Technology Transfer
&
The Role of Information in Korea

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I. Introduction

Many developing economies have shown a keen interest in technological development during their economic development on account of the close correlation between the two. As Paul Krugman has asserted, the technology gap must narrow in order for developing economies to narrow the income gap with developed economies. As Romer has also argued, there are two kinds of gap between developed and developing economies: the object gap and the ideas gap.

Poor countries are poor because they lack the materials necessary for production, such as machines and equipment, the object gap, but also because their citizens do not have access to the ideas that are used in developed countries, the ideas gap. The ideas gap is usually referred to as the knowledge and information gap. The new growth theory argues that technology and the accumulation of human capital are the two most important determinants of productivity and industrial development.

A World Bank report has pointed out that the knowledge gap must narrow for developing economies to catch up. In short, narrowing the income gap means narrowing the technology gap, and narrowing the technology gap implies narrowing the information gap.

However, narrowing the technology and information gaps is not an easy task and, in fact, in some developing economies the technology gap tends to widen. Furthermore, some studies show that there is little evidence that technology plays a significant role in economic development in developing economies, such as those found in East Asia. Krugman argued that Asian economic development was not due to the increase in total factor productivity that can be accounted for by technology, but was in fact simply an increase in factor inputs, such as labor, capital and intermediate goods.

However, it is widely recognized that Korea has succeeded in industrial development through the process of successful technology transfer. The Korean experience in technological development might be able to play as a benchmark for the latecomers. It is also important to study the role of information in the process of industrial development.

This is particularly true in a knowledge-based economy or a digital economy where technology or knowledge is a critical source of growth and a key determinant of competitiveness.

In this paper, I wish to study technological development, placing special emphasis on the role of information that is playing an increasingly significant role in the process of industrial development, particularly in a new economy characterized by the fast growth of information and communication technology (ICT) and industries related to it. I wish to discuss the relationship between technology, economic growth and industrial development. I will also discuss the characteristics of technology development in the process of industrial development, breaking it into two phases: the earlier phase of heavy and chemical technology (HCT) and the later ICT phase. Particularly, I wish to compare the pattern and characteristics of technology development and transfer between the two phases.

Based on this comparison, I will discuss the role of information in technology transfer in both the HCT and ICT phases. Although technological information and knowledge is very much important in technology development, studies related to this have not much been done. An infrastructure and a distribution mechanism, to disseminate and diffuse technological information, determine the level of technology and industrial development. It is expected that the role of technological information is increasingly important in a digital economy. This was the motivation behind this study. After elaborating on the case of Korea, I will discuss the implications and relevance to other East Asian economies and whether the Korean experience can be applied to other developing economies, drawing some policy implications based on this discussion.

II. Technology and Economic Development

1. The Role of Technology in Economic Growth

It is familiar in economics to try to find the relationship between technology and economic growth; there have been many studies on this issue. Denison studied the contribution of total factor productivity on U.S. economic growth in the post-war period. Boskin and some others also conducted an international comparison of factor contributions to economic growth. The results of this study generally showed that there was a close correlation between technology and economic growth. As Table 1. shows, increases in total factor productivity accountable for by technology are the factor most attributable to economic growth in industrialized countries.

〈Table 1〉 The Contribution of Factor Inputs in Economic Growth

(Unit: %)

Country	Period	Capital	Labor	Technology Progress	Intermediate Goods
U.S.	1948-85	24	27	49	
Japan	1957-85	40	5	55	
Germany	1962-85	32	-10	78	
U.K.	1957-85	32	-5	73	
France	1957-85	28	-4	76	
Korea	1967-93	13.67	4.62	10.8	70.9

Sources: Boskin and Lau (1992); and Hong S.D. & Kim J.H. (1996).

According to Boskin's study, the contribution of total factor productivity to economic growth in the U.S. over the past three or four decades was 49%, and it was 55% in Japan.

As the study shows, technology was a key determinant of a nation's economic development. Technological change enhances a nation's productivity by making it possible to develop new products, new processes and even new industries. Technology refers to the entire process of physical transformation from input to output, including the knowledge and information required for organizing all of the activities involved in this process. When accounting for growth, technology is treated as a residual of the production function, often called Solow's Residual.

However, in the case of developing economies, particularly in East Asia, this is somewhat controversial. Young and Krugman asserted that the contribution of total factor productivity in East Asian economies is about one third, and most economic growth is attributable to an increase in simple factor growth, such as labor and capital. A study on the Korean case also showed similar results.

According to Kim, the contribution of total factor productivity to economic growth in Korea is just 11%, less than average for East Asian economies. However, this figure underestimates the role of technology in economic growth because most technological development in Korea was accomplished through the import of capital goods in which technology is imbedded. The import of capital goods and technology imbedded in capital goods made it possible for Korean industry to accumulate technology and develop. However, in the Solow-type method of accounting for growth, capital augmentation is not counted as technology.

The Asia Development Bank (ADB), in a report, asserts that it is easier for developing economies to imitate foreign technologies during the early stages of economic development because they don't have the capacity to innovate. However, as they develop and approach the technological frontier, such countries are better and more capable of developing their own technologies by investing in research and development (R&D). This is why the contribution of technology to economic growth turned out to be somewhat insignificant in Korea, and why simple factor inputs were more significant during the earlier stages of development. Korea also seemed to follow the same path as the ADB report pointed out.

