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TECHNOLOGY TRANSFER : THE KOREAN EXPERIENCE

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I. Introduction

I .1. The Purpose and Approach of the Paper

It is often said that many Asian countries have followed the Japanese model of industrial and technology policy. Among these Asian countries, Korea has been regarded as the most faithful follower of the Japanese model. This paper reviews the Korean technology transfer of the past and compares it with the Japanese experience, and points out the similarities and differences between them. It also draws some implications and lessons that may be considered by other Asian countries for developing their own technology transfer strategies.

Technology is transferred through various channels and by many different agents. The paper first reviews these channels and agents, and then a brief comparison between Korea and Japan in technology trade and R&D is introduced. Although various forms of technology transfer are considered, licensing is discussed more often than others in this paper. Since Korea's outward technology transfer is negligible, only inward technology transfer is discussed here. Having reviewed the historical evolution of technology development and transfer, the main features and characteristics of the process are pointed out. In order to gain some insights, technology transfer in the Korean electronics industry is examined in more detail. Finally, the paper discusses the challenges ahead for korea and makes some

suggestions for Korea and other Asian developing countries.

Since a country's technology transfer is affected by the overall industrial and technological policy of the country and by R&D efforts of firms, these factors are also considered in the following review. Although Korea has been fairly successful in its economic growth, its technology policy and performance have not always been as successful. Depite its remarkable achievement in building up its technological capability, there remain many areas which have been neglected and many problems to be solved. In this sense, the Korean case renders not only lessons to assimilate, but also mistakes to avoid.

I .2. Forms and Channels of Technology Transfer

As shown in Table 1, we may consider several forms and channels of international technology transfer. Technology can be transferred between two countries (bilaterally) or among many countries, through international institutions (multilaterally). It can take the form of commercial or non-commercial transactions in public or private sectors. Major channels and means of technology transfer include licensing, FDI, trade of capital goods, and strategic alliances. Technology transfer may take the form of intra-firm transfer, inter-firm transfer, or inter-government transfer. Our main concern in the following review is technology transfer in the private sector on a commercial basis.

〈Table 1〉 Forms of Technology Transfer

Forms			Objcetives	Characteristics	Remarks
Private Sector	Intra-Firm		• Protection of technology • Strengthening subsidiary's competitiveness	• Monopolistic ownership of technology by parent company • Risk of weakening monopoly power of parent company	FDI Internal transaction
	Inter-Firm	Market Type	• Royalty earnings • Direct technology transfer	• Technology markets • Licensing	Commercial transaction
		Non-Market Type	• Utilization of externalities	• Low degree of transfer effects • Technology transfer by contacts	Non-commercial Learning effects
		Alliance	• Utilization of complementary assets	• Cross-licensing, collaborative R&D, co-ownership of technologies • OEM, exchange of complementary assets and function by joint venture, etc.	Quasi-commercial transaction
Inter-Government			• Technology assistance • Collaborative technology development and utilization	• Political objectives • Common use of public welfare-oriented technologies • Human resource development	Non-commercial transaction

Source : Yoo Soo Hong, *Japan's Strategy for Technology Transfer to Asia and Korea's Response*, 1993, p.22.

Firms in Korea acquire foreign technologies mainly through licensing, and the role of FDI is limited. Table 2 is one survey result which confirms this characteristic of the various channels of technology transfer ; licensing accounted for 31.8%, the highest, whereas FDI accounted for only 6.5% in 1991. Many other surveys report similar observations that the role of FDI

in technology transfer to Korea has been negligible. This phenomenon is a result of the strong orientation of Korean entrepreneurs and government toward independent operation of business, which is in turn deeply rooted in the personality of the Korean people and the bitter experience of colonization. However, due to the reasons to be discussed below, the role of FDI will increase in the future, while the importance of licensing will not diminish substantially.

〈Table 2〉 Main Channels for Foreign Technology Acquisition

(%)

	Licensing	Sending Engineers Abroad	Technology Training	Information Associated with Capital Imports	Foreign Direct Investment	Information from Suppliers	Recruit of Overseas Scientists	Others
Electronics	88	66	57	32	15	11	7	0
Electricity	90	71	54	24	20	15	2	10
Machinery	86	66	61	27	18	11	2	5
Chemicals	90	49	53	35	29	10	1	3
Textiles	91	50	63	31	11	12	3	0
Metals	80	61	57	54	20	15	0	0
Ceramics	94	69	50	42	22	8	3	0
Shipbuilding	90	74	74	16	5	11	0	14
Phamaceuticals	22	50	46	68	5	9	9	0
Foods	80	50	67	40	7	10	3	0
Average	88	62	58	34	18	11	3	3
Composition	31.8	22.4	20.9	12.3	6.5	4.0	1.1	1.1

Note : Up to three choices were allowed. Composition is the percentage of each average to the total of averages.

Source : Korea Development Bank, *Effect Analysis of Technology Imports,* 1991, Adapted.

I .3. Comparison of Technology Trade and R&D in Korea and Japan

Japan achieved self sufficiency in technology much faster than Korea in the Post-War period. Both countries imported foreign technologies mainly by means of licensing rather than through foreign direct investment. The ratio of technology payment to indigenous R&D expenditure is an important indicator which characterizes the role of technology transfer. This ratio has been much higher in Korea than in Japan, which implies that Korea has been more dependent upon foreign technologies than Japan, and that Japan has exerted more effort to digest and improve imported technologies than Korea.

In Table 3 we can observe that, in the case of Japan, the ratio of technology import to R&D steadily decreased from 0.10 in 1971 to 0.03 in 1986, and has not changed much since then. The ratio of technology export to R&D has remained in the neighborhood of 0.03. The ratio of technology export to technology import can be regarded as an index of self-sufficiency in technology. The ratio steadily increased to 1.00 in 1989, which implies that Japan achieved self-sufficiency in technology in that year. One should note that Japan, in fact, achieved self-sufficiency in technology much earlier than 1989, if one considers payments for technologies imported in each year only, since the figures in the table include the running royalties for technologies imported in the past.

