepreneurial population that can both create and use new knowledge; a dynamic information infrastructure that can facilitate effective communication, dissemination and processing of information; an efficient innovation system comprising firm, science and research centers, universities, think tanks, consultants and other organizations that can interact and tap into the growing stock of global knowledge, assimilate and adapt it to local needs, and use it to create new knowledge and technology.*

In summary, the followings will be key promotional factors for ICT industries: industrial policies; education and entrepreneurs; information infrastructure; and innovation. Market structures, which have close relations with local needs, will also have an affect on the formation of industrial clusters. Among these factors, the improvement of environments for innovation and new business will be the main policy issue for promotion of ICT application industries.

3.2. R&D Policy

3.2.1. History of R&D Strategy

The Korean government look a leadership role in its remarkable industrialization. But regarding R&D strategy, its introduction lagged behind Japan and the government's initiatives were limited. The government started the process from 1962, undertaking a series of five-year economic development plans in which specific industries were given priority. It was in the 1980s when various tools were introduced by the government to promote private R&D through an incentive program for the private sector to set up R&D laboratories. But R&D was promoted through private sector monopoly rents yielded from domestic market protection. The rents financed R&D conducted by Korean conglomerates known as *chaebol*. Except establishments of industrial technology research consortia supported by the government for specific R&D projects, which concentrated into electronics and machinery industries, the role of the government in R&D promotion was limited. Although the government's R&D policy took mainly indirect forms, the government also established national research laboratories such as the Korean Institute of Science and Technology (KIST) in 1966 in order to support the industry's technological learning. It also funded university R&D, including the establishment of the Korean Advanced Institute of Science (KAIS) in 1971 (Sakakibara [1999]). Today, the Korean Advanced Institute of Science and Technology (KAIST), which has its origin in KIST and KAIS, has become one of the centers of excellence in the cutting edge of technologies including ICT.

3.2.2. Daedeok Science Town: R&D Center

Daedeok Science Town is located in Daejeon Metropolitan City, an industrial city in the center of the country, 150 km south of Seoul and 280 km north of Busan. In accordance with the government's decentralization policy in the 1990s, some governmental organizations such as the Small and Medium Business Administration (SMBA), Intellectual Property Rights Office, and Public Procurement Service relocated to this city. Today, Daejeon is not only one of the most advanced research areas but also the second administrative city of Korea.

The national project to build Daedeok Science Town was started in 1973 and construction completed in 1992. As of the end of 2001, there were 116 institutes, of which 12 were related to the information industry, and 15,899 researchers, of which 4,455 were Ph. D. holders, in the 27.8 km^2 site. Demographic data in Table 7.4 shows that although the private sector presence is largest, human resources are dominated by the governmental sector. Historically speaking, there were only three chaebol's R&D institutions in the 1980s, with the other private institutions being established in the 1990s (Yoon [2001]). Among educational institutions, KAIST, which relocated to the park in 1989, is one of the most renowned. Some 300 Ph. D.s, 600 masters and 500 bachelor-degree students are graduating from it annually.

Taking advantage of its location and solid scientific infrastructure named 'Daedeok Valley,' Deajeon government started policies for promoting venture business aiming to become a leading city in cutting-edge technology in the 21st century as well as a station for logistic distribution industry. The policy includes expansion of facilities for venture companies (ex. operation of a start-up business incubating center), expansion of investment capital

Table 7.4: Number of Institutions and Human Resources in Daedeok Science Town (As of December 31, 2001)

	Institutions	(%)	Human Resources	(%)
Corporate R&D	27	23.3	3,297	20.7
Government Corporations	18	15.5	6,473	40.7
Government R&D	10	8.6	2,452	15.4
Highest Education	4	3.4	2,319	14.6
Public Institutions	9	7.8	422	2.7
Supporting Institutions	4	3.4	37	0.2
Venture Company	44	37.9	899	5.7
Total	116	100.0	15,899	100.0

Source: http://www.tasto.or.kr/ (downloaded on September 10, 2002).

for venture business (expansion of the Daedeok Venture Investment Society, activation of Daedeok Angel Mart, and induction of venture capital to the city), supporting solid marketing, and construction of a system to foster specialized personnel.

Research Institutes and universities are closely involved in this policy, especially in the field of human resource training and development of companies. To foster management capabilities, KAIST established the graduate school of management (KGSM) in 1996. Some institutions established incubating centers where about 350 start-ups participated.

