TECHNOLOGICAL ADAPTATION AND INNOVATION IN NEWLY INDUSTRIALIZED COUNTRIES: THE CASE OF KOREA

by

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ABSTRACT

This thesis discusses the pattern of technological progress from the perspective of less developed countries. This path of technological development is different from the pattern of technological development in developed countries.

In examining technological progress in less developed countries, I provide an overview of technological development in Korea. Korea has successfully achieved the adaptation of imported technology and is now capable of developing indigenous technology.

The research has been done based on articles, books, and journals, attending seminars, meeting scholars, and visiting research institutes in Korea and the United States.

A less developed country tends to progress in its technological capability through three stages of development: acquisition & implementation, assimilation, and improvement. In order to achieve technological progress, there are some critical elements. For example, the educational level of labor, the industrial infrastructure, the receptiveness of management skills, entrepreneurship, and government industrial policy appear to be important factors in contributing to technological progress.

At the same time, as a country progresses from the early stages of development to the later stages of development, it seems that a country needs to develop higher levels of indigenous technology. Competitiveness and comparative advantage change from labor intensive to capital and technology intensive products, and the importation of high-technology tends to be made difficult by increasing protection of intellectual property rights and increasing competition of existing products in the global market.

This research will hopefully provide lessons for other developing countries for their technological development in the process of industrialization. Although the case of Korea shares common features with other developing countries, the implementation of technology policy should depend on the specific condition of a particular country.

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INTRODUCTION

This thesis considers what technology means to less developed countries and how these countries are able to develop their capability to make use of knowledge and skills for production. Therefore, technological development should be understood in a broaden sense than merely from the perspective of developed countries.

In doing so, I will investigate the Korean experience of industrialization/economic development in achieving its present economic status in the international community. A general overview will be presented -- Korea's development process with its outward-looking economy and highly concentrated economic structure dominated by large firms. In some ways this strategy has enhanced technological progress by exposing Korean business to the outside world and encouraging them to compete in world markets.

First I will focus on the issue of adaptation of technology from other industrialized countries through three key stages: the acquisition/implementation, assimilation, and improvement stages. This kind of technological progress I call "incremental." This pattern of technological development is different from the dynamic model experienced in developed countries, such as radical/product and incremental/process innovation, through idea generation, problem solving, and

implementation.[1]

According to several Korean scholars, the technological development of less-developed countries is distinguished from this dynamic model in terms of the reduced availability and capability of scientific and technological knowledge in the early stage of their economic development.

What they observe in less developed countries, and particularly in Korea, is a reverse pattern of that in developed countries. This is because less developed countries usually import technologies from developed countries in the early stages of their development, then are only able to produce new products in the later stages when they have accumulated sufficient technological capability.

Second, I will look at the specific channels of technology transfer from developed countries to less developed countries. It is argued that there are basically two kinds of channels: informal and formal. Informal is identified as technology transfer through informal contacts with sellers and buyers, journals, staff education/training abroad, and importation of foreign products. Formal is exemplified by joint ventures and licensing agreements.

Since informal channels of technology transfer are poorly documented, I will focus on the formal channels of technology transfer: joint ventures and licensing agreements. In addition, I will investigate the role of multinational companies(MNCs) in technology transfer to local firms and industry.

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[1] For example, Abernathy and Utterback define the development of technology based on the product cycle: product and process innovation. Product innovation occurs when the basic and applied science and knowledge are materialized in new products, and process innovation occurs in the later stages of product cycle in an efforts of increase efficiency and productivity.

It is important to point out that the efforts and commitments in absorbing the foreign technology made by Korean firms was the most crucial factor in the development of their ability to advance in production. The Korean government is also effective in facilitating technology transfer through appropriate policies.

Third, I will address the issue of technological independence in Korea. I will present its needs and background in terms of Korea's situation in the international market and its competitiveness as one of the newly industrialized countries(NICs). Not only does Korea face the challenges of changing internal and external factors but also of developing its indigenous technology.

I will investigate Hyundai Motor Company's efforts for technological "self-reliance." Hyundai has so far performed better than the other major Korean auto makers which largely depend on the technology of their foreign partners. In presenting Hyundai's example, I will also discuss the experience of Toyota. Its early development seems to share some common approaches to Hyundai.

Finally, I will incorporate the linkages between large firms and small firms in Korea. As previously mentioned, the Korean economy is largely concentrated in large firms. The promotion of the large firms was rationalized as a means of growing fast and for targeting efficiency. In recent years, however, as Korea requires more advanced technology, it is obvious that an economy dominated by large firms tends to be inefficient and too rigid for a dynamic and creative business environment.

At the same time, advanced component industries are in demand while Korea

still depends for its component supplies on manufacturers in developed countries. The bilateral trade deficit with Japan is due to the importation of industrial components. There is a need for small firms' flexibility in innovating new products and producing sophisticated components. This kind of problem is already on the way to being resolved. Academic studies show that new small firms tend to be more innovative and productive than existing small firms, in areas such as R&D investment and employment generation. It is argued that in order to promote an advanced economy, the roles of small firms and the linkages between large and small firms will be important. This is because large firms are the main potential market for these creative small firms, as well as a channel of technology transfer. A market-incentive policy measure is more effective than subsidies and other direct financial support in promoting innovative small firms.

Korea faces new opportunities as well as challenges in its progress to advanced-country status. Korea is on the second transition from a NIC to developed country just as it successfully transformed itself from a poor country to a newly- industrialized country. The promotion of small firms is part of the new strategy needed to ensure this next progression.

CHAPTER 1: KOREA'S ECONOMIC GROWTH THROUGH "INCREMENTAL INNOVATION"

1.1: INTRODUCTION

This chapter presents the development of what I call "incremental innovation" in the process of industrialization in Korea. This pattern of technological development in Korea is different from the pattern in developed countries, and provides a lesson for less developed countries with a similar experience in economic and social environments in the early stages of their economic development.

It is appropriate to examine Korea's technological development in its context as a technological recipient, in the absence of accumulation of technological knowledge and capability,[1] at the beginning of its industrialization. For example, the incremental innovation practiced in Korean industries, and in other newly industrialized countries, is characterized by a gradual improvement in productivity and quality of products that use foreign technologies, that does not necessarily exceed the productivity of developed countries. In less developed countries, technology development follows acquisition/implementation, assimilation, and improvement phases.

The analysis will not follow the pattern of innovation practiced in developed

[1] Here, "technological capability" is defined as the ability to make effective use of technological knowledge in assimilating, using, adapting, creating new technology.

countries, from production innovation to process innovation depending on the position in the product life-cycle. Technological development in Korea has progressed from process development in the early stages of industrialization to product development in the later stages of industrialization: the reverse of the conventional developed country pattern. Thus this analysis will be based on how a less developed country has adopted foreign technologies and then develops its own capacity to innovate in an incremental way.

In analyzing incremental innovation, I will discuss the major factors which have contributed to the particular development of innovation in Korea; I argue that the stage of industrialization, the pace of industrialization, and the needs of an outward looking economy have each indirectly promoted the process of incremental innovation.

This incremental approach has largely been pursued by large firms in an effort to reduce production costs and improve the quality of existing goods. At the same time, this type of approach to technological innovation has provided a strategic rationale for the Korean government to support large firms. The advantages of economies of scale were reaped by large firms, and used as a weapon for price competition in international markets.