〈Tabel 3〉 Japan's Technology Trade and R&D

	Tech Imports (¥ billion)	Tech Exports (¥ billion)	R&D (¥ billion)	Tech Imports /R&D	Tech Exports /R&D	Tech Exports /Tech Imports
1971	135	27	1346	0.10	0.02	0.20
1975	169	67	2622	0.06	0.03	0.40
1980	240	160	4684	0.05	0.03	0.67
1981	260	175	5364	0.05	0.03	0.67
1982	283	185	5882	0.05	0.03	0.65
1983	279	241	6504	0.04	0.04	0.86
1984	281	276	7177	0.04	0.04	0.98
1985	293	234	8116	0.04	0.03	0.80
1986	261	224	8415	0.03	0.03	0.86
1987	283	216	9016	0.03	0.02	0.76
1988	312	246	9775	0.03	0.03	0.79
1989	330	329	10909	0.03	0.03	1.00
1990	372	339	12090	0.03	0.03	0.91

Source : Science and Technology Agency, Japan, *Science and Technology White Paper,* Recent years.

Table 4 shows that the ratio of technology import to R&D in Korea remained around 0.23. The ratio of technology export to technology import was close to zero for the entire period, which implies that Korea has been far from achieving self-sufficiency in technology and that Korea has been heavily dependent upon foreign technologies.

Another difference between Korea and Japan, which is not shown in the tables, is the fact that Japan spent more on domestic R&D expenditures to assimilate imported technology than Korea. The amount that Korea spent for assimilation of foreign technology was negligible. Thus, it is not at all surprising to observe that Japan has been greatly successful in commercializing imported foreign technology, whereas Korea has not been so successful.

〈Table 4〉 Korea's Technology Trade and R&D

	Tech Imports ($ million)	Tech Exports ($ million)	R&D ($ million)	Tech Imports /R&D	Tech Exports /R&D	Tech Exports /Tech Imports
1971	6.1	0.0	29	0.21	0.00	0.00
1975	26.5	0.0	88	0.30	0.00	0.00
1980	107.2	6.0	321	0.33	0.02	0.06
1981	107.1	11.8	418	0.26	0.03	0.11
1982	115.7	18.2	611	0.19	0.03	0.16
1983	149.5	16.9	782	0.19	0.02	0.11
1984	213.2	16.8	1008	0.21	0.02	0.08
1985	295.2	11.3	1298	0.23	0.01	0.04
1986	411.0	9.2	1768	0.23	0.01	0.02
1987	523.7	9.1	2370	0.22	0.00	0.02
1988	676.3	8.9	3431	0.20	0.00	0.01
1989	888.6	10.5	3980	0.22	0.00	0.01
1990	1087.0	21.8	4481	0.24	0.00	0.02

Source : Korean Industrial Technology Association, *Major Indicators of Industrial Technology*, Recent issues.

Ⅱ. Historical Overview of Technology Transfer

Ⅱ.1. Evolution of Technology Transfer and Building Technology Capability

A country's technology development is closely related to its industrial development. Table 5 shows the evolutionary stages of industrial development in Korea and its relationship with science and technology development. Technology import is an important vehicle for technology development, particularly in the earlier stages of development. Taking a look at the process of industrialization of Korea, one who is familiar with the his-

tory of industrialization in Japan, Taiwan, and Singapore can easily conclude that the process is very similar among these conuntries with some time lags only.

〈Table 5〉 Outline of Development of Industry and Science and Technology

	Industrialization	S&T Development
1960s	• Develop import-substitution industries • Expand export-oriented light industries • Support producer goods industries	• Strengthen S&T education • Deepen scientific and technological infrastructure • Promote foreign technology imports
1970s	• Expand heavy and chemical industries • Shift emphasis from capital import to technology import • Strengthen export-oriented industrial competitiveness	• Expand technical training • Improve institutional mechanism for adapting imported technology • Promote research applicable to industrial needs
1980s	• Transform industrial structure to one of comparative advantage • Expand technology-intensive industry • Encourage manpower development and improve productivity of industries	• Develop and acquire top-level scientists and engineers • Perform national R&D projects efficiently • Promote industrial technology development
1990s	• Promote industrial structure adjustment and technical innovation • Promote efficient use of human and other resources • Improve information networks	• Reinforce national R&D projects • Strengthen demand-oriented technology development system • Internationalize R&D systems and information networks

Source : MOST, Korea, *Science and Technology in Korea : 1994.*

Technology transfer is not realized in a vacuum, but is affected by many factors such as the economic environment of transferring and receiv-

ing counries, strategies for industrial and technological development, and incentives to those transferring the technology. In the case of Korea, these factors have changed over time, as shown in Table 6. These will be discussed in more detail in the following review of each sub-period. The table also shows an evolutionary pattern of technology transfer, starting from a lower level of imported technology and moving toward a more advanced level.

〈Table 6〉 Environment and Policy for Technology Transfer into Korea

	1960s	1970s	1980s	1990s
Stage of Industrialization	Import Substitution, Basic industry	Heavy and chemical industry	Technology-intensive industry	High tech industry
Characteristics of Industry	Labor-intensive	Capital-intensive	Capital and Technology -intensive	Tecnnology-intensive
Incentives for Foreign Technology Inducement	• Use of labor • Sales to local market	• Technology sales to heavy and chemical industries	• Increased demand for high tech • Joint production by JV	• Increased demand for high tech • Strategic alliances
Technology Policy	• Control of FDI and technology imports	• R&D initiatives of government • Conditional liberalization of technology import	• Encouragement of R&D in private sector • Liberalization of technology and capital imports	• Encouragement of R&D in private sector • Liberalization of technology and capital imports

Source : Compiled by the author.