In spite of this good environment for venture business, Daejeon's share of the country's venture business remains below 10 percent. By referring to the data before 1998, Yoon [2001] explained Daedeok Science Town's situation thus; on the one hand greater priority was given to the goal of national technological policy than the needs of the private sector especially small- and medium-size enterprises (SMEs). While on the other hand not enough was done to help the local manufacturing base to turn R&D results into businesses. He evaluated that the science town is not an agglomeration of cutting-edge industries but a center of technological knowledge in Korea and a region with potential to become an advanced industrial region.

In practice, during the dot-com boom at the end of the 20th century, most dot-com companies located in Seoul as observed above. This implies that analysis by Yoon [2001], of which result seem to be mentioned with an eye on the manufacturing sector, cannot completely explain the background for development of start-ups.

3.3. Business Promotion Policy

3.3.1. Incubation Business

As is often seen in many countries' ICT business promotion policies, Korea is augmenting centers to incubate businesses in order to provide a better environment for start-ups.

The foundations for the incubation of businesses started in the 1990s, but it was after the financial crisis happened in 1997 that it got into full swing. Two governmental organizations are implementing these policies. One is the Small and Medium Business Administration (SMBA), and the other is the Ministry of Information and Communication (MIC). MIC's incubation efforts focus on the ICT sector, supporting software and on-campus incubation, while SMBA's is more broadly targeted. MIC is establishing incubation businesses in large cities throughout the nation. This policy is promoted through cooperation between MIC and the Korean Industry Promotion Agency (KIPA). In addition to provisions of support for policy making by MIC, for human resource management, and for the digital contents business, KIPA founded i-Park in the US (Silicon Valley) in 1998, China (Beijing) in 2000 and Japan in 2001, in order to develop foreign ICT markets (Sakata et al. [2001]).

Thanks to this support, the number of incubations has increased from 30 in 1998 to 279 in October 2001, 232 of which are operated by universities, 17 by research institutes and 11 by local governments.

3.3.2. Venture Capital

The venture capital industry was formed by policy initiatives in the early 1980s to carry out government policy of providing funds for, or mainly loans to SMEs. The launch of KOSDAQ in July 1996 opened up opportunities for investments. As of the end of 2001, there were 145 venture capital firms established between 1999 and 2000. Although the industry experienced a steep decline recently, the IT industry enjoyed the benefits and received two-thirds of total investments in recent years (MIC [2002a]).

According to SMBA, 28.7 billion won of venture capital funds were invested in 1,973 companies in 2000. About 60% of the companies were less than one year old, and 34.9% of funds were invested in them. Two- and three-year-old companies (21.8% of the companies) got 29.8% of the funds. Most of the funds were invested in the ICT sector. As of June 2000, 32.8%

of the funds were invested in electric and electronic businesses and 32.5% to engineering and information businesses. As a result, the number of venture companies listed on KOSDAQ increased from 52 at the end of 1996 to 353 at the end of 2001, 30% of which were IT firms.

These facts imply that there was a change in behaviors of financial sector and in peoples' future expectations. In addition, as is often seen in Korea's industrial policy, the government took strong initiatives to encourage the venture industry by forming new investment funds by themselves and reducing income and capital gains tax (MIC [2002a]).

4. INDUSTRIAL AGGLOMERATION AND REGIONAL GROWTH

4.1. Mechanism of Agglomeration Formation

Improvements in environments for business practices and innovative activities may be only prerequisites for the growth of industries. And it may be more difficult to explain the dynamic aspects such as industrial growth and agglomeration. In order to analyze these phenomena, past econometric analysis considered the following aspects as factors affecting regional growth: local competition; diversity; and regional specialization (Glaeser *et al.* [1992]). Bitter local competition caused by agglomeration is more likely to force companies to seek technological innovations and introduce new technologies. Correspondingly, more diversified agglomeration is more likely to allow knowledge spillover between different industries. Regional specialization has a trade-off aspect. That is to say, regional agglomerations that are more specialized in a specific industry have more advantages in knowledge spillover within the specialized industry, and disadvantages between different industries.

Recent study results of new spatial economics also identified the indigenous mechanism of agglomeration. Fujita [2001] mentioned three sources of agglomeration: diversity or heterogeneity; increasing return; and transportation costs. Diversity is composed of three types: diversity of (1) consumption goods; (2) intermediary goods for production; and (3) human resources. Interaction among these three bears agglomeration dynamics.