2. Technology and Industrial Development

There are two sources of technological development: technology transfer and R&D. According to a report from the Organisation for Economic Co-Operation and Development (OECD) in 1981, technology transfer is the process by which science and technology are diffused through human activity. During the earlier stages of economic development in Korea, technology transfer played a much greater role than did R&D. Korean firms did not have the capacity to innovate their own technologies through R&D investment. It was easier for them to imitate foreign technologies through technology transfer. In fact, technology transfer was a major instrument for technology development throughout the entire period of economic development over the past four decades, while R&D has been playing an increasing role only during the more recent stages.

Technology transfer expedited the accumulation of technology and contributed to the rapid shift to a high value-added industrial structure, including HCTs. During the early stages of industrial development in the '60s, Korean industrial structure was mostly composed of labor-intensive industry: textiles, clothes, shoes, toys, wigs and plywood. In the '70s, the industrial structure was upgraded to a higher value-added one with shipbuilding, iron & steel, home electronics and construction. In the '80s, Korea could produce technology-intensive products: computers, semiconductor memory chips, video recorders, automobiles and industrial plants. And in the

'90s, the Korean industrial structure was further upgraded to high-tech products such as mobile phones and HDTVs.

It was possible for Korea to upgrade its industrial structure every 10 years—from labor-intensive, to capital-intensive, to technology-intensive and finally to high-tech—through technology transfer and learning by doing.

We can now arguably decompose the process of industrial development in Korea into two phases: the phase of HCT and that of ICT. In the period of HCT, starting in the mid-'70s, technology was more imitated through technology transfer, but in the stage of ICT, starting in the mid-'90s, technology was relatively more developed through R&D as Korea, as a whole, approached to technological frontier and began accumulating the capacity to innovate.

III. Technology Transfer in the Process of Industrial Development

1. The Technology Transfer of Heavy & Chemical Technology (HCT)

There are three major channels of technology transfer. One is via foreign direct investment (FDI), one through licensing and the third through the import of capital goods. Beyond these three channels, technology can be transferred through corporate mergers or acquisitions, strategic alliances, technology cooperation or outsourcing.

In Korea, technology transfers have been mostly channeled through imports of capital goods during the period of HCT. Seoul has pursued an industrialization policy focusing on heavy industry whose industrialization depends on the import of capital goods (Table 2). Introduction of FDI and licensing was regulated by the Korean government and was not encouraged. It was not until very recently that technology transfer through FDI and licensing have increased and played increasingly important role as a means of accumulating technology in Korea.

〈Table 2〉 Foreign Technology Transfer

(in millions of dollars)

source	1972-76	1977-81	1982-86	1987-91	1992-96	1997-99
FDI	879.4	720.6	1,767.7	5,635.9	8,399.3	31,364.7
Licensing	96.6	451.4	1,184.9	4,359.4	7,317.8	7,486.9
Capital-Good Imports	8,841	27,978	50,978	120,952	220,211	137,845

Sources: Korea Industrial Technology Association; Korean Society for Advancement of Machinery

As mentioned before, technology transfer through the import of capital goods made it possible for Korea to compress growth and quickly shift to a high value-added industrial structure. Technology transfer in Korea followed the typical trajectory of technology acquisition, assimilation and improvement according to the explanation of Linsu Kim. For example, when Hyundai tried to develop and produce its first sedan, the Pony, in the early '80s, they did not solely rely on the import of capital goods. They purchased technology from Ford and learned how to manufacture by reverse engineering. During the early stages of technology transfer, they developed a production processes through the acquisition of packaged foreign technology, including assembly processes, product specifications, production know-how, technical personnel and components & parts.

During the second stage, that of assimilation, production technologies were quickly diffused across the country. As a late entrant, Korea acquired technological capability by recruiting experienced technical engineers from overseas. This was clear in the automobile industry when Daewoo and Kia tried to develop their own small passenger cars. This process also occurred in the semiconductor industry. When Samsung first developed the 64K DRAM chip in 1984, Hyundai and LG followed by developing chips of their own.

They did so by acquiring technology from foreign firms and by recruiting engineers from abroad, as well as from domestic competitors. The government also assisted in this process by acquiring and diffusing wanted technologies. It was at this stage that the dissemination and diffusion of technology information played a significant role in accelerating the assimilation of technology within the industry and the country.

During the third stage of technology transfer, technology improvement, imported technologies were applied to different product lines and improvements were made through R&D. Particularly in Korea, there was a concerted effort between the private sector and the government when investing in R&D. However, during the earlier stages of industrial development, the government played a bigger role in R&D investment. The government directly invested in R&D by founding and funding government-sponsored research institutes such as the Korea Institute for Science and Technology (KIST), the Korea Academy for Science and Technology (KAIST) and the Korea Institute for Industrial Technology Information (KINITI). This indirectly gave incentives to the private sector to increase their R&D investment.

But during the later stages of industrial development, the private sector—particularly the five largest conglomerates in asset size—played a bigger role than the government and invested more in R&D. Table 3. shows the trend of R&D investment, its ratio to GDP and the proportion of government spending compared to the private sector.