Finally, I will discuss the new challenges facing the Korean economy: the recent appreciation of the Won, domestic wage increases, and the increasing threat of international protectionism. I will consider the approaches of the Korean government and these firms to these emerging problems, in their attempts

to sustain economic growth.

This new kind of problem facing the Korean economy increases the need for indigenous technology. The achievement of this need largely depends on Korea's ability to develop new products. Product innovation in Korea will be on the basis of using accumulated existing incremental innovation to secure technological independence and renewed industrialization.

1.2: KOREA'S ECONOMY: THE IMPORTANCE OF EDUCATION

Korea has emerged as a major newly industrialized country (NIC). A few key factors should be highlighted as responsible for its impressive economic development: an outward-looking development strategy, the high level of education of the Korean people, and the successful effort to internalize foreign technologies for local uses. Since 1962, Korea has grown at an annual average rate of 8.4% per year, its GNP per capita in real terms has grown about ninefold from 1966 to 1986.[2]

[2]Principal Economic Indicators, Bank of Korea, 1987.

Table 1.1: Basic Statistics of Korean Trade & Growth

Period	GDP Growth Rate(%)	Export Growth Rate(%)	Export/GDP(%)
1961-65	6.5	39.6	3.1
1966-70	12.7	32.0	8.2
1971-75	9.0	32.5	19.9
1976-80	7.6	15.3	26.1
1981-85	7.6	12.6	30.0

Source: Korean Traders Association

In the beginning of its economic development, Korea had a comparative advantage in labor-intensive products in world markets. In order to expand its economy, Korea had to concentrate on labor-intensive industries for promoting exports, such as apparel, plywood, and textiles.[3] Korea adopted very low level technology through informal channels in the early stages of its industrialization, such as consulting technical and trade journals, copying foreign products, and sending nationals abroad for education. This kind of technological implementation represents reverse engineering through learning by doing.

In the later stages of its industrialization, Korea has acquired its technologies through formal channels, such as joint ventures and licensing agreements. For example, the number of licensing agreements was minimal in the 60s and early

[3] A World Bank Country Study, Korea: Managing the Industrial Transition, Vol. 1, March, 1987.

70s compared to the late 70s and the 80s.[4] As Korea transforms from low technology-intensive to high technology-intensive industries, technological development through the formal channels of transfer has increased. The channels and patterns of technology transfer are different according to the development stage and the types of industrial technology.[5]

Through its economic development, Korea gained a substantial technological capability. The major factors behind Korea's successful adaptation of imported technology are three: availability of local entrepreneurs, skilled engineers and technicians, and government development policy. For example, a large pool of skilled labor has facilitated increases in productivity and quality improvements for existing products. The high skilled labor force, that quickly learned and assimilated product design and production techniques, contributed to the achievement of the indigenous technological stage.

In Korea, the illiteracy rate dropped from 27.9% in 1960 to 11.6% in 1970 and became almost negligible by 1980. Korea surpasses other NICs in almost all indices of educational attainment. At the same time the share of education spending in the government budget rose from 2.5% in 1951 to 22% in 1985, while the government expenditures accounted for only one-third of the total educational expenditures, the remainder being borne by the private sector and

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[4] Ministry of Science and Technology. '88 Sicence and Technology Annual, March 15, 1989. Also see Exhibit 1.

[5] Jinsoo Lee, Zong-tae Bae, & Dong-kyu Choi, "Technology Development Processes: A model for a developing country with a global perspective," R&D Management, Vol. 18, No. 3, July, 1988.

parents.[6]

Therefore, it seems that education is one of most important factors in the development of technological capability in Korea. This argument is already supported by evidence from the 19th century of the correlation between educational indices and the speed with which individual Western countries were able to adopt and modify Britian's new industrial technology.[7]

This path of technological progress in Korea departs from the "incremental innovation" discussed by William J. Abernathy and James M. Utterback, although some aspects share common characteristics with Korean development. They argue that incremental innovation generally occurs after radical innovation in largely established products, and in those with high volume and considerable standardization in the later stage of the product life-cycle. These products primarily compete on the basis of price and efficiency, by gradual and cumulative improvements in productivity, typified by learning by doing. This contrasts with product innovation, which is the result of specific research and development projects in search of innovative products.

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[6] L. Kim, "Technological Transformation in Korea: Progress Achieved and Problems Ahead," The World Institute for Development Economic Research, Helsinki, 1986.

[7] N. Rosenberg, Perspectives on Technology, Cambridge University Press, London, 1976.

1.3: OUTWARD-LOOKING AND LARGE FIRM DOMINANT ECONOMIC GROWTH

In Korea, large firms have played a major role in contributing to economic growth through an export led strategy, so encouraging the incremental approach. Because Korea pursued rapid industrialization with only a limited amount of basic knowledge in science and technology, it concentrated on price competition based on efficiency instead of competition on the basis of product differentiation or radically new products. In order to achieve price competitiveness in international markets, the Korean government promoted large firms through providing financial and technical assistance, allowing them to reap the benefits of economies of scale and diversified organizational capacity in managing and marketing.

According to The Economist, in Korea financial repression channelled cheap credit to a relatively small number of large firms, while the average size of firms went up by 180% between 1966 and 1976. Although these large firms had almost total control over the domestic market, they rarely introduced new products. This observation underlines that these firms more concentrated on more adopting foreign technologies than on innovating their own.

Why did Korean large firms focus mainly on incremental innovation rather than radical innovation, despite their ready access to cheap loans and their relatively strong domestic market power? The explanation turns largely on the stage of Korean industrialization, in conjunction with the pattern of available

capital and human resources, the type of competition, and the thrust of government industrial policy.

A study by the Korean Industrial Research Institute shows that the ratio of Korean to foreign patents granted was less than 7% prior to 1980. In the early stage of economic development, the demands of the small domestic market did not initially provide a sufficient incentive for the domestic monopolists to invent products, while the export-oriented nature of the economy drove these firms in the direction of innovation for process technologies. One of the reasons to import technology was the effort needed to absorb necessary technologies in a short time span, not only to meet the demand in domestic markets, but more importantly to compete effectively in world markets.

This pattern of technological development contrasts with the Chinese and Indian cases. China and India have sought technological "self-reliance" through active in-house technical capabilities and promotion of basic and applied research. But problems have arisen with the slow growth of technology development.[8] Their strategies may have reflected the larger size of their domestic markets. Both countries have a substantially bigger population and inherited a less devastated situation than Korea which was wrecked by the Korean War. Therefore, in Korea, technological development had to take place through acquisition of foreign technologies, and through aiming for promotion of exports.

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[8]Jinjoo Lee et al, 1988.

Since the mid-1960s, exports have accounted for 20-50 % of the increase in GDP. Between 1985 and 1986, for example, the rate of consumption growth increased only slightly from 4.8 % to 6.3 %, but GDP growth more than doubled from 5.2 % to 12.0 % due to a sharp improvement in exports. Export growth stimulated the inflow of technology and the acquisition of know-how.[9]

For example, the export-oriented economy encouraged local firms to invest for capacity beyond local market needs to utilize economies of scale, and to acquire technological capability rapidly for improvement of their competitiveness in international markets, and to meet technical specifications required by foreign buyers in providing informal technical assistance.[10] Therefore, it appears that the export-oriented strategy provided an incentive for local firms to advance their technological capability.