Diversity of consumption goods increases real income because it can provide consumers with more opportunities to satisfy their needs. This attracts more people to cities. The resulting market growth enables companies to specialize in specific fields of goods and services. In the case of diversity of intermediary goods, complementary relations throughout a supply chain make agglomeration of an industry more productive. The resultant expansion of the market of intermediary goods also increases demand for specialized services. The increasing return, which can be derived from diversity, drives the formation of agglomeration.

Diversity of human resource means that each individual has different knowledge and information. Knowledge and information are public goods, which means that their consumption does not decrease their stock. This characteristic brings about effects of increasing return of agglomeration to create knowledge.

4.2. Knowledge Creation, Agglomeration and ICT

Interaction between people can be done through face-to-face communications or telecommunications. This implies that diversity of human resource and transportation costs have a close relation in the formation of agglomeration. Transportation costs, as interpreted broadly by Fujita [2001], include costs for transfer of people, information, goods and services, and whatever can move spatially. One noteworthy result of spatial economics is the non-linear effect of transportation costs on agglomeration. Without transportation costs, agglomeration would never occur. If face-to-face interactions were indispensable, agglomeration of diversified people would occur to promote knowledge creation.

Ongoing innovations in ICT are decreasing transportation costs. This will result in a change in current agglomeration. One of the interesting issues in knowledge-based economy may be whether ICT will substitute for or complement face-to-face communications. Imagawa [2002] indicated that local calls in Japan were made more frequently but durations of local calls were shorter than long-distance calls despite the fact that the toll for long-distance calls was more expensive than local calls. This seems to imply that local calls complement and long-distance calls substitute for face-to-face communication.

Fujita [2001] insisted that face-to-face communications and ICT are complementary, that face-to-face interactions are indispensable as part of the process of technological innovation, and that leading industries such as game and software concentrate in urban areas as a result of necessity of face-to-face interactions. On the other hand, he also evaluated that the US Air Force, Stanford University and Hewlett-Packard (HP) performed a catalytic role for the so-called 'big push' in the initial stages to accelerate high-tech agglomeration in Silicon Valley.

4.3. Analysis on Regional Growth in Korea

In order to implement economic analyses, very simple models and methods based on Glaeser *et al.* [1992] will be applied to data on Korea in 1998 and 2000.[2] The data source is the same as in Table 7.1. That is to say, at the beginning, a regression analysis on the following simple model will be conducted to confirm the factors that explain regional growth in Korea:

$$\log\left[\frac{l_{2000}}{l_{1998}}\right] = f\left[\frac{w_{2000}}{w_{1998}},\ \textit{national level change, specialization, competition, non-diversity}\right],$$

in which ℓ_t is the number of employees in a region in an industry at *t* period, *w* is a wage in a region. Among factors that will have effects on knowledge spillover, *specialization* is defined as (industry employment in a region in 1998/total employment in a region in 1998)/(industry employment in Korea in 1998/total employment in Korea in 1998), local *competition* as (firms in an industry in a region in 1998/workers in an industry in a region in 1998)/(firms in an industry in Korea in 1998/workers in an industry in Korea in 1998), and *non-diversity* as (a region's employment in the top five industries except the given industry in 1998)/(a region's total employment in 1998). At last, *national level change in industrial structure* which is added to correct for demand shifts, was defined as log (employment in an industry except the region in 2000/employment in an industry except the region in 1998).

According to the theoretical backgrounds mentioned above, it may be possible to hypothesize a positive coefficient of competition and a negative one of non-diversity. Concerning specialty, the coefficient would be negative if higher specialty resulted in lower regional growth. The result of the regression analysis is shown as coefficient (1) in Table 7.5. The coefficient of competition is positive and significant at the 5% level and of non-diversity negative and significant at the 5% level. The coefficient of specialty, which was inversed to derive a larger t-statistic, is significant at the 5% level. This result does not deny the hypothesis that a more competitive and diversified, and less specialized region tends to accomplish higher growth even in a short period.

Table 7.5: Results of Regression Analysis on Regional Growth

Variable	Coefficient (1)	Coefficient (2)	Coefficient (3)
Constant	0.101	0.200	0.089
	(1.381)	(1.994)	(0.918)
Change in Industrial Structure	0.786*	0.762*	0.786*
	(15.058)	(14.296)	(15.049)
$\log(W_{2000}/W_{1998})$	0.078	0.106	0.077
	(0.827)	(1.102)	(0.824)
Competition	0.040*	0.040*	0.040*
	(6.571)	(6.539)	(6.569)
Non-diversity	–0.294*	–0.283**	–0.293*
	–(1.999)	–(1.939)	–(1.990)
1/Specialty	0.002*	0.002*	0.002*
	(3.132)	(2.847)	(3.127)
Tele-density in 1998		–0.002**	
		–(1.563)	
Internet Penetration in 2000			0.000
			(0.193)
F-statistic	64.819	49.673	53.943
Adjusted R-squared	0.327	0.321	0.326
Number of observations	659	618	659

Note: t-statistic in parentheses. * signififant at the 5%, ** 10%, and *** 15% level.