Like the case of industrialization, Korea's pattern of technology transfer over time is very similar to that of Japan, although Japan took a much

longer period for its earlier stages which ended before World War II. We may generalize a country's evolutionary pattern of technology transfer. A country starts as an imitator of foreign technologies. As experience in utilizing technologies is accumulated and the economy develops, it achieves self-sufficiency in technology, and if everything goes well, eventually it becomes a net technology exporter.

As pointed out earlier, Korea has relied heavily on imported technology. By importing and utilizing foreign technologies and building up its technological capabilities through learning by doing, Korea exploited the late-comer advantage.

During the early stages of industrialization, the major means of technology transfer were the import of capital goods and turnkey plants, and technology transfer through FDI and foreign licensing was quite limited. Table 7 shows that imports of capital goods consistently far surpassed other means of technology transfer in terms of value. However, one should not have the false perception that capital goods are the same as technologies. Only a portion of a capital good is embodied technology. Since we cannot separate the technology portion from a capital good, we cannot measure the amount precisely. FDI shares a similar problem for not being able to distinguish the technology portion. In the beginning of the 1980s, the Korean government liberalized its FDI policy as a way of inducing more sophisticated foreign technologies. Technology transfer through foreign licensing increased dramatically in the 1980s to become the most im-

portant means of technology import. Although Korea and Japan share similarities in many aspects of technology transfer, Japan has been less dependent upon capital imports than Korea for its technology transfer.

〈Table 7〉 Foreign Technology Transfer by Form to Korea

($ million)

	1962~66	1967~71	1972~76	1977~81	1982~86	1987~91
Foreign direct investment	47.4	219.0	879.4	720.9	1,767.6	5,636.0
Foreign licensing	0.8	16.3	96.5	451.4	1,184.9	4,359.4
Technical consultation	-	16.8	18.5	54.7	332.3	1,349.7
Capital goods import	316	2,541	8,841	27,978	44,705	52,155

Source : Ministry of Finance, Ministry of Science and Technology, and Economic Planning Board, *The Major Statistics of the Korean Economy,* Various issues.

II.2. Development of labor-intensive Industries

Korea began its industrialization in the early 1960s. During the 1960s Korea implemented its first (1962~1966) and second (1967~1971) five-year economic plans. The industrial development strategy adopted during this period was to develop import-substitute industries such as the cement, fertilizer, oil refinery, and steel industries and, at the same time, to develop export-oriented light industries such as textiles, plywood, and processed agricultural products. Although Korea had a comparative advantage in inexpensive but skilled labor, it had neither indigenous technological capability nor sufficient domestic savings to establish and operate production fa

cilities and plants. In order to overcome the problem of insufficient domestic savings, the country began to borrow foreign savings. The strategy of industrialization in this earlier stage was to combine foreign capital and technology with domestic low-cost, high-skill labor. Instead of FDI, loans were preferred for foreign capital. For the payment of these loans, Korea had to earn foreign reserves, which made Korea adopt an outward-looking industrialization policy. Export-led outward-looking strategy placed pressure on firms to acquire foreign technology and use it effectively in order to be able to compete in the world market. Without local capability to establish and operate production systems, Korean entrepreneurs had to rely heavily on imported technolgy. These technologies were in general rather simple technologies in their mature stages and learning by doing through reverse engineering was relatively easy.

In order to minimize the cost of obtaining foreign technology and to maintain Korea's technological independence from the dominance of multinationals, the Korean government had very restrictive policies toward FDI. As shown in Table 2, technical assistance from capital suppliers and independent consultants played an important role in helping Korea's learning by doing. This was possible because of the highly trained human resources and entrepreneurship potential in Korea. Korea has heavily invested in human resource development since the Korean War. Korea's human resources became an important foundation for subsequent industrialization by enabling the rapid adoption of imported technology

and reverse engineering of foreign products.[1)]

The choice of appropriate technology and assimilation required a minimum level of indigenous R&D capability. For the building up of scientific and technological infrastructure, the Ministry of Science and Technology (MOST) and the Korea institute of Science and Technology (KIST) were established in the 1960s. Also, the Science and Technology Promotion Law, providing a legal basis for various promotion measures, was inacted.

II.3. Development of Capital-intensive Industries

In the 1970s, the industrial strategy shifted toward the development of heavy and chemical industries, improving the process of technology assimilation and promoting research to meet industrial needs. These industries included shipbuilding, iron and steel, electrical and non-electrical machinery, petrochemicals, etc. Unfortunately, the first and second world oil shocks and the following recessions drastically curtailed the demand in the world market for capital goods, and the Korean economy suffered from heavy losses in valuable capital due to under-utilization of untimely constructed plants and infrastructures. Korea overcame these problems by penetrating into the Middle East and postponing some planned investments.

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1) Kim, Linsu and Dahlman, C.J., "Technology Policy for Industrialization," *Research Policy,* 21, 1992, pp 437~452.

Since these industries were still incapable of developing their own R&D, the government and government-sponsored research institutes played a key role in the establishment of domestic R&D capability. Learning from the experience and example of KIST, about 10 government-sponsored research institutes in the areas of machinery, electronics, chemistry, shipbuilding, etc., were established. These research institutes focused on the development and dissemination of industrial technology.

During this period, the government conditionally liberalized technology imports which had been under its strict control and scrutiny. It was inevitable for Korea to at least partially liveralize its technology transfer and FDI policy in order to assist the development of heavy and chemical industries, which required more sophisticated foreign technologies. At the same time, the government imporoved institutional mechanisms for increasing indigenous technological capability.

II.4. Development of Technology-intensive Industries

The decade of the 1980s was characterized by structural adjustments and technology-intensive industrial development. Over-investment in the capital-intensive heavy and chemical industries required contractive structural adjustments in these sectors. A rapid increase in real wages and labor disputes forced firms to seek technological innovation as a solution. Protectionism in developed countries not only forced Korea to open protected domestic markets toward major trading partners, but also constrained

transfers of advanced technologies from those countries to Korea. The gradual opening of domestic markets forced Korean firms to enhance their technological capabilities through foreign technology transfer and their own R&D. Korean industries required high technologies in the areas of micro-electronics, telcommunications, bioengineering, environment, etc. These sophisticated technologies were not easy to import due to the constraints placed by advanced countries aiming to rapidly develop technology-intensive industries of their own.