With an emphasis on R&D, the absorption capacity of the conglomerates was so remarkably enhanced that they could catch up with technology supplying companies every time they developed a new product. For example, there was a four years technology gap

〈Table 3〉 Ratio of R&D Investment to GDP and Proportion of Public to Private R&D

(Unit: billion Korean Won)

	1970	1980	1990	1999
R&D	1.1	28.3	335.0	11,921.8
Public	0.9	18.0	65.1	3,203.1
Private	0.1	10.3	269.0	8,711.7
Public & Private	97:03	64:36	19:18	27:73
R&D/GDP	0.38	0.77	1.95	2.46

Source: Ministry of Science and Technology.

between Samsung and Micron Technology when Samsung purchased the memory chip technology from Micron and developed the 64k DRAM in 1984. There was a two-year gap between them when Samsung developed the 1M DRAM a few years later. However, when she developed the 16M DRAM, the technology gap between them was down to only 3 months. Samsung finally surpassed Micron Technology when she developed the 256M DRAM and the 1G DRAM. In proceeding along this trajectory of acquisition, assimilation and improvement, technology was introduced, accumulated and diffused in the technology-receiving countries.

One has to be aware that the third stage of technology transfer is equivalent to the R&D stage of technology development. There is no original technology, one arrived at through R&D, in corporate Korea. Every innovative result of R&D activities was a simple improvement on a foreign technology.

At the earlier stage of technology transfer in the 1980s, there was a controversy about the appropriate technology, whether or not the nation should import and develop from industrialized countries assembly technology for automobiles. The World Bank cautiously recommended to Seoul that assembly technology of passenger cars is not appropriate for introduction or development for the reason that there is no demand for this technology since the domestic market is too small to have economies of scale in the automobile industry. They recommended that Seoul develop automobile parts and components instead of full assembly lines. However, Hyundai and Daewoo introduced assembly technology from Ford and GM and developed it, targeting the export market rather than the domestic market.

In the process, there was a learning effect as well as a linkage effect that nobody expected at the time. Hyundai quickly learnt the assembly technology for small cars, the Pony, and applied it to medium-sized car when they developed the Sonata.

When Samsung first developed the 64K DRAM chip there was also a controversy surrounding the appropriateness of its technology. Many doubted whether or not it would succeed. However, Samsung was very adamant in learning the acquired technology and applied it to the development of the 1M DRAM chip. In the process of acquiring and learning foreign advanced technologies, their absorption capacity of technology improved. In the case of Samsung's memory chip development, they even leapfrogged technological steps, surpassing the technology level of the technology-supplying firms.

The success of catching up technologically and leapfrogging in some fields is attributable to two major factors: the effort of the big conglomerates and environmental factors, like government policy. First, big conglomerates targeted the development of new products that they found profitable and promising in future markets. Once they targeted the development of new products, they utilized every possible means and ways they could. They used financing from banks and foreign financial sources and recruited the best-qualified engineers from abroad or from competitors.

The largest conglomerates proved to be very efficient and effective in mobilizing resources and pushing the development of new products and technologies. Fierce competition among the conglomerates also contributed to the competitive development of technology. In its literal sense, technology transfer and development in Korea was initiated and led by the 5 largest conglomerates.

However, as a side effect the big 5 suppressed and sometimes suffocated the technological capabilities and development at small and medium enterprises (SMEs), and even at other very large firms. Such SMEs have been almost always in an inferior position when it comes to developing their own products because they were short of financial capabilities, engineering manpower and market access. Those big 5 monopolized the product market as well as the factor market, such as finance, labor and R&D. Second, it was relatively easier for firms to acquire and assimilate foreign technology since the necessary technologies were visible and tangible. Product technologies in HCT industries, such as end products for home electronics, automobiles or industrial plants, were easily adapted by reverse engineering. Most product HCTs were at the mature stage from the standpoint of the technology-supplying countries or firms. So they were willing to provide their old technology to technology-demanding countries like Korea.

As for environmental factors, the Korean government played a key role in motivating the private sector to develop technology and technology intensive products. The government adopted an industrial targeting policy, focusing on fostering strategic sectors, such as HCTs, and provided every possible subsidy and incentive to the firms that participate in these targeted sectors.

As a matter of fact, the companies that were interested in taking government subsidies were willing to participate in the process of technology development even though they did not make much profit in developing those targeted products. Government also founded general research institutions like the Korea Institute for Science and Technology (KIST) and sectoral level research institutions like the Electronic and Telecommunications Research Institute (ETRI). It tried to disseminate those technologies that were developed by researchers in these institutions to private sector by spin-off.

This kind of effort was not always successful but it was enough to stimulate and encourage the private sector to increase their R&D investment. Besides the government policies that encouraged technological development, the relatively high quality of manpower and education contributed to the fast catch-up of technology and the successful accumulation of technology.

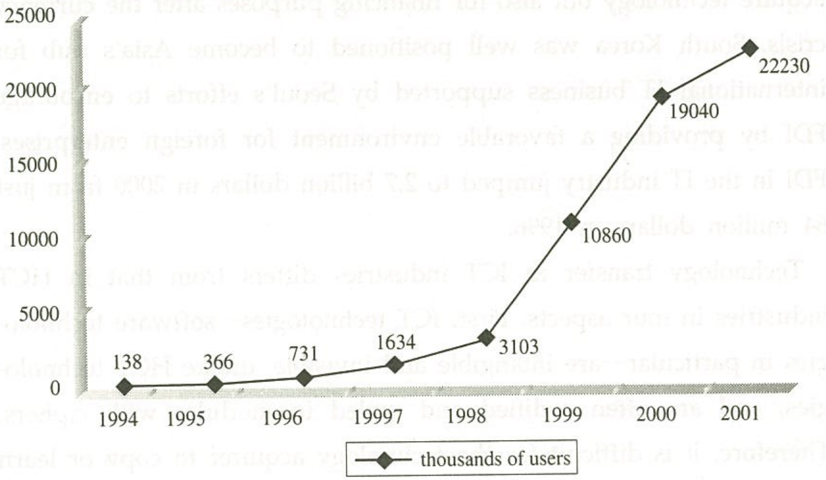
2. The Technology Transfer of Information and Communication Technology (ICT)