4.4. Effect of Telecom Infrastructure on Regional Growth

Telecommunications infrastructure can have effects on regional growth as mentioned before. But its effects may be complicated. That is to say, it could be positive to the growth of peripheries if long-distance calls and data communications substituted for face-to-face communications (F2F), and be negative if local calls and data communications complemented face-to-face communications. In order to test its effect, tele-density is added to the model conducted above.

As shown in Table 7.5, the effect of tele-density on regional growth is negatively significant at the 10% level. This implies that, after adjusting factors of knowledge spillover, parts of which will be done through complementary use of telephones to face-to-face communications, companies are accessing information accumulated in high tele-density areas such as Seoul and Incheon from outside of these areas (Table 7.6). Internet penetration rates in 2000 were added as an explanatory variable for reference. Although the coefficient became positive, it was not significant.

Table 7.6: Tele-density and Internet Penetration by Regions

(Unit: %)

Region	Teledensity (1998)	Internet (2000)	Region	Teledensity (1998)	Internet (2000)
Seoul	53.5	51.9	Gangwon	44.9	40.6
Busan	43.1	43.5	Chungbuk	42.3	37.8
Daegu	46.5	38.5	Chungnam	42.7	37.5
Incheon	57.9	46.2	Jeonbuk	41.2	38.2
Gwangju	42.0	42.8	Jeonnam	41.1	36.5
Daejeon	42.7	46.7	Gyeongbuk	38.6	31.4
Ulsan	n.a.	52.4	Gyeongnam	42.2	38.7
Gyeonggi	35.3	50.8	Jeju	42.7	44.4

Source: *Regional Statistics Yearbook*, Korea National Statistical Office, *2002 Internet White Paper Korea*, MIC.

5. CHARACTERISTICS OF THE ICT SECTOR

As expressed as knowledge-based industry, the ICT sector has different characteristics from other sectors. This fact will imply that different powers can act on growth of the ICT sector. On the other hand, though the hardware and software sectors can be categorized as one sector named as the ICT sector, the two have different features. This consideration may also necessitate consideration of the growth of each sector. This section will analyze these issues based on the model conducted above.[3]

5.1. Specialization in the Software Sector

As observed from Table 7.3, the software sector was intensively concentrated in Seoul. This aspect is reflected in the knowledge-spillover-related data of the software industry in Table 7.7, which indicate that Seoul is highly specialized in the software sector. On the other hand, Daejeon is in a more competitive business environment than Seoul.

Although the software sector is highly concentrated in Seoul, a characteristic of the sector i.e. its division of labor, can be completely built on telecommunications infrastructure, which is often seen as a favorable condition to development of local areas. As a consequence, today many local governments including those in Korea are promoting the software industry.

In order to examine the availability of software industry promotion policies, characteristics of the software industry should be tested. For this purpose, I introduced a dummy variable that equals 1 in the case of the software sector. The result is indicated in Table 7.8.

Table 7.7: Knowledge Spillover Factors of Computer and Related Activities in 1998

City	Competition	Rank	Specialization	Rank	Non-diversity	Rank
Seoul	0.71	16	3.06	1	0.54	4
Busan	2.25	10	0.41	5	0.52	6
Daegu	2.42	9	0.43	4	0.49	10
Incheon	2.43	8	0.25	7	0.42	15
Gwangju	2.22	11	0.43	3	0.51	7
Daejeon	1.98	12	0.67	2	0.51	8
Ulsan	3.48	5	0.09	15	0.50	9
Gyeonggi	1.58	15	0.31	6	0.41	16
Gangwon	3.54	4	0.09	12	0.58	2
Chungbuk	3.80	3	0.09	13	0.47	12
Chungnam	4.85	1	0.04	16	0.49	11
Jeonbuk	3.90	2	0.12	11	0.53	5
Jeonnam	1.88	13	0.17	9	0.55	3
Gyeongbuk	1.78	14	0.20	8	0.47	13
Gyeongnam	3.32	6	0.15	10	0.44	14
Jeju	2.83	7	0.09	14	0.64	1

After separating the specific effects of software from those of other sectors, the negative non-diversity and positive specialty effects are kept. On the other hand, considering the coefficients with a dummy variable, signs of the specialty coefficient changed in the software sector, and negative sing of tele-density became larger than other sectors (coefficient (5)). Considering its character of less capital- and material-intensive inputs structure as shown in Table 7.11, the development policy specialized in the software sector seems to be justified in periphery economies.