These characteristics of technological development, through adaptation of foreign technology, follow a pattern shared by the late industrialized countries, such as Korea and Japan, in contrast to the pattern of innovation and technological change of the early industrialized European countries. In particular, Japan depended heavily on imported technology throughout the entire prewar and the earlier years of the postwar period.[11]

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[9]Korea Industrial Research Institute, Industrial Technology White Paper, Korea, October, 1988.

[10] Linsu Kim, Jangwoo Lee, and Jinjoo Lee, "Korea's Entry into the Computer Industry and Its Acquisition of Technological Capability," Management Behind Industrialization: Readings in Korean Business, Korea University Press, Seoul, Korea, 1989.

[11]International Development Center of Japan(IDCJ), Working Paper Series No. 38, March, 1987.

According to Kenji Tahara, Japan followed a strategy of secondary import substitution, which allows a period of learning to compete with the rest of the world in ever more sophisticated goods; and secondary export substitution, which promotes invention in the process of industrialization. Kenji Tahara identifies the "turning point" where the country changes from reliance and dependence on borrowed technology to the emergence of domestic technological invention.

In the case of Korea, this "turning point" seems to have been reached in recent years, as Korean exports shifted from light manufacturing and intermediate goods, to machinery and consumer electronic goods. This has led to the identification of an emerging need for product innovation in this changing environment. At the same time, uncertainty about the demands of future markets creates the need for technological change. This kind of reaction is defined as "defensive" technological innovation.

Because the Korean economy was largely export-oriented with a relatively small domestic market, large firms had to focus on international markets. International competition drove firms to reduce production costs and to improve the quality of products by employing process technologies, rather than by inventing new products. During the HCI(heavy and chemical industries) drive period of the late 70s, economic development was largely geared to promoting petro-chemical and steel industries based on "process-based" technology. Korea has now(in 1990) become one of the ten major trading countries.

1.4: EFFORTS AND STRATEGIES IN TECHNOLOGICAL ADAPTATION

At the same time, it is important to point out that firms in Korea did not settle for simply copying and imitating imported technologies. They undertook subsequent minor technological modifications and gradual improvement, such as the mastering of production-related technology for manufacturing equipment and plant engineering.

For example, Korean pharmaceutical firms mainly imported raw materials from abroad and manufactured drugs by fabricating, producing and packing imported raw materials at the beginning of the technology development. From 1965, however, moves toward the localization of raw materials became active in an effort for internalization of foreign technologies.

The Korean automobile industry, also has been transformed from its accumulation stage of related technology(-1961), initiation stage(1962-74), early internalization stage(1975-81), to a late internalization stage(1982-).[12] The initiation stage of the Korean automobile industry was characterized by the manufacturing of Japanese, U.S., and European auto models on semi-knockdown(SKD) or completed knockdown(CKD) basis. The first indigenous Korean passenger car was developed and went into production in 1975, the beginning year of the internalization stage. The localization ratio of this

[12]Hyun and Lee, 1987.

passenger car reached up to 85 % at that time.[13]

In the meantime, the Korean government promoted imports of licensed technology by providing various assistance in order to achieve faster economic development. In 1961, 49 percent of Korea's gross domestic product(GDP) was in agriculture, 13 percent in manufacturing, and 38 percent in services. By 1981, the GDP share of manufacturing almost tripled to 37 percent, while that for agriculture declined to 20 percent, and that of services rose to 43 percent. This rapid pace of industrialization required mass production at relatively low cost by learning in a short period of time. Therefore, in Korea, accelerated industrialization influenced local firms to concentrate on incremental approach in technological progress to secure improvements in productivity and quality.

In addition, the new international division of labor, a more efficient production mode exploiting the specialization of labor, also affected indirectly the learning of "know-how" in processing , while a large pool of skilled labor in Korea provided multinational firms assembly bases with relatively low real product wages. For instance, since 1967 the Korean government has established technical training agencies to train young people in various trades. The minimum requirement for admission to training agencies is a middle school education(9 years). To train workers to meet increasing industrial demands, the government founded the vocational training institutes.

In 1982, the government established the "Korea Vocational Training &

[13]Jinjoo Lee, Zong-tae Bae, and Dong-kyu Choi, July, 1988.

Management Agency"(KVTMA) to manage the vocational training institutes. Besides formal vocational schools, there are public, in-plant, and authorized training agencies. The total number of vocational training centers as of September 1982 was 514, which trained about 900,000 workers during 1961-1981.[14]

This kind of production setting made it easier for Korean large firms to learn shop floor knowledge through technology transfer and information flows from the multinational firms. For example, Hyundai, one of the largest conglomerates in Korea, has been able to attract workers who already have experience in manufacturing. Large firms tended to benefit by recruiting these experienced workers. At the same time, economies of scale in production gave the large firms an advantage in cost reduction. With lower costs of production through faster learning and economies of scale, large firms were able to contribute to faster economic growth.

The characteristics of incremental innovation through Korean industrialization are distinguished from the pattern of innovation for early industrializing countries, which concentrated on product innovation through small, technology-based units in the beginning of their industrialization, then adapted process technologies as the new product became obsolete.

[14]Ministry of Labor, Korea, 1982.

1.5: THE TEXTILE INDUSTRY

Korean experience shows how a technologically backward country adopts technology, accumulates technological knowledge, and progresses according to the requirements of its strategy of industrialization. For example, in the textile industry, the technological development has transformed from the early stage of technology import, a later stage of technology import, the early stage of technology internalization, and then a later stage of technology internalization.

The early stage of technology import lasted from 1917 to 1964. The relatively long duration of this static development phase is explained by Japanese colonial rule. In the textile industry, the operation was owned and managed by Japanese, and Japanese management rarely transferred technology to Koreans to expand their market. Moreover, the Korean War and social instability delayed any technological progress.[15]

During this period, cotton was the dominant item in the textile industry and quality was poor with only a small amount of cotton exported, although Jeil Wool Company started to produce wool on the basis of accumulated technological knowledge with previous cotton production. At the end of the 1950s, the industry began to import low levels of technology such as techniques for producing P.V.C. and nylon.

The later stage of technological imports was from 1965 to 1971. The textile

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15 Korea Economic Research Institute, Technological Innovation Process of Korean Industries and Governmental Policies, Korea, April, 1986.

industry was identified as a key industry and subsequently tax and other financial supports were increased as well as the importation of foreign technologies and textile exports. During this period, imported machineries were modernized and training for use of these machineries was provided by sellers. At the same time, productivity increased noticeably from 0.66 worker per roll of cotton in 1960 to 0.41 worker in 1970, while the quality of fabric improved by using thinner yarns.[16]

In the case of wool, domestically produced wool was rewarded a "wool mark" which denotes the attainment of an international standard for quality, from the International Wool Society(IWS). In the middle of 1960s, when synthetic fiber began to attract customers, the industry felt the need to produce it, and the major domestic companies built plants. But, acquiring the new technology for synthetic fibers was difficult and expensive. In facing the difficulties, the local firms began to establish their own R&D institutes.