Since the mid-90s, the Korean economy has shown clear signs that she was entering into a new economy, often called the digital economy. As Table 4. shows, 22.3 million people as of June 2001 enjoyed communicating and searching for information through the Internet, more than half the population of South Korea. More than 30% of all Koreans have PCs for their individual use. From 1995 to 2000, the average annual growth of Internet users was 127%, double the world average of 62%. The government has connected all 43,000 elementary, middle, and high schools in the country to the Internet. While Korea ranks fifth in terms of absolute numbers, it ranks fourth in terms of penetration among the entire population.

In addition, telecommunication networks have been upgraded continuously in terms of both speed and service. More than 3 million homes now have high-speed Internet access the figure of which is contrasted with Japan's 450,000 homes. Based on this enormous increase in Internet users, e-commerce is also increasing rapidly in Korea. Among all types of e-commerce, B2C was dominant in the beginning while B2B has emerged as the dominant since late 1998.

The digital economy is, of course, being led by the fast development of ICT industries. As Table 5. shows, the production of ICT industries in value-added terms has increased at an average annual rate of 27.5% from 1995 to 1999 while GDP has grown by 3.7% in real terms over the same period. Therefore, the importance of ICT industries to

〈Table 4〉 The Number of Internet Users in Korea



Source: Korea Network Information Center

economic growth has increased over the same period. The share of ICT industries to GDP in real terms was 5.7% in 1995 but it has increased to 13.1% in 1999, more than doubling.

〈Table 5〉 Ratio of ICT Industry to GDP

(unit: 100 million won, percent)

	1995	1996	1997	1998	1999	Annual Increasing Rate
Real GDP (A)	3,773,498	4,028,212	4,230,067	2,947,104	4,367,985	3.7
IT Industry (B)	215,851	251,213	328,232	400,354	570,309	27.5
Ratio (B/A)	5.7	6.2	7.8	10.1	13.1	

Source: BOK, KDB.

As for the transfer of ICTs, South Korean development relied on diverse channels, unlike HCTs whose major source of technology transfer was the import of capital goods. In order to acquire core and original technology from abroad, the country did not solely depend on the import of capital goods or core parts but attracted

FDI and licensing. The country did not seek FDI in IT simply to acquire technology but also for financing purposes after the currency crisis. South Korea was well positioned to become Asia's hub for international IT business supported by Seoul's efforts to encourage FDI by providing a favorable environment for foreign enterprises. FDI in the IT industry jumped to 2.7 billion dollars in 2000 from just 64 million dollars in 1996.

Technology transfer in ICT industries differs from that in HCT industries in four aspects. First, ICT technologies—software technologies in particular—are intangible and invisible, unlike HCT technologies, and are often codified and sealed in modules with ciphers. Therefore, it is difficult for the technology acquirer to copy or learn them by reverse engineering.

Second, the product cycle in this industry is usually so short that competition is fierce not only between the technology suppliers but also between the technology acquirers. In order to survive in the market, technology acquirers should introduce new technologies or emerging technologies.

Third, intellectual property rights are strictly protected in this area. Many HCTs are used, old technologies, at the stage of maturity, whose effective period of patent protection is over in many cases. In contrast to that, many new ICTs are well protected by patent rights so that technology acquirers have to pay costly royalties for licensing.

Fourth, technologies in ICT industries—software technologies in particular—are imbedded in human capital and preserved in the form of tacit knowledge so that technologies usually have to be transferred face-to-face. Therefore, in spite of the rapid change in technology in ICT industries, it is not easy for technologies to be transferred from one country to the other.

Because of the reasons mentioned above, the role of technology information is increasingly important in the technology transfer of ICT industries. In addition, because of the difficulties involved in transferring technology, technology acquirers usually prefer FDI or mergers and acquisitions (M&A) as a means to acquire technologies instead of licensing. For example, Hansol M. Com, a Korean telecommunications company, succeeded in attracting FDI from Bell Canada in the area of mobile telecommunication services. KT Freetel, another Korean telecom, brought in Microsoft to invest in their mobile telecommunications software. Thrunet, a Korean cable Internet company, also attracted Softbank, a large Japanese investment bank, to invest in their high-speed broadband Internet services.

3. Comparison of Technology Development During the HCT and ICT Periods

We have looked at the process transferring HCTs and ICTs. There are, of course, some similarities and differences between them. The similarities are that both of them contributed to rapid industrial development even though we have yet to fully see the transfer of ICTs. But some differences have already been observed.

First, most HCT products were originally produced on an original equipment manufacturing (OEM) basis, while ICT products are now produced on an original design manufacturing (ODM) basis and developed on an original brand manufacturing (OBM) basis. The development of manufacturing technologies on an OEM basis, through to ODM and OBM, contributed to the creation of value-added products and their constant upgrading and improvement.

One may say that this was not a result of R&D activities alone but the result of comprehensive capabilities of firms—such as marketing, business and technology skills. However, there is no doubt that vivid R&D activities contributed to the creation of high value-added products. Samsung Tekwin's camera is a good example of such development.