5.2. Effects of Educational and R&D Institutions on Growth of the ICT Sector

It seems obvious that educational and R&D institutions will play an important role in development of the ICT sector. In order to confirm the relation between educational and R&D institutions with growth of regions, and the software and hardware sectors, their number as of 1998 as an initial condition and dummy variable will be added into the model as explanatory variables in Table 7.8. The results of regression analyses are indicated in Table 7.9 and Table 7.10.

As shown in Table 7.9, in the case of the software sector, the significant

Table 7.8: Structural Differences of Software Sector

Variable	Coefficient (4)	Coefficient (5)	Coefficient (6)
Constant	0.198*	0.198**	0.065
	(1.967)	(1.939)	(0.668)
Change in Industrial Structure	0.802*	0.817*	0.830*
	(11.75)	(11.899)	(12.388)
$\log(W_{2000}/W_{1998})$	0.118	0.116	0.090
	(1.215)	(1.195)	(0.945)
Non-diversity	–0.304*	–0.269**	–0.253**
	–(2.070)	–(1.839)	–(1.728)
Competition	0.041*	0.046*	0.046*
	(6.658)	(7.813)	(7.813)
1/Specialty	0.002*		
	(2.854)		
Specialty		–0.011	–0.013*
		–(1.233)	–(2.103)
Tele-density in 1998	–0.002**	–0.003**	
	–(1.447)	–(1.562)	
Internet Penetration in 2000			0.001
			(0.389)
Software Dummy	0.871	0.980***	
	(1.258)	(1.453)	
Soft Dummy*1/Specialty	–0.010		
	–(1.128)		
Soft Dummy*Specialty		0.223*	0.145**
		(2.701)	(1.916)
Soft Dummy*Tele-density	–0.010	–0.016*	
	–(1.310)	–(1.947)	
Soft Dummy*Internet			–0.003**
			–(1.786)
No. of Obs.	618	618	659
F-statistic	33.490	33.318	40.156
Adjusputed R^2	0.322	0.320	0.323

Note: t-statistic in parentheses. * signififant at the 5%, ** 10%, and *** 15% level.

positive coefficients of R&D and R&D multiplied by software dummy are not derived. The coefficients of education and education multiplied by software dummy were derived to be negative, which is contrary to common belief that educational institutions will have a positive effect on industrial growth by becoming the origin of knowledge spillover.

Table 7.10 shows the results of the analyses applying the same variables in Table 7.9 to the hardware sector. Contrary to software sector results, significant positive coefficients of R&D multiplied by hardware dummy and

Table 7.9: Effects of Educational and R&D Institutions on Regional Growth and Software Sector

Variable	Coefficient (7)	Coefficient (8)	Coefficient (9)
Constant	0.152	0.223*	0.152
	(1.338)	(2.119)	(1.332)
Change in Industrial Structure	0.819*	0.822*	0.822*
	(11.896)	(11.958)	(11.969)
$\log(W_{2000}/W_{1998})$	0.113	0.119	0.116
	(1.163)	(1.230)	(1.194)
Competition	0.046*	0.046*	0.046*
	(7.833)	(7.80)	(7.870)
Non-diversity	–0.218	–0.300*	–0.236***
	–(1.396)	–(1.985)	–(1.513)
Specialty	–0.011	–0.012	–0.012
	–(1.201)	–(1.283)	–(1.277)
Tele-density in 1998	–0.002	–0.003***	–0.002
	–(1.309)	–(1.617)	–(0.946)
Software Dummy	0.972***	0.987***	0.968***
	(1.438)	(1.463)	(1.436)
Soft Dummy*Specialty	0.221*	0.346*	0.369*
	(2.523)	(2.991)	(3.101)
Soft Dummy*Tele-density	–0.015**	–0.014**	–0.013***
	–(1.917)	–(1.676)	–(1.576)
R&D in 1998	0.000		0.000***
	(0.952)		(1.488)
Soft Dummy*R&D in 1998	0.000		0.000
	–(0.173)		(0.873)
Education in 1998		0.000	0.000
		–(0.387)	–(1.244)
Soft Dummy*Education in 1998		0.000***	0.000**
		–(1.466)	–(1.680)
No. of Obs.	618	618	618
F-statistic	27.294	27.499	23.588
Adjusted R^2	0.319	0.321	0.322