Korea's Science and technology policy during this period has emphasized localization of key strategic technologies, development of high caliber technological manpower, and promotion of private sector R&D capabilities. The special National R&D Program started in 1982 is one of the most ambitious policies ever adopted by the government.

The Korean government tried to induce more advanced technology through FDI by liberalizing its FDI policy. The "positive list" (listing industries open to FDI) system was replaced by the "negative list" (listing those that were closed) system. The notification system was introduced in 1991. Domestic incentives such as more favorable tax-exemptions, special free tax zones for high-tech FDI, and off shore financing are now provided according to the recent revision of the FDI policy. Also, Korea's intellectual property laws were recently revised to recognize both material and process patents and protection of IPRs has been enforced. This policy shift had increased the demand for technology transfer through FDI.

Ⅲ. Main Features and Characteristics

Ⅲ. 1. Trends in Technology Transfer

Reflecting the rapid economic growth of Korea, technology transfer from foreign countries continued to increase until the end of the 1980s. However, technology imports declined over three consecutive years, 1990 ~1992, due to a domestic recession and increased technology protectionism by developed countries. Technology imports have been increasing again since 1993, which implies that Korea is coming out of the recession and has improved its relationship with developed countries to induce more advanced technologies from them. Table 8 shows the recent trends in technology imports.

〈Table 8〉 Annual Technology Imports of Korea

	1987	1988	1989	1990	1991	1992	1993
Cases	637	751	763	738	582	533	707
	(23.2)	(17.9)	(1.6)	(-3.3)	(-21.1)	(-8.4)	(32.6)
Amount	523.7	676.3	888.6	1,087.0	1,183.8	850.6	946.4
($ million)	(27.4)	(29.1)	(31.4)	(22.3)	(8.9)	(-28.1)	(11.3)

Note : ( ) denotes annual rate of increase.

Source : Korea Industrial Technology Association.

Korea imported most its technologies from the U.S. and Japan. For example, as shown in Table 9, technology imports from the U.S. amounted

to $418.4 million for 224 cases in 1993, and those from Japan amounted to $352.9 million for 285 cases.

If we compute the amount per case for the U.S. and Japan respectively, we find that the former is much higher than the latter, which implies that more high-technologies seem to have been imported from the U.S. than from Japan.

〈Table 9〉 Korea's Technology Imports by Country

($ million)

	U.S.	Japan	Germany	France	England	Total
1988	330.0	214.7	22.1	47.9	15.6	676.3
	(200)	(354)	(49)	(47)	(20)	(751)
1989	415.7	273.9	52.8	39.9	34.3	888.6
	(244)	(343)	(37)	(41)	(23)	(763)
1990	514.1	341.4	59.3	29.9	44.7	1,087.0
	(221)	(333)	(55)	(25)	(28)	(738)
1991	622.2	372.5	60.1	48.9	23.3	1,183.8
	(165)	(277)	(35)	(26)	(25)	(582)
1992	452.5	266.2	27.1	56.1	15.8	850.6
	(163)	(232)	(26)	(18)	(30)	(533)
1993	418.4	352.9	53.3	32.6	30.4	946.4
	(224)	(285)	(31)	(23)	(36)	(707)

Note : ( ) denotes the number of cases, and the total is the sum of the countries including other countries not shown in the table.

Source : Korea Industrial Technology Association.

Table 10 shows the shares of major technology exporters to Korea for the past three decades. The above observation that the U.S. seemed to have transferred more advanced technologies is valid for the entire period.

Furthermore, we can observe that the U.S. ranked first in terms of the amount of technologies imported, whereas Japan ranked first in terms of the number of cases.

〈Table 10〉 Share of Technology Imports by Country

(%)

		1962~86 Average	1987	1988	1989	1990	1991	1992
U.S.	Cases	24.2	28.3	26.6	31.9	29.9	28.3	30.5
	Amount	45.2	45.8	48.9	46.8	47.3	52.6	53.2
Japan	Cases	54.2	48.2	47.1	44.9	45.1	47.5	43.5
	Amount	30.1	34.6	31.7	30.8	31.4	31.5	31.3
Germany	Cases	5.3	5.5	6.5	4.8	7.5	6.0	4.9
	Amount	4.1	3.6	3.3	5.9	5.5	5.1	3.2
England	Cases	3.5	3.3	2.7	3.0	3.8	4.3	5.6
	Amount	-	-	2.3	3.9	4.1	2.0	1.8
France	Cases	3.2	6.3	8.8	5.4	3.4	4.5	3.4
	Amount	2.9	4.8	7.1	4.5	2.8	4.1	6.6
Others	Cases	9.6	8.4	8.3	10.0	10.3	9.4	12.1
	Amount	17.7	11.2	6.7	8.1	8.9	4.7	3.9

Note : Before 1988, the royalty payments to other countries included England.

The leading sector in technolgy imports had been the electronics industry. Table 11 shows that the industry ranked first in terms of the amount and the number of cases since the second half of the 1980s. The electronics industry is followed by the machinery sector. Third was chemicals. These figures roughly reflect the industrial structure and relative importance of industries in Korea.