Second, R&D activities for ICTs are usually required in every phase of the production process from product development to design, manufacturing and marketing, while R&D into HCTs is needed only during the development stages.

Third, R&D activities for ICTs—normally undertaken at SMEs—are increasingly more involved in R&D activities, particularly for venture businesses. For HCTs, there was no room for SMEs to engage in research activities. They did not have the capacity or intention because there were no opportunities for R&D investment. SMEs involved in HCT-based industries imitated and copied products developed by bigger or foreign firms. If they developed products independently, then they usually ended up bankrupt either because they could not afford to finance the R&D expenses or because their technologies were so poor that they could not meet the market needs.

However, for ICT-based industries, many SMEs, or venture firms, are themselves equipped with high technologies and are eager to exploit new markets with the products they independently developed.

Last but not the least, the government support of R&D had a triggering effect on the ICT-led new economy. The Seoul government not only directly invested in R&D activities, such as founding government-sponsored research institutes, but also provided the private sector with various tax and financial incentives. At this stage of ICT, the market infrastructure developed well and supported a favorable environment for R&D activities. The development of KOSDAQ and the stock market in general also contributed to the financing of R&D investment for such venture firms.

IV. The Role of Information in Technology Development

1. The Significance of Information in Technology Development

We can define technology transfer as the process of information diffusion from a technology-providing country or firm to a technology-receiving country or firm. Whether technology is imbedded in capital goods or human capital, or transferred through licensing or printed material, all technology transfer includes the diffusion of information from a technology-supplying agent to a technology-demanding agent.

According to Ikuiro Nonaka, there are two dimensions of knowledge: explicit or codified knowledge and tacit knowledge. On top of this, there are four different types of conversion between these two dimensions of knowledge: tacit to tacit (socialization); explicit to explicit (combination); tacit to explicit (externalization); and explicit to tacit (internalization).

Technological capability at a firm is not a collection of explicit knowledge. Rather, it is largely a collection of tacit knowledge. Technology transfer mostly involves learning on the part of the technology-receiving firms by the transfer of explicit and tacit knowledge of the technology-providing firm to the tacit knowledge of the technology-receiving firm. In this regard, the role of technology information is significant.

Information is unique in that it cannot be depleted and it is non-exclusive. Even if a certain consumer utilizes information, the information is not used up. Also, consumption does not exclude any other person's consumption or utilization of the same information. Therefore, information is a public good with positive externalities when decreasing returns to scale are applied. If information can be disseminated and diffused in such a manner—as much as possible—then the economy as a whole is better off. Likewise, technology information is a public good by which technological capabilities are enhanced. Particularly, at the assimilation stage of technology transfer, the dissemination of technology information has a great effect on technological development.

But at this stage of assimilation, there are two problems that should be solved in order for technology information to be disseminated as efficiently as possible. First, the technology-acquirers usually do not have much incentive to disseminate the information that they spent time and money on procuring. On the contrary, they tend to keep such information secret, inside their firms, and can be very reluctant in exposing such knowledge to competitors.

But it is those competing firms that are desperate to acquire the technology information either from the first acquirer or from the original, usually foreign, source. From the point of view of the national economy as a whole, it would be better for the information to be disseminated as much as possible.

Second, it takes a considerable amount of initial investment in order to disseminate technology information. It is for this reason that governments must be involved in the task of disseminating technology information in order to guarantee the effective facilitation of technology assimilation within the country.

During the R&D stage, information is needed and demanded much more than during earlier stages of development. According to a study by the U.S.' National Science Foundation (NSF), over half of the time allotted for R&D purposes is spent on acquiring and collecting required data and information. Another study shows that for ICTs it takes only one to two years from R&D to the commercialization of a product, while for HCTs it takes from five to six years.

Because of this ever decreasing time frame, product development information needs to be gotten and organized in a much more timely manner. It is known that information, as an economic good, should meet the condition of timeliness, accuracy and economy in order to satisfy customer demand. Information plays not only a role in facilitating R&D activities and strengthening technological infrastructure but it also helps build high value-added content that is indispensable in technology development.

2. A Comparison of the Role of Technology Information During the HCT and ICT Periods

In spite of the significance of information in technology development, there is a difference in its relative importance during the HCT-led and ICT-led stages of growth. With HCTs, technology information and its dissemination played a minor role since it was relatively easier to acquire technology information. First and foremost, in HCTs, most technology information and know how was acquired by reverse engineering of imported products in which the technology was imbedded. Many HCTs are tangible and visible, embedded in capital good, so that it was easier for technology imitators to copy and learn them. Second, many export goods were produced in OEM. Buyers mostly provided the technology information necessary for OEM.

Third, it was easier to get information from industrialized countries because most products were mature. Product cycles in HCTs are relatively long so that technology-receiving firms can survive in the local market even if they purchase mature technologies. It is particularly true in the area of machinery and some other heavy industries.

Fourth, SMEs acquired technology information directly from large firms for which they are subcontractors. For example, auto parts and components manufacturing firms could acquire technologies and technology information from Hyundai or Daewoo. Therefore, technology acquirers usually resorted to the technology information dissemination institutions to acquire information.

On the other hand, it was increasingly difficult to have access to technology information through ICT transfer. Most such technology information and know how is intangible and invisible, often sealed in modules with a cipher, so that it is difficult to learn by reverse engineering. Furthermore, patent rights strictly protect many new technologies so that acquirers usually have to pay costly royalties for licensing.