Note: t-statistic in parentheses. * signififant at the 5%, ** 10%, and *** 15% level.

education multiplied by hardware dummy were observed. What should be noted is that the negative coefficient of telecommunications on the software sector seems to be more robust than that of the hardware sector. The decentralization of the software sector can be promoted by telecommunications infrastructure if the factors of intra-regional knowledge-spillover effects were excluded.

Table 7.10: Effects of Educational and R&D Institutions on Regional Growth and Hardware Sector

Variable	Coefficient (10)	Coefficient (11)	Coefficient (12)
Constant	0.148	0.202**	0.136
	(1.306)	(1.930)	(1.195)
Change in Industrial Structure	0.766*	0.764*	0.765*
	(14.274)	(14.226)	(14.272)
$\log(W_{2000}/W_{1998})$	0.106	0.111	0.107
	(1.101)	(1.151)	(1.116)
Competition	0.045*	0.045*	0.045*
	(7.742)	(7.627)	(7.702)
Non-diversity	–0.192	–0.261	–0.199
	–(1.236)	–(1.736)	–(1.283)
Specialty	–0.010	–0.010	–0.010
	–(1.041)	–(1.108)	–(1.102)
Tele-density in 1998	–0.002	–0.002***	–0.002
	–(1.336)	–(1.484)	–(0.872)
Hardware Dummy	–0.659	–0.361	–0.547
	–(1.162)	–(0.641)	–(0.946)
Hard Dummy*Specialty	0.011	0.017	0.002
	(0.165)	(0.252)	(0.028)
Hard Dummy*Tele-density	0.009	0.000	0.005
	(0.765)	(0.007)	(0.388)
R&D in 1998	0.000		0.000
	(0.775)		(1.416)
Hard Dummy*R&D in 1998	0.000*		0.000
	(2.445)		(1.385)
Education in 1998		0.000	0.000
		–(0.513)	–(1.295)
Hard Dummy*Education in 1998		0.000*	0.000
		(2.231)	(1.009)
No. of Obs	618	618	618
F-statistic	27.504	27.198	23.468
Adjusted R^2	0.321	0.318	0.321

Note: t-statistic in parentheses. * signififant at the 5%, ** 10%, and *** 15% level.

5.3. Input-Output Structure of the Hardware and Software Sectors

Why can structural difference between the hardware and software sectors be observed? Their industrial structures were considered to be a factor on location selection by companies. Hence, the differences in input-output structures between the hardware and software sectors can be considered as a background factor regarding differences in location.

As shown in Table 7.11, the hardware sector obtains inputs mainly from electronic and other electric equipment, computer and office machinery, and computer-related services (software sector), research, wholesale and retail trade, and the chemicals sector. Its products go mainly to computer and office machinery, and the computer-related services sector. This means the hardware sector has close relations with the electronics and ICT sectors.

In the software sector the main inputs come from real estate and business services, computer and office machinery, own sector, communications and broadcasting, and printing, publishing and reproduction of the recording media sector. Its products go to finance and insurance, electronic and other electric equipment, computer-related services, and wholesale and retail trade. This implies that the software sector has a closer relationship with sectors that usually locate in urban areas.

Compared with the hardware sector, the software sector does not have close relations with the ICT sector, and its output coefficients are more dispersed. Regarding its relationship with the research sector, the hardware sector has much closer relations with the R&D sector than does the software sector. In addition, the structure of the relationship with the research sector is contrastive. In the case of the hardware sector, the input coefficient of the research sector is larger than the output coefficient. Whereas the software sector has a larger output coefficient than input one.

In addition, neither sector has close relations with the school education sector as input's source. This fact can be observed in input-output relations. The software sector also does not have a directly closer relationship with the research sector than the hardware sector, and is built into industrial systems in urban areas. On the other hand, the coefficient of compensation for employees in the software sector is 0.281 and much larger than hardware's 0.065. This implies it is very important for software companies to assure the source of better human resources.

Actually, the highest class of software experts gathered in Seoul. In December 2000, 414 top-class experts stayed in Korea. Among them, 368 were in Seoul, followed by Gyeonggi (24), Daejeon (8), Busan (7), Gyeongnam (3), Daegu (2), and Chungnam and Inchon (1) according to the Korea Software Industry Association (http://www.sw.or.kr/.).