〈Table 11〉 Technology Imports by Industry in Korea

($ million)

	Food	Textiles	Chemicals	Metals	Electronics	Machinery	Others	Total
1962	21.7	49.6	345.6	92.9	441.8	450.7	347.7	1,750.0
~86	(146)	(206)	(796)	(293)	(909)	(1,272)	(460)	(4,055)
1987	4.3	8.3	65.4	12.0	197.2	131.3	105.2	523.7
	(24)	(37)	(135)	(31)	(164)	(161)	(85)	(637)
1988	5.2	8.3	112.1	6.0	265.0	126.8	152.9	676.3
	(15)	(52)	(161)	(26)	(212)	(195)	(90)	(751)
1989	8.9	13.2	151.5	10.5	388.4	156.9	159.2	888.6
	(22)	(56)	(150)	(23)	(231)	(168)	(113)	(763)
1990	9.5	14.5	217.1	8.6	467.7	232.6	137.0	1,087.0
	(18)	(44)	(138)	(21)	(219)	(188)	(110)	(738)
1991	14.4	25.2	187.2	6.9	472.6	358.0	119.4	1,183.7
	(16)	(37)	(105)	(13)	(178)	(163)	(70)	(582)
1992	8.8	23.7	110.8	9.2	450.6	131.2	116.3	850.6
	(12)	(18)	(73)	(12)	(194)	(177)	(47)	(533)
Total	72.8	142.8	1,189.7	146.1	2,683.3	1,587.5	1,137.7	6,959.9
	(253)	(450)	(1,531)	(419)	(2,107)	(2,324)	(975)	(8,059)

Note : ( ) denotes the number of cases.

Source : Korea Industrial Technology Association.

Ⅳ. The Case of the Korean Electronics Industry

Ⅳ.1. A Brief History of the Industry

It is of much interest to review the development of the Korean electronics industry in order to better understand the pattern and role of technology transfer due to the following reasons. First, the electronics industry is the leading manufacturing sector in Korea, and it imported more foreign technologies than any other sector. Second, the industry demonstrates well

the main features of technology in Korea, both strengths and shortfalls.

Most firms in the industry in the 1960s were either manufacturers of simple home electronics such as radios and black-and-white TV sets or OEM suppliers for foreign firms. The growth and success of the industry, an obvious late-comer, during the past three decades is remarkable. Between 1985 and 1993, the Korean electronics industry grew at an average rate of 23.2 percent per year as shown in Table 12. Consumer electronics is the major subsector of the electronics industry. The industry has displayed remarkable progress in terms of both product quality and diversification. During its early stages in the 1960s and 1970s, the Korean consumer electronics industry focused mainly on assembling foreign parts, usually for radios and black-and-white TV sets. During the 1980s, however, the Korean consumer electronics industry has diversified its technological capabilities to such products as color TV sets, microwave ovens, compact disk players, camcorders, and digital audio tapes. The industry has shifted from consumer-oriented production to industrial production with technology-intensive processes. Today, Korea is the third largest producer and exporter in the world of consumer electronics. In 1970, Korea sold merely $55 million worth of electronics to the world market. By 1993, that figure has skyrocketed to $22.2 billion, over 6 percent of the world market. Despite growing trade restrictions by the U.S. and other developed countries, personal computers and VCRs made in Korea now occupy an impressive share of their respective markets all around the globe, with exports representing more than three-quarters of total production.

〈table 12〉 Status of the Electronics Industry in Korea

($ million, %)

	1970	1980	1985	1990	1991	1992	1993	Annual Growth rate (1985~93)
Production								
GNP(A)	8,800	60,500	83,100	242,300	281,700	294,500	328,700	18.8
Electronics(B)	106	1,179	8,460	29,711	33,104	33,407	36,465	23.2
Consumer El.(F)	-	1,475	3,586	10,261	11,054	10,545	11,198	15.3
B/A	1.2	5.3	10.2	12.3	11.7	11.3	11.1	-
C/A	-	2.4	4.3	4.2	3.9	3.6	3.4	-
C/B	-	46.4	42.4	34.5	33.4	31.6	30.7	-
Exports								
Total Exports(D)	835	17,505	30,283	64,016	71,870	76,632	82,236	13.3
Electronics(E)	55	2,055	4,532	17,215	19,334	20,683	22,226	22.0
Consumer El.(F)	-	1,036	1,839	5,529	6,054	5,966	6,253	16.5
E/D	6.6	11.7	15.0	26.5	26.9	27.0	27.0	-
F/D	-	5.9	6.1	8.5	8.4	7.8	7.6	-
F/E	-	50.4	40.6	32.1	31.3	28.8	28.1	-

Note : 1) Since GNP is value added and electronics is sales, the ratios in the table should be carefully interpreted.

2) Amounts and growth rates are based on current prices.

Sources : Bank of Korea, Electronic Industries Association of Korea.

IV.2. Foreign Investment and Licensing

It goes without saying that foreign capital and technology have played an important role in the development of Korea's industries. More than most of Korea's other developing industries, the consumer electronics industry has relied quite substantially on foreign investment, typically in the form of OEM agreements. Korea possessed very little indigenous technolo-

gy in the area of consumer electronics during its early stages. At the same time, however, its workers porvided a reliable and cheap source of labor for foreign (usually American and later Japanese) companies. Under its export-led growth strategy, Korean electronics manufacturers had no choice but to heavily depend on OEM agreements to provide both technology and access to overseas markets. With a limited technology base, negligible brand recognition overseas, and no international marketing presence, there were few alternatives for the industry.[2)]

Although many of these early agreements initially did not provide much opportunity for the transfer of electronics technology to Korea, a very limited amount of technical know-how was gained and diffused through the Korean electronics industry. The contribution of foreign firms to the production and exports of the Korean electronics industry has declined over time, although they still maintain significant shares in electronics production and exports as shown in Table 13. Firms with foreign capital produced 15.9 percent of total domestic consumer electronics production and exported 25.5 percent of all Korean electronics exported in 1982. However, their shares in 1990 were 6.0 percent and 9.2 percent, respectively. The production share of local firms increased from 84.1 percent to 94.0 percent, and the export share increased from 74.5 percent to 90.8 percent during the same period.

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2) Bloom, Martin, *Technological Change in the Korean Electronics Industry,* 1992, p.13.