Second, competition is acute and fierce between ICTs because of the short product cycle.

Third, ICTs are tacitly imbedded in human capital. Therefore, technologies should be transferred through human contact. Because of difficulties involved in technology transfer they need to develop their own technologies through R&D. During R&D, it takes much time and cost to collect and acquire information. According to another study from the NSF, 51% of the time spent on R&D is simply for collecting and analyzing information. Therefore, they have to depend more on professional technology information dissemination institutions in order to acquire information. That is why the role of information and information dissemination institutions got increasingly important with ICTs.

3. The Experience of Disseminating Technology Information

In accordance with this demand, the Seoul government in 1987 founded a government-sponsored institution, the Korea Institute for Industrial Technology Information (KINITI). It was merged with other government institutes and became the Korea Institute for Science and Technology Information (KISTI) in 2000. KINITI's job was to disseminate industrial technology information to companies. By doing so, the government intended to facilitate technology transfer from foreign sources to domestic firms and between domestic firms.

KINITI possessed about 30 million units of technology information, most purchased from foreign data banks or databases; it had 9 million pieces of patent information, 7000 periodicals and 40,000 technological reports. It provided companies with information in response to their requests. As of September 2001, some 50,000 people and companies subscribe to KINITI databases and regularly use its information services.

Table 6. shows how the number of users of information services sharply increased since 1999, while it was stable and rather stagnant before 1998. Before the mid-'90s when industry used mostly HCTs, information users did not exceed more than 20% of total firms. This proves how information does not play a significant role in HCTs.

〈Table 6〉 Number of Subscribers for Technology Information Services

(Unit: number, percent)

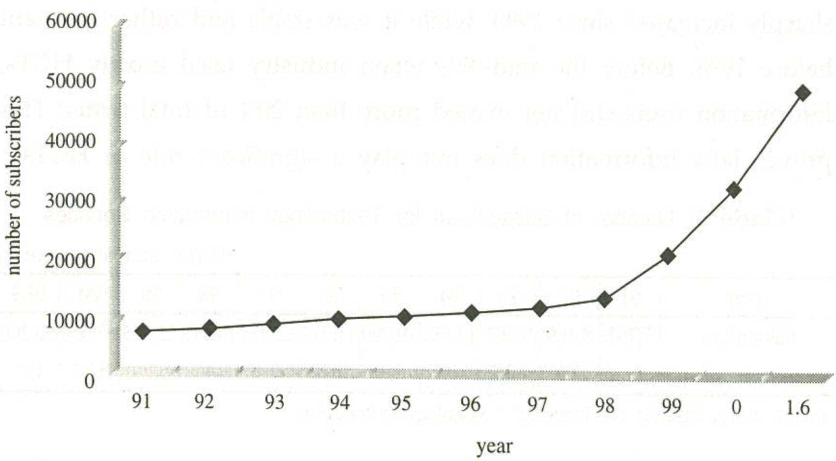
Year	91	92	93	94	95	96	97	98	99	00	01.9
Subscribers	7,703	8,469	9,367	10,152	10,990	11,717	12,933	14,319	22,033	33,654	50,260
Growth rate		9.9	10.6	8.4	8.3	6.6	10.4	10.7	53.9	52.7	49.3

Source: Korea Institute for Industrial Technology Information

The rapid growth of technology information users was partially a result of price reductions in information services but more important factors were the sharp increase in on-line users. From 1999 to 2000, on-line users of technology information increased by 288% according to KINITI and the number of clicks by on-line users increased by 372% in just one year. This sharp increase reflects the rapid growth of the digital economy. It also shows that information plays an increasingly greater role in ICTs.

Some 50,000 subscribers use about 400,000 pieces of information a year. Among them, big companies use about 30% of information services, SMEs 25%, research institutions 15% and private citizens make up the rest, as of the end of 1999. Information service users at big companies have been decreasing not only in relative terms but also in absolute numbers for the past 10 years, while use by SMEs and private citizens has increased over the same period. This reflects how R&D activities at SMEs have increased recently and that is plays an increasing role in the age of ICTs. Table 7. shows the growth of such information use.

〈Table 7〉 Numer of Subscribers for Technology Information Users



KINITI also established an information network with foreign information institutions such as the Japan Science and Technology Center (JST), the Canadian Institute for Science and Technology Information (CISTI) and the National Technology Information Services (NTIS). It constructed a cyber information network for SMEs centered on searching for information online. If you click on www.innonet.net, you can get information related to SMEs ranging from finance, technology, marketing, manpower, trade and investment. Most of this information is now delivered via e-mail.

According to KINITI, the most common customer from the industrial sector is from the chemical engineering industry followed by the electrical & electronic industry and then from machinery. The frequency of accessing information reflects the technology intensity of the industries. Technology-intensive industries such as chemical engineering or electrical & electronics more frequently need access to technology information.

This trend will be intensified as the economy become more and more digital. Machinery, energy and construction need less access to technology information compared to other industries even though such industries contributed heavily to industrial and technology development in the past. It seems that machinery, energy and construction technologies were transferred through capital good imports with reverse engineering rather than by searching out and implementing technology information. Table 8. shows the uses of technology information.

KINITI also played a bridging role between technology suppliers and acquirers by providing a technology market. It opened a standing cyber market to bridge the gap between technology sellers and buyers.