The early stage of technological internalization took place from 1972 to 1979, when the industry achieved some degree of internalization of foreign technology. For instance, labor productivity increased from Won3892 in 1970 to Won6980 in 1975, and the value-added per person increased from Won1385 to Won2664 over the same period at 1975 market price. In the meantime, global competitiveness also strengthened. At the same time, exports of textiles jumped from Won552 billion in 1970 to Won3185 billion in 1975 and by 1975 almost

[16]Korea Textile Association.

half of production went for exports(49.5%).[17]

Table 1.2: Development of The Textile Industry

	'17-'64	'65-'71	'72-'79	'80-
No. of Firms	1,240	1,308	1,260	2,093
Production	213,886	321,208	651,597	1,720,585
Export	11,063	55,176	318,490	702,763
%	5 %	17 %	48.8 %	41 %
LCR	87.9 %	98.1 %	100 %	100 %
VA	n.a.	1,385	2,664	3,975
LP	n.a.	3,892	6,980	10,742
Tech. Imports	n.a.	5	15	15

Notes:
- Production and Export in million won.
- LCR stands for local content ratio.
- VA stands for value-added per person.
- Lp Stands for labor productivity.

Source: Economic Planning Board, Ministry of Science and Technology.

During this period, the importation of technology increased to 15 methods compared to 5 methods between 1965 and 1971 as production required more sophisticated techniques.[18] The labor requirement per roll of cloth also fell in half from 0.41 in 1970 to 0.23 in 1975.

[17]Economic Planning Board.

[18]Ministry of Science and Technology.

Since 1980, in the later stage of internalization, the industry has succeeded in internalizing foreign technology and partly new products and technologies have been developed by its own R&D efforts. Facing intense global competition, the Korean textile industry is active in designing and developing sophisticated and quality fabrics. For instance, in March 1985, rapiers and water-jets were employed in production, while Sunkyung textile company produced films and K textile company invested a new product with indigenous technology. The industry has started to export its plant technologies to other developing countries.[19]

Through the development of technology in the Korean textile industry, we have observed the pattern of Korean technological progress. The industry started to acquire technology through informal channels in its early development, and in the later stages of development, the industry internalized foreign technology through assimilation. Recently, the industry has become able to produce new products with its own technological capability. Therefore, the process of incremental innovation in the textile industry has developed through effective adaptation of foreign technology and gradual improvement of its own technological capability.

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[19] Korea Economic Research Institute, Technological Innovation Process of Korean Industries and Governmental Policies, April, 1986.

1.6: NEW CHALLENGES AND RESEARCH & DEVELOPMENT

The Korean economy, however, has recently experienced a few key difficulties in pursuing its price competition strategy in international markets. The main concerns are recent high wage increases and appreciation of the won. The won appreciated 8% against the U.S. dollar in 1987 and a further 13.7% in 1988; wage increases averaged 17% in 1987 and 14% in 1988.[20]

This has driven up the cost of production in comparison with other developing countries that compete with similar products to those of Korea. At the same time, increasing protectionism by industrialized countries has made it harder for Korea to export its goods and to purchase foreign technology.

This kind of environmental change has created the need for new technology in product invention by firms. Price competition alone will not be able to support economic growth in Korea, considering that Korea still largely depends on exports for its economic development. As a result, Korea is aiming to shift its economy from being capital-intensive industry-based to being technology-intensive industry-based in its promotion of the industries of machinery, bio-technology, and software, in addition to its earlier focus on steel and shipbuilding which are internationally price competitive industries.[21]

Firms also began to establish their own research institutes, while they

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[20]Principal Economic Indicators, Bank of Korea, April, 1989.

[21]Korea Industrial Research Institute, Industrial Technology White Paper, 1988.

increased their ratio of R & D expenditure to sales from 1.16 % in 1983 and 1.39 % in 1985, to 2.07 % in 1987. A study done by the Korean Industrial Research Institute of R & D investment as a proportion of sales, by industry, for 1987 shows that electronics is most research intensive, with a share of 3.45 %, machinery 2.07 %, chemicals 1.12 %, textiles 1.27 %, food 0.92 %. These data reflect the importance of the electronic industry and machinery industry in terms of research. These figures partly indicate how the high-technology sector is considered a key sector for further Korean economic growth.[22]

In order to promote technology-intensive industries, research and development efforts are seen as of crucial importance by the Korean business community and by the government. According to a survey by the Ministry of Science and Technology in Korea, the R & D expenditure to GNP ratio has increased from 0.5 % in the 1970s to 1.5 % in 1985. The targeted R & D expenditure to GNP ratio is 2.5 % for 1991.[23]

Hyundai, a conglomerate in Korea, has begun independent research and product development, while it has relied on in-house design of sections of the body of its new Sonata model, recently launched in the U.S.. These increasing efforts for technology development will certainly help promote the development of technology-intensive industry, although expenditures on R & D do not

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[22]'88 Ministry of Science and Technology Annual, 1989.

[23]'88 Ministry of Science and Technology Annual, 1989.

necessarily indicate direct technological progress in new products.

In addition to this R & D effort, large firms need to be able to adapt to the reindustrialization of new markets, new products, and new technology. Industrial policy could be used in restructuring Korean business which has been dominated by large firms, and a dynamic approach should be considered in terms of the relative contribution of firms of different sizes to innovation in a particular industry. Each form of innovation has its own implications for the organizational structure most appropriate to its implementation. Thus radical forms of innovation, such as the creation of new products using new technologies often require new organizational structures.[24]

Korea attempts to progress to a new stage of industrialization, in the face of emerging competition from other developing countries in existing product markets and the need for technological independence in order to advance its economy and overcome the restrictions in technology transfer by industrialized countries. Therefore, the incremental innovation approach adopted successfully up until now could be reinforced by a new phase of indigenous technology and the development of new technology.

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[24]Roy Rothwell and Walter Zegveld, Reindustrialization and Technology. Chapter Four of this thesis discusses the complementary role of small and large firms in technological innovation.

1.7: SUMMARY

In this chapter we have discussed the stages of technological development and "incremental innovation" in Korea. Korea's technological development has progressed through acquisition, assimilation, and improvement stages in the utilization of foreign technologies, and the recent efforts of development for indigenous technology are viewed as the results of accumulated technical knowledge experienced throughout its industrialization process.

The Korean innovation pattern does not follow the "product generation cycle" that Abernathy and Utterback describe, namely that innovation evolves from a change in basic design to process innovation. Korean innovation has evolved through incremental progress by importing technology from industrialized countries in the early stages of its industrialization, and its focus on new technology and product innovation in recent years.

This kind of technological development has indirectly been influenced by the stage of industrialization, the pace of industrialization, and the needs of an outward-looking economy. At the same time, the high level of education has been one of the most important factors in successful adaptation of imported technologies, including entrepreneurship and government policy, although Korea had small domestic markets and a low base of technological knowledge at the beginning of industrialization.

From this study, the pattern of technological development depends on

available resources and knowledge, the speed of industrialization, the phase of industrialization, and policy orientation in achieving economic growth in the particular country. For these reasons, Korea has pursued an incremental approach to technological innovation to achieve economic development.

The next challenge is how Korea approaches the task of product innovation to overcome uncertainty in the world market, while retaining its outward-looking economic strategy. As Korea shifts its concentration from low technology intensive to high technology intensive industry, it might need to modify its economic structure by expanding participation of small firms, in addition to continuing effort in R&D investment.

CHAPTER 2: STRATEGIES FOR TECHNOLOGICAL ADOPTION AND LOCALIZATION

2.1: INTRODUCTION

In Chapter one, we observed how Korea progressed in its technological development through acquisition, assimilation, and internalization of foreign technologies in the context of a less developed country. This chapter will focus specifically on the informal and formal channels of technology transfer in the process of economic development in Korea. This investigation will show how a less advanced country has achieved economic growth through successful adaptation of technology from advanced countries.