Table 7.11: Coefficients of Input and Output of ICT Industry in 1995

ID No.	Industry	Hard (No.13)		Soft (No.25)	
		Output	Input	Output	Input
1	Agriculture, Forestry, and Fisheries	0.0000	0.0000	0.0017	0.0000
2	Mining and Quarrying	0.0000	0.0000	0.0018	0.0000
3	Food, Beverages and Tobacco	0.0004	0.0000	0.0146	0.0000
4	Textile Products and Leather Products	0.0004	0.0001	0.0156	0.0001
5	Wood and Paper Products	0.0002	0.0026	0.0046	0.0020
6	Printing, Publishing and Reproduction of Recorded Media	0.0008	0.0052	0.0062	0.0191
7	Petroleum and Coal Products	0.0002	0.0008	0.0047	0.0075
8	Chemicals and Allied Products	0.0008	0.0284	0.0260	0.0086
9	Nonmetallic Mineral Products	0.0002	0.0013	0.0068	0.0000
10	Primary Metal Products	0.0014	0.0060	0.0380	0.0000
11	Fabricated Metal Products	0.0002	0.0034	0.0044	0.0003
12	General Machinery and Equipments	0.0009	0.0033	0.0128	0.0015
13	Computer and Office Machinery	0.1347	0.1849	0.0082	0.0714
14	Electronic and Other Electric Equipments	0.0048	0.4763	0.0423	0.0033
15	Precision Instruments	0.0028	0.0021	0.0031	0.0009
16	Transportation Equipment	0.0008	0.0004	0.0147	0.0021
17	Furniture and Other Manufactured Products	0.0003	0.0001	0.0020	0.0010
18	Electric, Gas, and Water Services	0.0004	0.0018	0.0031	0.0034
19	Construction	0.0016	0.0001	0.0162	0.0004
20	Wholesale and Retail Trade	0.0042	0.0356	0.0414	0.0060
21	Restaurants, Hotels and Other Lodging Places	0.0004	0.0000	0.0013	0.0000
22	Transportation and Warehousing	0.0004	0.0105	0.0134	0.0073
23	Communications and Broadcasting	0.0010	0.0028	0.0317	0.0422
24	Finance and Insurance	0.0058	0.0140	0.0900	0.0025
25	Computer-related Services	0.0245	0.0041	0.0416	0.0446
26	Real Estate and Business Services	0.0038	0.0198	0.0234	0.3118
27	Public Administration and Defense	0.0058	0.0000	0.0107	0.0000
28	School Education	0.0027	0.0006	0.0077	0.0009
29	Research	0.0070	0.0472	0.0187	0.0011
30	Health Services	0.0005	0.0002	0.0117	0.0004
31	Social and Other Services	0.0017	0.0003	0.0139	0.0013

Note: Total Supply (Output) =1, and the ID number is different from Table A-1.
Source: *Input-Output Table* [1995] Bank of Korea.

6. CONCLUDING REMARKS

Although the series of analyses conducted above are very preliminary, the following things seem to be identified. Firstly, local competition had a positive impact on regional growth consistently. Secondly, high specialization in the software sector helped high growth in the short term, which was unique compared with the system of overall regional growth. Thirdly, the possibility was not denied that location in the software sector may not be limited to high tele-density areas and can disperse throughout the country. These results will support industrial policies focused on the software cluster based on the hypothesis that the policies can be effective in peripheries with low tele-density throughout the whole region.

On the other hand, many venture companies concentrated in Teheran Volley in Seoul. MIC [2002b] cited the following aspects as the reasons: formation of a networking group to strengthen cooperative ties between venture companies; easy exchange of information with one another by sharing IT infrastructures; numerous advanced intelligent buildings and optical network infrastructures in Teheran Volley; and existences of financial institutions, associations, institutions and governmental offices that are closely related with venture businesses. All of these points will emphasize the merit of economy of agglomeration.

In addition, there is a possibility that the knowledge spillover effects directly from educational and R&D institutions on development of the software sector will be limited in the short term, though the correlation between R&D and educational institutions and the hardware industry were observed. As a background to this issue the following two points can be considered: longer-term dynamic effects and synergy between R&D and educational institutions and the software sector; and less accumulated knowledge and experiences in the software than the hardware sector.