〈Table 13〉 Share of Production and Export of Consumer Electronics by Type of Company in Korea

(%)

	1982		1985		1990	
	Production	**Export**	**Production**	**Export**	**Production**	**Export**
Local Firms	84.1	74.5	88.9	83.2	94.0	90.8
Joint Ventures	4.9	6.1	5.4	7.7	4.8	6.0
Foreign Firms	11.0	19.4	5.7	9.1	1.2	3.2

Source : Electronic Industries Association of Korea.

The Korean electronics industry has been heavily dependent upon licensing from foreign firms. One constructive case study can be seen in the licensing agreements between Phillips and several Korean companies to manufacture compact disk players. Since Korean electronics corporations possessed most of the technical background to produce such products, and since Phillips, itself, was a major producer of compact disk player deck mechanisms, Phillipsn licensed the remaining technology to ten Korean corporations for unrestricted production of compact disk players. Likewise, when Hitachi wished to shift its own focus from 1M DRAM microprocessors to 4M DRAM microprocessors, it licensed the technology and provided technical assistance to Goldstar to produce 1M DRAM microprocessors. This allowed such corporations to improve their technological base even further. Such technological transfers have proved to be mutually beneficial for both Korean companies and for Phillips and Hitachi, respectively.[3)]

The semiconductor industry, a subsector of the industrial electronics

3) These cases are borrowed from Hong, Yoo Soo, "Leveraging Technology for Strategic Advantage in the Global Market : Case of the Korean Electronics Industry." 1993.

industry, is the most successful within the Korean manufacturing sector. It began assembling discrete devices in the 1960s. Having taken over many foreign subsidiaries and joint ventures, local semiconductor producers heavily invested in DRAM facilities to meet growing domestic and foreign demand during the 1980s. Semiconductors are now Korea's largest single export item. Korea accounted for 35 percent of world 4M DRAM production in 1993, and is expected to account for 40~50 percent of world 16M DRAM production in 1994.

The industry's technology level for discrete and memory devices has nearly reached the same level as advanced countries. Table 14 shows the breath-taking development of Korean DRAM technology over the past 10 years. This vividly demonstrates the possibility for a developing country to catch up with advanced countries in the technology race, if the country satisfies certain conditions.

〈Table 14〉 Korean DRAM Technology Gap

	64K DRAM	256K DRAM	1M DRAM	4M DRAM	16M DRAM	64M DRAM
• Developed Country	1979	1982	1985	late 1987	early 1990	late 1992
• Korea	1983	1984	1986	early 1988	middle 1990	late 1992
Gap	4years	2years	1year	6months	3months	same

Source : The Ministry of Trade, Industry and Energy.

IV.3. Strategic Alliances

Most Korean electronics manufacturers established strategic alliances

with major manufacturers in developed countries, in particular the U.S. and Japan. Strategic alliances aim to utilize partners' complementary assets, resources, and markets in order to enhance comparative advantages.Among the many forms, strategic technological alliances are the most prevailing. The semiconductor industry is the most active subsector in the Korean electronics industry for strategic alliances. The technological capability of the sector is demonstrated by the fact that Samsung, Gold Star, and Hyundai set up

〈Table 15〉 Korean-U.S. Semiconductor Technology Alliances

Korean Firms	U.S. Firms	Memory	Non-Memory	Others
Samsung	Micron	T, E		
	Intel	T, M	T, S	
	TI	T, E		JV in Portugal
	HP	M	T, R	
	IBM	M, T		
	AT&T	T	T	
	HMS			Assumption of new device (GaAs, etc.) business
	AMT, Varian			Joint development of 8" equipment
Gold Star	AT&T	T, E		
	AMD	T		
	Motorola	M		
	Zilog		S	
Hyundai	TI	T, M		
	Intel	M		
	GI	M		
Daewoo	Zilog		T, E	
Anam	TI	M(Assembly)		
	AMD			Merging a Phillipino factory
	Motorola			Licensing

Note : T=Technology Transfer, M=OEM, E=Joint Venture, R=Joint Development, S=Second Sourcing

Source : Samsung Electronics

16M DRAM production systems in 1993, and that Samsung developed 256M DRAM chip technology in 1994. Table 15 (Table 16) summarizes major strategic alliances between Korean and U.S. (Japanese) semiconductor producers. All forms of strategic alliances such as technology transfers, OEM, joint ventures, joint R&D, second sourcing, etc. have been established.

〈Table 16〉 Korean-Japanese Semiconductor Technology Alliances

Korean Firms	Japan Firms	Memory	Non-Memory	Others
Samsung	Toshiba	R, T		
	Sharp	T		
	NTT	T		
	Fujitsu	T		
	Oki	T		
	DNS			E (Facility)
Gold Star	Hitachi	T, M		
Hyundai	Sharp	T		
	Ricoh	M		
	Fujitsu	M		
	TI Japan	M		

Note : T=Technology Transfer, M=OEM, E=Joint Venture, R=Joint Development,
Source : Samsung Electronics

As shown in Table 17, strategic alliances in the electronics and communications sectors are characterized by the involvement of large firms. This is a common feature in Korea, where big conglomerates are the industrial leaders.

Since more than 90 percent of strategic technological alliances are formed between and among large firms in developed countries, the opportunities for Korean firms to exploit this new strategy may be limited.

However, the number of strategic technological alliances is expected to continue to increase in the future due to the following reason. First, the ever shortening technology life cycle and the increasing risks and costs of R&D encourage strategic technological alliances. Foreign firms can utilize the technology drive of the Korean government and R&D investments of conglomerates in Korea. Second, firms in developed countries sometimes want to establish strategic alliances with firms in countries such as Korea, Singapore, Taiwan, etc. in order to utilize specific local merits or to use them as complementary alliances. Third, Korea can be utilized as a foothold for expanding business to the rest of Asia, and Korea's market itself is attractive to foreign firms.