It is also argued that a country tends to acquire foreign technologies through informal channels in its early stages of technological development and through more formal channels in later stages of technological development as a country requires new technologies, through joint ventures and licensing agreements.

In dealing with this issue of technological transfer, I will investigate the following aspects of the Korean experience: What are the important factors for successful technological adaptation? In order to probe these questions, I will present a brief history of Korean economic development, followed by a description of the different channels of technology transfer, such as joint ventures and licensing agreements, which are common in Korea.

I will argue that an effective technology transfer is only feasible when both parties, licensor and licensee, can capture benefits through the engagement. For instance, a licensor takes advantage of hiring inputs at lower cost in exchange for sharing its technology with the licensee, while the licensee can acquire valuable know-how in a short period of time and also at lower cost.

Particularly for licensee countries, a reasonable establishment of infrastructure is essential to accomplish the successful transfer and adoption of technology. This includes a high degree of managerial skills and receptive industrial skills. At the same time, the industrial policies of licensee countries should be geared to achieving economic development.

In Korea, throughout the five-year plans, the adaptation of particular technologies have been prioritized in key industries which are crucial for economic sustainability and further growth in the different stages of industrialization. What is so unique about Korean technology adaptation is the effort to develop its "native" technology as much as possible through mastering imported technology.

I will observe in depth how the different types of technological adaptation have been practiced, with the linkage of key industries at different stages of economic development. It is useful to address this aspect of technology transfer in a particular developing country, because I suspect that Korea has adopted mainly standardized technologies in the early stage of its

industrialization, only moving on to sophisticated and more complex technologies in the later stage.

At the same time, I will look at joint ventures and licensing agreements throughout the Five-Year Plans. Multinational companies' roles in technology transfer from advanced countries to Korea will also be examined.

As we will observe throughout this chapter, joint ventures and licensing agreements have been used as effective channels for acquiring technology in Korea. These kinds of low cost technology transfer have helped Korea promote economic development at a fast pace despite its limited natural resource endowment.

However, as the Korean economy transforms from an infant stage to a more mature stage of industrialization, accompanied with the increasing protection of intellectual property rights by advanced countries, Korea faces challenges ahead in acquiring and absorbing high technology for further economic growth. Considering that the Korean economy largely depends on exports for its growth and increasing competition in domestic and world markets, competitiveness in international markets remains a crucial factor.

2.2: KOREA'S ECONOMIC DEVELOPMENT: FIVE-YEAR PLANS

The Korean economy shows some distinctive characteristics in terms of its astonishing growth rates, its export-oriented economy, and its high concentration ratio and dominance by large firms. This kind of economic structure was not accidental. Recovering from the Korean war, the domestic market was relatively small, natural resources were scarce, and technological capability was thin.

In this sense, it can be said, ex-post, that Korea did not have any other option than to follow an export-oriented strategy. What is important to learn from the Korean case, however, is that Korea has succeeded in formulating and implementing a national development strategy that is consistent with its initial conditions and opportunities.

In order to foster economic growth from a position of backwardness, the Korean government started the first Five-Year Plan in 1962. Since then, four more plans have been enacted to 1987 and the sixth is taking place up to 1992. At each plan, the government promoted a few key industries crucial to export-oriented industrialization. With import-substitution policies, the nondurable consumer goods sector, several supporting industries, and the manufacture of engineering goods received special support.

During the 1970-1978 period, production of manufactured goods increased

by 17.5 percent annually.[1] Priority was given to shipbuilding and to the consumer goods sector during the 1960s, while during the Third and Fourth plan periods of the 1970s, manufacturing machinery and the chemical and petrochemical industries were given much greater emphasis. During the 1970s, production of capital goods has increased fifteen-fold, and Korea has become one of the leading capital goods producers amongst developing countries.[2]

The share of manufactured exports in the country's total exports increased rapidly, from 14 percent in 1960 to 82 percent by the Mid-1970s.[3] Korea initially started to export light industrial products such as textiles, garments and wood products. It then diversified increasingly into engineering goods such as electrical appliances and machinery and metal products. By the early 1980s, the rapid expansion of exports of manufactured goods indicates the advanced level of technological capability and absorption.

In the meantime, Korea had secured rapid economic growth, accompanied with substantial investment. Per capita income had increased from $87 in 1962 to $3132 in 1987 (this could be larger following the recent won appreciation), indicating the fast pace of economic growth over the last 25 years.

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[1] Korean Machinery Industry, 1981, Korea.

[2] German Development Institute, Development and Perspective of the Korean Machinery Industry, Berlin, 1978.

[3] Korean Machinery Industry, Korea, 1982.

Table 2.1: GNP Annual Growth Rate (%)

	1975-79	1980-84
United States	3.2	1.8
Japan	4.7	3.9
Korea	9.9	5.3

Source: T.W. Kang in "Is Korea the Next Japan?"

The Korean economy has been dominated by a few large conglomerates. The top 10 large firms shared about 50 % of total GNP in 1977 and the top 5 large firms shared the same proportion of GNP in 1984. This highly concentrated economic structure is also consistent with export-oriented based economic growth.

Economies of scale have been a positive factor in terms of output and production cost in order to compete in global markets. This pattern of industrialization had been successfully implemented by the Japanese through "picking winners", in favor of some industries and firms via special facilities and incentives for investment. Therefore, it was less risky to follow the example of Korea's neighbor, particularly in its early stage of industrialization. During the oil shock, large scale investment projects were regarded as natural counterbalances to this kind of external shock.[4]

[4] Silvio de Franco, Alberto Eguren, and David Baughman, Korea's Experience with the Development of Trade and Industry, The World Bank, An EDI Policy Seminar Report. No.14, October 1988.

Next, I will look at how the export-oriented and highly concentrated economy has been able to achieve rapid economic growth by utilizing imported technologies and how Korea has acquired and absorbed this technological knowledge.

2.3: TECHNOLOGICAL ADAPTATION AND STRATEGIES

In the process of technology adaptation throughout Korea's industrial development, the Korean government has played a crucial role. During the 1960s, the self-sustainment of the national economy, sound development, and the improvement of the balance of payments were greatly emphasized.

With a shortage of local capital and a lack of technological capability, the country has relied heavily on foreign capital for financing investment and importing technology for production. During the period 1973-79, the foreign debt increased from US$4,300 million to US$20,000 million which represents a growth of 372 percent, but the debt/GNP ratio barely grew at all -- from 31.6 percent in 1973 to 32.9 percent in 1979.[5]

At the same time, the entry of foreign companies was limited during the 1960s to protect the relatively weak local industrial base. During this period,

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[5] The World Bank, An EDI Policy Seminar Report: Korea's Experience with the Development of Trade and Industry, no. 14, 1988.

the major channel of technology acquisition was through "turnkey" arrangements, which were usually associated with foreign supplier loans and credits.

These agreements generally provided for short-term specialized services by foreign engineering or consulting companies and were used for plant construction for light industrial projects. Most basic industries, such as oil refining, fertilizers, petrochemicals, and transportation, were established through the "turnkey" arrangements during the 1960s.

In the 1970s, the inflow of foreign direct investment accelerated. The Korean government prioritized investments in the development of the chemical and machinery industries, and in the export-oriented manufacturing sector. The government succeeded not only in channeling such investments into priority sectors but also in ensuring the effective participation of domestic companies in local multinational company operations.