There may be two clues in the Korean experience to consider this problem. Firstly, Seoul with the largest accumulation of software industry and excellent universities won the largest share of both the software and education sectors. With this fact will remain the possibility of synergy of the two sectors and existence of an industrial cluster nucleated by the software sector. What should be mentioned is that unemployed persons or business persons independent from large firms started many e-businesses in this period which can weaken the correlation between them.

The second is the demand structure to the software sector. This implies the possibility that the software sector constitutes a part of an industrial cluster nucleated by other industrial sectors. If this hypothesis were correct, Korea can use its knowledge that has been accumulated in the process of its industrialization in order to develop the software sector.

If the first hypothesis is correct, more detailed study on the software sector classified by products' and services' categories, division of labor in the sector, and its relations with other sectors should be conducted. Study on the internal structure of the software sector will be necessary in order to analyze the uneven distribution of engineers, especially concentration of the highest level of engineers to Seoul. If the second hypothesis is not denied, it will be necessary for policymakers to identify how the software sector or synergy effect between the software sector and existing industrial clusters should be used in order to promote the development of new industries or to reactivate existing industries. In both cases, the promotion of FDI by software-related firms will also be an affirmative strategy for regional development.

Notes

1 Definition of HHI: $HHIj = \Sigma_i$ *(share of j)*^{2}: *(i, j)* can be *(an industry, an administrative unit)* or *(an administrative unit, an industry)* depending on the purpose of the analysis.

2 Ordinary Least Squares (OLS) was used to conduct all of the regression analyses.

3 Ahn *et al.* [2000] investigated the effects of exogenous IT improvements together with knowledge spillover by modifying the model of Glaeser *et al.* [1992] by using data of 167 regions and 20 industries in Korea in 1994 and 1998. To identify the effects of IT improvements, they constructed the regional IT index by measuring the size of industries which need IT services based on 1995 Input-Output table. That is, they used the amount of IT services required as inputs of industries as the measure of IT. The results of the regression analyses were different from the model with and without IT index. Competition had a positive significant effect and non-diversity had a negative significant effect on the regional growth in the model without IT index. But the effect of non-diversity changed into a negative non-significant one in the model with IT index, although competition had a positive significant effect. Specialization had a positive non-significant effect in both models. IT index had a positive effect. One of the explanations provided by the authors on the reason that the effects of knowledge spillover except competition are not significant any more was that the improvement in IT reduced the opportunity cost of correcting information and hence could lessen the needs for a region's specialization or diversification. The analy-

ses conducted in this paper are different from Ahn *et al.* [2000] from the point of view that the focus is drawn to the ICT industry and the effect of ICT on the regional growth is measured by simple index, or telephone penetration rates and is tested by introducing dummy variables.

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Appendix 7.1: ID Numbers of Korean Industries Used

ID	Industry	ID	Industry
3	Mining	29	Sale of Motor Vehicles and Motorcycles; Retail Sale of Automotive Fuel
4	Food Products and Beverages		
5	Manufacture of Tobacco Products	30	Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles
6	Textiles, Except Sewn Wearing Apparel		
7	Sewn Wearing Apparel and Fur Articles		
8	Tanning and Dressing of Leather	31	Retail Trade, Except Motor Vehicles and Motorcycles
9	Wood Products of Wood and Cork		
10	Pulp, Paper and Paper Products	32	Hotels and Restaurants
11	Publishing, Printing and Reproduction	33	Transport, Storage and Communication
12	Coke, Refined Petroleum Products	34	Financial and Intermediation Insurance
13	Chemicals and Chemical Products	35	Real Estate Activities
14	Rubber and Plastics Products	36	Renting of Machinery and Equipment without Operator and of Personal and Household Goods
15	Non-metallic Mineral Products		
16	Manufacture of Basic Metals		
17	Fabricated Metal Products	37	Computer and Related Activities
18	Manufacture of Other Machinery	38	Research and Development
19	Computer and Office Machinery	39	Other Business Activities
20	Electrical Machinery n.e.c.	40	Education
21	Radio, TV and Communication Equip.	41	Health and Social Work
22	Medical, Precision and Optical Instruments	42	Recreational, Cultural and Sporting Activities
23	Motor Vehicles and Trailers Mfg.		
24	Manufacture of Other Transport Equip.	43	Sewage and Refuse Disposal, Sanitation and Similar Activities
25	Furniture, Articles n.e.c.		
26	Recycling	44	Membership Organization n.e.c.
27	Electricity, Gas and Water Supply	45	Other Services Activities
28	Construction	0	All Industries