Besides KINITI, the government also established various institutions

Table 8. Users of Technology Information by group

(unit: cases, percent)

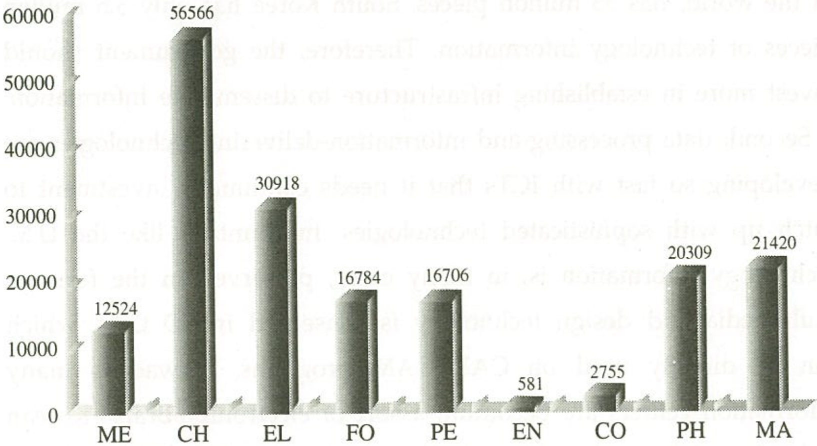
	1990		1999	
	Cases	Proportion	Cases	proportion
Large Firms	247,965	55.1	117,110	29.1
Small&Medium Firms	83,255	18.5	103,486	25.7
Research Institutes	62,554	13.9	64,719	16.1
Private Institution	28,801	6.4	29,195	7.3
Private Citizen	27,452	6.1	87,428	21.8
Total	450,027	100.0	401,938	100.0

Source: Korea Institute for Industrial Technology Information

related to the dissemination of technology information. Under the Ministry of Science and Technology, there was formed a scientific technology information dissemination institution, the Korea R&D Information Center, which was merged with KINITI in 2001. The new name is the Korea Institute for Science and Technology Information (KISTI).

In order to promote technology transfer, it was necessary to make a free market environment to support and expedite the transaction of technology. For this, the government supported to establishment of the Korea Technology Transfer Center (KTTC) through which technology is moved on a commercial basis. Both KINITI and KTTC function as a technology evaluator through their market operations. Table 9. below illustrates the use of technology transfer services by industry.

〈Table 9〉 Uses of Technology Information Services by Industry



Note: ME stands for metal industry, CH for chemical engineering, EL for electric & electronic, FO for food, PE for petrochemical, EN for energy, CO for construction, PH for pharmacy, and MA for machinery industry.

Source: Korea Institute for Science and Technology Information (KISTI)

4. Problems Underlying Information Dissemination

Even though the government tried hard to establish an information infrastructure to expedite the transfer of technology information and technology itself, it was not sufficient or efficient enough to meet the increasing demand for technology in the era of fast growing ICTs. It is expected that there will be increasing demand for technology information from the SMEs. However, among SMEs, less than 20% are regular users of information from organizations like KINITI, though use is growing very rapidly.

Poor use of the technology transfer infrastructure seems to arise for two reasons: supply and demand. According to one study, Korea's capacity to retain technology information is only one tenth that of Japan or the U.S. For example, the JST possesses 27 million pieces of technology and ORBIT of the U.S., one of the biggest data banks in the world, has 35 million pieces. South Korea has only 3.5 million pieces of technology information. Therefore, the government should invest more in establishing infrastructure to disseminate information.

Second, data processing and information-delivering technologies are developing so fast with ICTs that it needs continuous investment to catch up with sophisticated technologies. In countries like the U.S., technology information is, in many cases, preserved in the form of multimedia and design technology is conserved in 3D CDs, which can be directly used on CAD/CAM programs. Nowadays many information centers are becoming a sort of electronic library. Korean technology information dissemination institutions like KINITI lag far behind those in industrialized countries in its technological facilities and capacities.

Third, customers of technology information services need comprehensive custom-tailored services. They need not only technology information but also market, business or legal information that can help solve problems. They need consulting services on business and technology-related problems. Therefore, information dissemination institutions should not only play the role of just dissemination but also create a value-added role by consulting. In this context, the content of information should be improved frequently on a monthly basis in order to meet the sophisticated consumer's demands.

Fourth, the private market for technology information distribution is not well developed. As mentioned above, technology information distribution has been developed by government initiation. Recently, big companies like LG or Daewoo have begun constructing their own data bank. However its capability is yet to be enhanced to compete with government-sponsored institutions like KINITI, notwithstanding competition from foreign institutions.

Fifth, the users of technology information have to be eligible to use the information resources. Many SMEs do not have the capability or labour force to use the technology information provided by the government-supported institutions. The utilization of technology information is not the entire process of developing technology or performing R&D. It is merely one step, closely related to other R&D activities. The government should also invest in labour force training programs in this field.

Last but not least, the digital age has made it easier for information users to search for information. They simply click and visit websites all over the world and search for whatever information they wish to find. They are not satisfied with merely local information unless the local providers have the capability to compete at a global level. The information dissemination institutions must keep abreast with the rapidly changing environment and should be able to compete with foreign information dissemination institutes like the NTIS of the U.S. and the CISTI of Canada to survive in the era of ICTs.