In 1981, the Economic Planning Board adopted measures to promote the flow of foreign direct investment into selected priority sectors following the liberalization of technology regulation measures. The major objective of these measures was to accelerate the inflow of advanced technology, that would be difficult to obtain without substantial equity participation by their foreign owners.

In the Fifth Plan of 1982-87, several industries were accorded priority based on their use of advanced and complex technologies, particularly in the

export-oriented area of electronics. Much of this technology was only available to foreign-controlled affiliates and not to independent domestic licensees. Foreign participation was considered desirable to ensure the commitment of technology licensors to transfer their technology effectively, and to allow its absorption by local licensee enterprises in a reasonable time. Foreign direct investment is presently encouraged to those that primarily use advanced technologies such as electronics, machinery and metallurgy.

Government industrial policy towards technology adoption through licensing agreements and joint ventures varied with the different stages of development. In the 1960s, the dominant industries were textile, chemical, and other basic industries; machinery and other manufacturing sectors were given priority during the 1970s; in the 1980s, electronics and electrical equipment have shown an increasing share of technology importation as the economy transforms into a more developed stage.[6]

At the same time, the share of technology imports between 1983 and 1987 represents about 51 % in number and 70 % of the amount paid for total technology importation from 1962 to 1987.[7] This figure reflects increasing technology importation in recent years, and the content of technology has changed from low-level to high-level technology, while the number of

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[6] Korea Economic Research institute, Technological Innovation Process of Korean Industries and Governmental Policies, April, 1986.

[7] Ministry of Science and Technology, Science and Technology Annual, Seoul, Korea, March, 1989.

technology imports has also been increasing. Thus, the pattern of technology adoption in Korea shows the transition from labor-intensive, then capital-intensive, and finally to technology-intensive production.

An important aspect of technology adaptation in Korea is how it has utilized foreign technology: Korea has hired technology but has not hired production. It welcomed foreign techniques but has not encouraged foreign ownership. In this way, Korean firms have been able to strengthen their bargaining position with multinationals and have forced them to sell technology at lower prices.

In the process of approving investment proposals, the Economic Planning Board generally discouraged the formation of wholly foreign-owned subsidiaries, instead favoring joint ventures with shares not exceeding 50 % of equity owned by foreigners. The Korean authorities have often prescribed well-defined performance criteria for foreign investors in joint ventures with local companies. The criteria cover the obligations of foreign partners, with special emphasis on their technological contribution.[8]

Korean engineers should be trained in the use of the foreign partner's latest technology, including process design, detailed engineering, operation, and maintenance. Korean engineers are encouraged to participate in all aspects of production and to replace foreign employees as soon as possible.

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[8] Jinjoo Lee, Effects of Legislation and Regulations on Transfer of Technology: An Empirical Analysis of the Experience of the Republic of Korea, Korea Advanced Institute of Science and Technology, April, 1986.

By acquisition of technology on the one hand and the production of goods on the other hand, Korean firms have been able to absorb know-how and modify imported technologies for their own specific use. This kind of practice facilitated Korean firms in developing indigenous technology.

In the process of technology transfer from more advanced nations to a less developed nation like Korea, the roles of multinational companies have had a great impact on the development of technological capability. But the development largely depends on a country's production capability, such as skilled labor and sufficient production facilities. In the 1970s, many multinational companies(MNCs) began to reallocate their production facilities as global competition intensified.

In order to achieve comparative advantages in production, MNCs from advanced countries moved their manufacturing facilities to less developed countries. During this transition, Korea has been one of most desirable places to manufacture goods, with its skilled labor, relatively low wages, and large firms with modern manufacturing facilities.

In fact, multinational companies generally shifted production of those goods that had reached the maturity of their product life-cycle. The technologies had already been standardized for sometime. For these kind of products, competition shifts to price/efficiency and away from design, with the emergence of a dominant design - "standardization." In this stage of the product cycle, scale and learning become important and specialized capital

becomes deployed as firms seek to lower unit costs through exploiting economies of scale and learning.

In this context, Korea is an attractive place for production. Large firms dominate the economy, and highly- educated engineers and skilled labor are available. In this sense, Korea offers unique complementary sources in providing trained labor, manufacturing facilities, and access to the Korean market. Large firms are more likely to possess the relevant specialized and cospecialized assets, while the foreign MNCs secure benefits by saving the expense of building complementary assets. In the meantime, large firms in Korea make possible the intensive exploitation of production capacity with better-equipped facilities and with well-trained labor.

In the productive process, learning takes place for local firms at the manufacturing stage, consisting of developing increasing skills in production, such as reducing real labor costs per unit of output. This improvement culminates in the prior training and experience of Korean workers and firms. Subsequently Korean firms have been able to achieve minor improvements that enhance the rate of productivity growth. Although these kinds of modification and improvements in production are not comparable to "Schumpeterian innovation," Korea has certainly been active in "incremental innovation" through "learning by doing."[9]

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[9] Arrow, "The Economic Implications of Learning by Doing," Rosenberg, ed., Inside the Black Box: Technology and Economics, U.K. 1982.

Through collaboration in joint ventures, Korean firms and MNCs have been able to capture mutual benefits. The local firms have acquired technological knowledge and know-how at the manufacturing stage, while MNCs have maximized their profits by lowering production costs. This kind of productive engagement represents a unique case of technology transfer from advanced nations to less advanced nations. In future research, I hope to compare Korea's success with that of other developing countries. What has made Korea relatively attractive to MNCs, and how has Korea extracted most benefit from the MNCs?

However, limitations arise where comparative advantages are not readily available and when there is asymmetric information between two parties. As technology becomes more sophisticated and complex and the life-cycle of the technology shorter, it becomes more difficult to acquire effectively and absorb know-how in a limited time. Nonetheless, joint ventures and licensing agreements are major channels of technology transfer from more advanced nations to less advanced nations.

2.4: SUMMARY

Throughout this chapter, I have investigated technological adaptation through joint ventures and licensing agreements in the process of economic

development in Korea. I also have argued that the types of technologies adopted by Korean firms have been largely influenced by different stages of Korea's economic development and demands of an export-oriented economy.

At each stage of industrialization, the Korean economy has targeted certain key industries to promote its economic development through exports, since its domestic market was initially insufficient to foster demand-driven growth. In the process of development on particular industries, it has deliberately selected appropriate technologies on the basis of priority industries through joint ventures and licensing agreements.

The observation of technological adaptation in Korea shows that it has changed its acquisition from low-technology to advanced technology. The frequency of technology importation has increased, as the economy transforms from the early stage to the mature stage of industrialization. This phenomenon may reflect the fact that technology has become a key factor in production for Korea, to gain competitiveness in the global market.

I have also analyzed the collaboration between Korean local firms and multinational companies as a mean of technology transfer from more advanced nations to less advanced nations. In doing so, I have pointed out that comparative advantages and manufacturing capability are considered important factors for MNCS and acquisition and absorption of technology are of great importance for local firms.

By engaging in collaboration in the form of joint ventures and licensing

agreements, MNCs are able to maximize their profits by lowering production costs, generating royalty fees, and gaining access to the local market, while local firms acquire necessary technologies with relatively low cost and within a short time. Thus, the engagements provide benefits to both parties. Another important aspect of this practice is that the technologies transferred are mainly standardized ones for products at the maturity of their life-cycle in the early stage of Korean economic development. Nonetheless, this type of technology makes transfer easier and more effectively employed in mass production.