〈Table 17〉 Strategic Alliances in Electronics and Telecommunications Industries

	Korean Firm	**Counterpart**
VAN	Samsung	IBM
	Hyundai	AT&T
	PosData	Compuserve, Sprint, etc.
	Ssangyong	Telenet
	Samsung	NEC
	Dacom	Infonet
	Gold Star	EDS
Telecom System	Dae Woo	Northern Telecom
	Kolon Data	AT&T
	Gold Star	NEC
	Samsung	Rolm
	OTELCO	Ericson
	Hyundai	Fujitsu
Computers	Samsung, Gold Star, Hyundai Dae Woo, Trigem,	Sun (Licensing)
	Samsung	HP
	Dae Woo	MIDS

Source : Compiled from company data.

IV.4. Technological Level of the Korean Electronics Industry

At least until the mid-1980s, low labor costs and favorable foreign exchange rates made local consumer electronics very price-competitive on the international market, even though they were made with foreign key parts and based on foreign technologies. But comparative labor cost advantages have eroded recently. Therefore, the development of technology is the most crucial issue for the Korean electronics industry, and the key to future success lies in extensive research and development. The level of technology in the Korean electronics industry nearly matches that of developed countries in terms of generalized products. However, Korea falls behind in both basic engineering and in the production of parts and materials. Fundamental technologies for designing and producing new products are also inferior to those in developed countries.

As of 1991, Korean video and audio equipment producers lagged behind their counterparts in advanced countries by a span of 2~4 years in the development of new products ; however, this gap widens to 5~7 years for the development of high-tech products for the next generation. Table 18 shows the technology gap in this area between Korea and Japan.

〈Table 18〉 Comparison of Product Development Year between Korea and Japan

(year)

	Existing Product					Next Generation Product			
	Color TV	VTR	Camcorder	Super TV	1M DRAM	HDTV	D-VTR	CD application	64M DRAM
Korea	1974	1980	1987	1987	1986	1993	1996	1996	1992
Japan	1960	1975	1984	1982	1983	1984	1989	1989	1992
Gap (year)	14	5	3	5	3	9	7	7	0

Source : Ministry of Trade and Industry.

Since the 1980s, Korean video and audio manufacturers have relied on receiving up to 80 percent of their technology from foreign sources, especially from the United States and Japan. As a result, localization of parts and components is still extremely low considering that Korea is on the verge of joining the ranks of the advanced countries in the immediate future.[4] Against these drawbacks, Korean electronics producers are striving to realize technological self-reliance in order to enhance their international competitiveness. Korea has still a long way to go to achieve self-reliance in the area of electronics technology. However, one cannot deny that it has already made remarkable progress in the indigenization of foreign technologies.

Ⅴ. Implications and Challenges

V.1. Implications

Without technology transfer, it may be very difficult for a developing country to build up its technological capability and, in turn, it may be difficult to effectively utilize imported technology without indigenous technological capability. That is the essence of the Korean experience. It is also true that, almost as a prerequisite to acquiring technology through

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4) Korea Development Bank, "The Current Status and Prospects of the Consumer Electronics Industry in Korea," *Quatterly Industrial Review,* Sept. 1991, p.10.

advantageous arrangements, it is essential for a receiver of technology to have already developed at least a minimum level of indigenous technology.

Having strived to enhance their indigenous technological capability, Korean firms are now in a position to leverage their newly-acquired indigenous technology for more strategic arrangements of technology transfer. This success can be attributed to the government's efforts to develop Korea's technological base and to the efforts of corporations in the private sector. A statistical overview of these efforts is shown in Table 19.

〈Table 19〉 Major R&D Indicators in Korea

	1970	1975	1980	1985	1990	1991
R&D Expenditures(Bil. Won)	10.5	42.7	282.5	1,237.1	3,349.9	4,158.4
Gov't Sources(Bil. Won)	7.5	28.5	180.0	306.8	651.0	815.8
Private Sources(Bil. Won)	3.0	14.2	102.5	930.3	2,698.9	3,342.6
Gov't VS. Private	70.3:28.7	66.7:33.3	63.7:36.3	248:75.2	19.4:80.6	19.6:80.4
Manufacturing(Bil. Won)	1.3[a]	12.3	81.4	751.0	2,374.5	2,965.6
R&D/Sales	n.a	0.39[b]	0.50	1.51	1.96	2.02
R&D/GNP	0.38	0.42	0.77	1.58	1.95	2.02
Number of Researchers[c](Persons)	5,628	10,275	18,434	41,473	70,503	76,252
Gov't/Public Inst.(Persons)	2,458	5,308	4,598	7,154	10,434	10,529
Universities(Persons)	2,011	2,312	8,695	14,935	21,332	20,680
Private sector(Persons)	1,159	2,655	5,141	18,996	38,737	45,043
R&D exp./researcher(Mil.Won)	1.9	4.2	15.3	29.8	47.5	54.5
Research/1,000 Population(Persons)	0.18	0.29	0.48	0.10	1.64	1.76
Number of Corporate R & D laboratories(EA)	n.a.	n.a.	54	170	1,201	1,435

Note: a 1971 figure b 1976 figure

c The figures do not include research assistants, technicians, and other supporting personnel.

Source: Korea Industrial Technology Association, *Major Indicators of Industrial Technology,* 1993.

In order for a developing country to avoid technological dependence, technology transfer must be successfully managed. Yet, the conditions for such successful technology transfer are difficult to come by due to many circumstances, including a lack of willingness on the part of foreign firms. As shown in the case of the Korean consumer electronics industry, the development of a country's own indigenous technological infrastructure is a crucial step in the expedient arrangements for favorable technology transfer between technologically-advanced and technologically-developing countries. Without earnest and successful efforts to develop the indigenous technological capability of a developing economy, even the most well-intentioned and altruistic arrangements for technological transfer are likely to be unproductive in the long run. With such an infrastructure, however, the developing country gains leverage in securing increasingly advantageous agreements with foreign firms, which often results in the further transfer of technology.