V. Implications for East Asian Economies

1. Different Pattern of Industrial Development in Asia

East Asian countries have a very diverse cultural background, they are at different stages of their industrial development, and have been through many dissimilar development patterns, even though they belong to the same region. There are extremely advanced countries like Japan that coexist with some of the least developed countries. There are enormous countries in size and population, like China, and tiny countries like Fiji. East Asia is very heterogeneous in history, religion, ethnics and culture. There are Islamic countries as well as countries that have Buddhist traditions or Confucian backgrounds.

The development strategies that these countries adopt are also diverse. For example, China is one of the fastest growing countries in the region on the back of an FDI-based strategy, while South Korea has developed in part by inducing foreign capital. Each is similar in that it adopted an outward-looking industrial development strategy, but they are each different in their particular investment policies.

The different development strategies seen in East Asia, particularly those of Korea and China, have led to different patterns of industrialization. Korea has shifted its industrial structure from labor intensive, to capital intensive, to technology intensive. Indeed South Korea was required to follow such a path as it was constrained by few natural endowments and scarce production factors, such as capital and technology. The so-called "flying geese theory" was faithfully applied to Korean industrial development; Korea tried to develop industrial capabilities for itself without delegating power to foreign firms or shareholders.

In the case of China, whose culture is more willing to attract FDI, it was able to overcome the constraints of scarce capital and technology. Beginning by simply attracting FDI, it has developed an industrial structure with high-value added products. The "flying geese theory" does not apply to Chinese industrial development. China could narrow the industrial development gap with Korea and build a similar industrial structure in a short period of time. Many developing East Asian economies, in particular Malaysia, Thailand, Indonesia and Vietnam imitated the industrialization strategy adopted by China.

2. The Role of Technology Information

In the process of development, China also developed technological capabilities through diverse methods of transferring technology. China did not merely rely on capital goods imported through technology transfer but depended on FDI. Even though China still heavily depends on capital goods and on imports from Japan or Korea, technology is more effectively transferred through FDI.

When technology is transferred through FDI, there are usually two stages of technology spill over from the technology-providing country to the receiving country. First, technology is transferred from parent company to subsidiary company. Then it is transferred from subsidiary company to local companies.

More often than not, technology transfer plays no role in the movement from subsidiary company to local companies, especially if there is some sort of technology protectionism on the part of the multinational or negative feelings toward the multinational on the part of the host country. However, in the case of China, there is no negative sentiment either from the investing country or the hosting country and technology is smoothly transferred to Chinese local firms. This kind of smooth transfer of technology arises in other Asian countries too, where FDI policy is a strategy of industrialization.

Even though FDI is a strong vehicle to transfer technology in China and other Asian countries, technology information and its dissemination is still important in enhancing the technological capabilities of these countries. First, technology information plays a significant role when it is transferred from subsidiary companies to local firms in host countries. Usually local firms do not have much information on how to acquire technology. Dissemination institutions should do the clearing-house, or gateway function, of transferring technology information.

Second, even tough China and some Southeast Asian countries are only at the HCT stage of development, they are steadily moving toward ICT-based industries since they can leapfrog intervening stages through FDI. When this happens, the role of technology information is even more significant.

China and Taiwan have government supported technology information centers, such as the JST in Japan and the KINITI in Korea. In case of Taiwan, its institution has more capacity than its Korean counterpart, but the Chinese institution is less capable. It belongs to a government organization and the director is a very high-ranking government official. That means that China recognizes the significance of technology information dissemination and its role in technology and industrial development.

3. Policy Recommendation & Further Studies

The importance and the role of technology information in technology transfer and development have been briefly identified. Despite the significance of technology information, the construction of infrastructure for the facilitation and dissemination of technology information in many East Asian countries is not satisfactory, except for Japan and Taiwan.

The most significant task for Asian governments, including the one in Seoul, is to increase investment in establishing technology information infrastructure. As mentioned before, technologies involved in delivering information are changing so fast that there needs to be continuous investment in the facilitation of information infrastructure.

Second, there has to be an increased effort to share and exchange technology information between countries and within countries. There have been such efforts before but their cooperation was not so intimate or even close enough to satisfy the increasing demand for technology information in the digital economy.

There are, of course, technical barriers in intensifying cooperation. Most technology information users are local SMEs and they need information in their local languages. In many cases, only local information dissemination institutions can meet this need. They should find more ways and means to increase cooperation, particularly to meet the ever more sophisticated customer demand in the digital economy.

Third, intellectual property rights, such as patent, copy and authorship, need to be strictly protected. Information related to intellectual property rights should be transacted on a commercial basis within a legal framework. Illegal transfers of intellectual property and technology information related to this will hinder the development of the technology information distribution market. In addition, the public in each country should well recognize and understand the importance of technology information, that it is really a nerve system of all technology and industry. Without technology information, there cannot be any activities related to R&D and technology transfer would be impossible.

This has been a very sketchy explanation on technology transfer and the role of technology information in the process of technology development in Korea and its implications for East Asia. One should understand that this is just the beginning of the study. Therefore, further study is needed.

First, the relationship between technology information and technology transfer in Korea should be further studied. It is desirable to study the relationship down to each industrial level. The role of technology information in technology transfer and development should be worked out industry-by-industry, particularly focusing on ICT-dependent industries.

Second, various patterns of industrial development and technology transfer among Asian countries should be studied.

Last but not least, regional cooperation for a technology information network between East Asian countries should be studied. In the world of globalization, information networking in the area of technology is crucial for the acceleration of technology and industrial development. For this, Japan or Asian regional institution like the Asia Development Bank should take a leading role.

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