However, joint ventures and licensing agreements have limitations because of increasing asymmetric information and direct costs of transfer, as the technology becomes more sophisticated and complex. For example, in the electronics industry, the foreign technology acquired has often been outdated and covers only a part of the required know-how for local manufacture of high-value components and parts. As the economy matures and concentrates in technology-intensive industries, more advanced technologies are required.

Joint ventures and licensing agreements are less effective tools in acquiring technology when the economy is in the later stages of industrialization. A country like Korea considers other modes of R&D to foster its economic growth. Efforts already have taken place to promote indigenous technological development and to improve the diffusion and assimilation of research findings by private industry, in facing the rapidly changing nature of advanced

technology, increasing protection of intellectual property rights from more advanced countries, and increasing price competition based on standardized technology from other developing countries in the global market.

CHAPTER 3: TECHNOLOGICAL INDEPENDENCE

3.1: INTRODUCTION

This chapter addresses the efforts of Korean industry to attain technological independence, facing increasing global competition, due to the relaxation of import restriction in domestic markets and intensified protectionism from Western countries.

In challenging these emerging problems, Korea has pursued production and innovation of new technologies and products, by accumulated technological capability through adaptation of imported technology and continuous investment in R&D. In examining this development, we will investigate the automobile industry which has the representative characteristics of being technology-intensive and being dominated by a few oligopolistic companies.

The automobile industry underlines the stage of economic and technological development in a particular country since it requires a certain level of technological capability in production and has significant backward linkages with other capital and technology intensive industries, such as the electrical, electronics, machinery, and chemicals industries. In this context, technological development in the automobile industry may reflect Korea's ability to produce other technology intensive products.

In the process of examining the issue of technological independence, we will follow the development of Hyundai Motor Company. The company is distinctive in its independent approach to technological enhancement from other Korean auto makers, that rely heavily on foreign technology in their production.

In examining technological independence, we also examine a Japanese case-study of the so-called "small-lot" system practiced by Toyota.[1] Toyota's experience might differ in the aspect of initial size and pace of development, but its efforts for technological independence share similar characteristics with the recent strategy of Hyundai Motor Company for technological independence. At the same time, they have performed better than other domestic auto makers in their countries. Therefore, it seems that technological independence provides other important elements to the firms in improving production and non-production performance.

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[1] Michael A. Cusumano, M.I.T Working Paper #1817-86, Small-Lot Production: Key to High Productivity and Quality in Japanese Auto Manufacturing, the Sloan School of Management, Massachusetts Institute of Technology, Cambridge, MA 02139, August, 1986.

3.2: BACKGROUND/DEVELOPMENT OF THE AUTOMOBILE INDUSTRY

The Korean automobile industry has largely depended on foreign technologies including those of the Japanese. The importance of the automobile industry arises from the fact that the automobile industry requires inputs from other high technology-intensive industries, such as the chemical, electrical, electronic, and machinery fields, and its high levels of linkages with other high value-added products that aid in the generation of a high level of income per unit of output. Korea is in the process of switching its economy from low-technology intensive to high-technology intensive products, and automobiles are part of this strategy. Automobiles also became one of the 10 major Korean exports for the first time in 1985.[2]

The Korean automobile industry is dominated by five producers, Hyundai, Kia, Daewoo, Ssangyong, and Asia. The Korean auto industry was initiated as a "sunrise" industry through the government's support in 1962, with import restrictions and a tax reduction on imported parts promoting import substitution. In the late 1960s the industry was mainly assisted by Japanese auto manufactures. For instance, Kia contracted with Honda to produce three wheeled vehicles, while Shinjin joined with Toyota in the production of four wheel passenger cars. In 1967, Hyundai was assisted by Ford.

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[2] A World Bank Country Study, Korea: Managing the Industrial Transition, Volume II, March, 1987.

In 1984, Pony's Canadian success helped the expansion of its market to the U.S. through well targeted advertizing, and selective, highly reputable dealers. This successful expansion of Korean car exports appeared to crystalize the internationalization of the Korean auto industry. The major advantage of the Pony was its low price compared to Japanese and US cars, and this was supported by government subsidized loans to Hyundai with low interest rates of 6.7 percent when the U.S. prime rate was about 14 percent.[3] High productivity and low costs share some similarities with the Japanese automobile industry in the 1970s, that depended on economies of scale supported by large investment in plant and equipment.

In 1986 when the Hyundai Excel was launched in North America with sales of 168,000, it was considered a huge success. Since then, however, the progress has been reversed, production falling by 13 % and exports of cars declining by 18 % in 1990, although this decline has been offset by a booming domestic market. However, this can not be a long term remedy for declining exports, because the domestic market is not large enough to sustain the auto industry indefinitely.

Moreover, a serious problem that Korean manufacturers face today is that they are overdependent on the United States market, while they are also constrained by lack of technology and a weakness in the domestic components industry. Korean manufacturers try to overcome their lack of technology by

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[3] Chosonilbo, November 6, 1982.

importing products and technology. For example, Hyundai purchased technology from Mitsubishi through a 15% share in a joint venture. Daewoo Motors is 50% owned by General Motors, while Kia Motors has technological assistance from Mazda, with marketing by Ford.[4]

Such linkages, however, cause additional problems, in creating dependency and the slow development of technologies necessary for design and components manufacture. At the same time, acquiring foreign technology is becoming more difficult. Volvo recently pulled out of its agreement with Ssangyong, and Samsung is having a hard time finding a foreign partner.

There are many examples of unsuccessful joint ventures. Mitsubishi was severely limited by its partnership with Chrysler. Chrysler decided to impose its marketing strategy on Mitsubishi USA, and this retarded Mitsubishi's flexibility. A technologically superior partner may impose constraints on the junior company's growth.

3.3: HYUNDAI MOTOR COMPANY

In 1967, Hyundai Motor Company was the first to establish an automobile assembly plant that could produce the whole vehicle within Korea. The company produced Korea's first indigenous passenger car the "Pony" (the

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[4] Ministry of Science and Technology, '88 Science and Technology Annual, 1989.

early edition of the current Excel). The production of "Pony" marked a transition from import substitution to exporting, and was followed by subsequent progress in production. In 1968, the company produced only 641 vehicles, but this had increased to 90,384 vehicles in 1982 this was about 57 percent of the total production of vehicles by all automobile companies in Korea.[5]

Since then Hyundai has become the dominant leader with a 49.3 percent market share in 1983 (the share in passenger cars was 76 percent), followed by Daewoo with 16 percent. In terms of production capacity, Hyundai was the largest producer with 41 percent of total capacity.[6] In 1985, Hyundai's Excel accounted for more than 90 percent of total passenger car exports.

Behind this success, Hyundai's effort to gain technological independence has played a major role. For example, Hyundai's strategy is quite different from other auto makers in Korea. Hyundai recognized that self-reliance is essential to become competitive in the world market. This rationale came from its experience with Ford in the early 1970s. Hyundai attempted to establish the joint venture with Ford as a channel of technology acquisition, but lack of commitment by Ford and conflicts over production between the two firms eventually resulted in a break-up.

At that time, the local market was very thin, therefore there was no

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[5] Hyundai Jadongcha, Korea, 1982.