V.2. Korea and Japan in Comparison

In general, a developing country tries at first to develop its industries and economy by acquiring rather low-level matured technologies from developed countries. Then, as the economy takes off and technological capability is strengthened, the country absorbs and improves medium-level technologies imported from developed countries. At the same time, it starts to increase technology exports. Eventually, as it joins the group of

developed countries, it becomes a net technology exporter. Korea and Japan followed this general pattern. However, there are several differences between the two countries from the earlier stage of technology imports.

First, by World War II, Japan had accumulated a reasonable level of technological capability. This enabled Japan to digest, absorb, and improve more effectively technologies imported after World War II. In contrast, Korea, without any such basis, had to hastily use imported technologies for production, neglecting further digestion or improvements.

Second, whereas Japan developed a cooperative industrial structure between large firms and small firms for production and technological development, Korea mainly developed large firms and has been heavily dependent upon these conglomerates for technological development, which has caused structural imbalances. Thus, Korea lacks the fundamental technological basis which may have been offered by small and medium firms.

Third, whereas Japan has been successful in technology dissemination through administrative guidance and other measures, Korea did not pay much attention to this, which has resulted in under-utilization of imported technologies.

Fourth, there are many differences in the process of liberalization of technology transfer. Whereas Japan started the liberalization after having built up its self-sufficient technological capability, Korea was pressured to liberalize technology transfer before it was sufficiently ready to do so.

Fifth, there are differences in the kinds of technologies imported. For example, Korea imported technologies for consumer goods such as medi-

cine, food, cosmetics, etc. in the 1960s. However, during the same period, Japan imported leading technologies such as transistors, nylon, black-and-white color TVs, and technologies for heavy industries such as iron and steal, shipbuilding, etc. When Korea exported $10 billion in 1977, it imported 920 cases of technology. However, Japan imported 9,862 cases of technology when it exported $10 billion in 1967.

Sixth, Korean firms placed more effort into sales competition after production with simple imported technologies, while Japanese firms placed more effort into the digestion and improvement of imported technologies. For example, Japanese firms on average used three dollars to improve one dollar's worth of imported technology during 1957~62. Expenditure for digestion of imported technology was twice as much as that for domestic R &D per case during the same period.

Finally, a favorable situation for Korea was that it had more sources of foreign technologies than Japan did when it started to import foreign technologies. Whereas Japan acquired most of its technologies from the U. S., Korea could obtain technologies from both the U.S and Japan.

In sum, whereas Japan has followed a sound technological development path, Korea has adopted a riskier approach under the time pressure.

V.3. Challenges Ahead

Although Korea has been fairly successful in its technological development, some problems or drawbacks should be pointed out for its future.

First, the most serious problem faced by Korea is the structural imbalance between large firms and small firms. It is an irony that Korea can produce world-class semiconductors while it suffers from high rates of defects in the production of rather matured technolgies. This is mainly due to the underdevelopment of small- and medium-sized firms and the insufficient technological capability of these firms. Without a sound basis for fundamental technologies of small firms, further development of the Korean industry will be hampered.

Second, although Korea has achieved remarkable progress in some high technologies and has masteted mature manufacturing technologies, it lacks self-sufficiency in core technologies for essential parts and sophisticated industrial equipment. Also, Korea lacks the design capability for many sophisticated products. Heavy dependence on foreign technologies for core parts causes two problems : worsening terms of trade of these technologies against Korea due to the expansion of technology protectionism by advanced countries, and crowding out of domestic R&D efforts.

Third, despite a great amount of R&D investments, R&D productivity is low in general, and dissemination and spill-over effects are also very limited. Thus, a more efficient national R&D system is an urgent necessity in order to maximize the effects of R&D.

Fourth, many governments in the world today have been strengthening their industrial technology policies to enhance international competitiveness. However, under the WTO and the new international technology order, protection of IPRs and limits against government subsidies for in-

dustrial R&D will be serious challenges to Korea. As Korean firms elevate their R&D activities, encouragement of technology transfer between firms through the market mechanism and the increase of strategic alliances will be some solutions to these challenges.

In sum, Korea is at a crossroad, having to decide whether it will pay more attention to the solution of domestic drawbacks or whether it will continue to only look outward without addressing its structural problem.

Ⅵ. Concluding Remarks

A difficult decision for a developing country to make is whether to follow a longer but more sound path like the Japanese model, or to follow a faster but much riskier path like the Korean model as we have reviewed so far, in order to successfully catch-up with developed countries in the area of technology.

A slower path implies support for and development of small- and medium-sized firms to build a sound foundation of fundamental technologies, which will in turn contribute to the building up of indigenous technological capability in key industrial sectors. This is analogous to Aesop's fable of "The Hare and the Tortoise". In the long run, this slower path strategy may turn out to be better. However, in my opinion, an increasing number of late-comers will choose a path similar to that of Korea as technological cycles become shorter and shorter and R&D costs skyrocket.

The experience of Korea renders, first and foremost, the lesson that a

nation must develop its own indigenous technological capabilities in order to gain leverage in much more advantageous technological transfer arrangements. Second, the government must play an active role in building science and technological infrastructure. However, technological innovation should be initiated by the private sector, fully utilizing the infrastructure provide by the government. Finally, a well-educated work force and a relatively stable political climate are needed for the development of such an indigenous technological infrastructure.[5)]

As for Korea, its future is uncertain. The country has yet to attain cutting-edge status in core technologies in major fields. Nevertheless, if the past is any indication of the future, Korea has the potential to catch up with advanced countries at least in some niche areas. Accurately predicting the future is impossible. However, the Korean experience can offer hope to developing countries working to develop key technology-based industries by developing an indigenous technological infrastructure.

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5) Hong, Yoo Soo, "Leveraging Technology for Strategic Advantage in the Global Market : Case of the Korean Electronics Industry", P.24.

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