[6] Annual of Korean Transportation, Transportation News, Korea, 1984.

incentive for Ford to commit technology transfer to Hyundai when Ford targeted on the domestic market, except so far as necessary to take advantage of lower labor costs through specializing the production process. Ford demanded that participate take place in only limited areas:

- only diesel engines would be produced
- investment only in the areas that have potential for profits
- concentration more on the domestic market than for exports.[7]

Ford was motivated by its global strategy for component specialization in each country in New Zealand, Philippines, and Taiwan. It was clear to Hyundai that the joint venture prohibited creativeness and independence that were considered critical to growth. It was the beginning of the path to Hyundai's technological independence.

Efforts for developing indigenous automobile production began in the early 1970s. Hyundai has concentrated on independent development by assembling its own-designed engines several years ago, by forming its own research center in 1970, and is now self-sufficient in most areas of design and manufacturing. For example, Hyundai produced the Pony I with 85 % local content in 1975, followed by the model Pony II, Stellar, and Excel. At the same time, Hyundai has also increased its participation in design, skin layout, the master drawing as well as in detail drawings from 35 % in Pony I to 80 % in

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[7] Hyundai Motor Company, The Twenty-Years History of Hyundai Motor Company, Korea, 1987.

Excels.[8] In 1989, Hyundai's success in developing the new model, "Sonata", reflects this self sufficiency.

Table 3.1: Participation by Korean Engineers in Hyundai's Production

Model	Pony I	Pony II	Stellar	Excel
Period	'74-'75	'80-'81	'81-'83	'82-'84
Skin Layout	20 %	45 %	50 %	60 %
Master Drawing	20 %	45 %	50 %	60 %
Detail Drawing	35 %	70 %	75 %	80 %

Source: Korea Economic Research Institute

In the meantime, Hyundai has also progressed in reducing production costs by implementing a Suggestion System, Quality Control Circles, a Supplier Quality Assurance System, and introducing Supplier Cooperative Association. At the same time, the inventory ratio, that divides sales over inventory assets, has improved from 5.3 in 1970 to 13.3 in 1987.

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[8] Korea Economic Research Institute, "The Automobile Industry," Technological Innovation Process of Korean Industries and Governmental Policies, Korea, April, 1986.

Table 3.2: Inventory Turn Over of Hyundai Motor

Year	'70	'73	'75	'78	'80	'82	'84	'86	'87
ITO	5.3	6.0	4.9	5.6	3.5	7.1	13.9	13.4	13.3

Source: Young-suk Hyun, "The History of Korean Automobile Industry," July 1989.

3.4: THE TOYOTA CASE

These kinds of efforts for technological independence share similarities with the early development of Toyota's "small-lot" production system that has flexibility in adopting new technology and skills, through allowing workers to perform several different machines simultaneously and to do their own maintenance in a small work setting. As a result, workers paid more attention to the whole process of production rather than on individual piece making.

This idea came from Toyota's inability to purchase foreign technology. According to Michael A. Cusumano, Toyota targeted the cultivation of in-house design skills by setting up an inexpensive production system for low volumes. Later, it bought universal machine tools and small stamping presses that were affordable and easily adaptable for model changes. This was the

beginning of Toyota's "flexibility," and Toyota chose not to become affiliated with European or U.S. auto producers, unlike other Japanese auto makers.

At the same time, Toyota adopted the concept of "just-in-time."[9] Since the company did not have in-house production of components, in order to increase equipment utilization and reduce inventories of work in-process, the company had to synchronize subassembly production, parts deliveries, and assembly.

By subcontracting component supplies, Toyota was able to decrease levels of in-house vertical integration between component production and final assembly, while building up networks of lower-wage subsidiaries and loosely affiliated subcontractors.

This kind of production system also stimulated technological transfer from Toyota to its subcontractors, resulting in improvement of the quality of components. The value -added productivity of Toyota subsidiaries tripled from 1960 to 1983, while that of Toyota increased by 2.8 times in the same period.[10]

Therefore, the "small-lot" system practiced by Toyota seems to increase worker's output and utilization of machinery, while subcontracting with component suppliers encouraged them to improve the quality of products

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[9] "Just-in-time" refers to a production practice where components are supplied by subsidiaries and other subcontractors at the time when they are needed, instead of being produced in-house. In that way, the company can save on the costs of inventories and efficiently utilize main production facilities.

[10] Michael A. Cusumano, M. I. T. Working Paper #1817-86.

through technological transfer and competition among themselves.

The lesson the automobile industry in developing countries can learn from Hyundai and Toyota's experience is how these companies have developed their technological capability through independent efforts.

3.5: SUMMARY

In this chapter, we presented the case of the Korean automobile industry in examining the issue of technology independence. It was seen that the automobile industry requires inputs from other capital and technology-intensive industries: great backward linkage. In that sense, technological capability in the production of the automobile reflects the relative stage of industrialization.

First we presented the emerging needs of technological independence. Second, the case of Hyundai Motor Company was presented in conjunction with Toyota's case in Japan, in Hyundai's efforts to develop indigenous technology from its early experience of joint venture with Ford. Both companies have performed better than other auto makers in their respect countries.

Although a technologically independent approach does not guarantee successful technological progress and improvements in production, it has a positive influence on flexibility in production and marketing. As a company

progresses to a more mature level, it seems that it requires a certain degree of indigenous technological capability to compete in global markets.

Although the technological independent approach does not guarantee the successful technological progress and improvement in production, it indicates some positive aspects in flexibility on production and marketing. As a company progresses to upper level, it seems that it requires a certain degree of indigenous technological capability to compete in global markets.

CHAPTER 4: COMPLEMENTARITY BETWEEN LARGE AND SMALL FIRMS

4.1: INTRODUCTION

In Chapter Four, we will explore the complementarity between large and small firms and how small firms can contribute in enhancing the competitiveness of Korean products in world markets as well as in minimizing technological dependence on foreign countries.

As we already mentioned in previous chapters, Korea has an outward-looking economy with high concentration by large firms: the so called big four -- Daewoo, Hyundai, Lucky-Goldstar, and Samsung. The dominance of these large firms has recently been viewed as ineffective for facing new challenges, such as innovation of new products and sophisticated technologies. We will argue that cultivating competitive home-based component suppliers is essential if Korea's economy is to advance into high technology intensive production.

Then, we consider how technological improvement will enhance exports in the future, while maintaining the steady economic growth and the need to service Korea's debt obligations. We examine carefully the trade deficit with Japan, because Korea has incurred the largest bilateral trade deficit with Japan, due to imports of industrial components.

The narrowing of this deficit will mirror Korean industry's technological independence by substituting domestic supply for imported components. Thus,

the bilateral trade deficit represents the heavy technological dependency of the Korean economy on Japanese manufactures.

Technological dependence is one of the major characteristics shared by less developed countries. According to the convergence theory (Kerr, Dunlop, Harbinson and Myers), most industrializing countries will become increasingly alike in the structure of their economies, regardless of their different cultures or political organizations.

Therefore, this research has significance in the implications that it provides other developing countries that follow a similar pattern to the Korean development strategy. Countries that have transformed from early stages to more mature stages of industrialization, will face similar kinds of technological challenges in the near future.

4.2: PROBLEMS OF TECHNOLOGICAL DEPENDENCE

Korea's dramatic speed of industrialization, technological progress, and increasing participation in world markets have caught developed countries by surprise, while its impressive rate of economic growth is envied by other developing countries.

The recent trade deficit, however, that has followed a couple of years of trade surpluses, has raised concern among Koreans. This is both because

Korean economic growth has been largely dependent on exports, and also because Korea still has a huge foreign debt obligation: it is the world's fourth largest debtor. The ratio of debt to gross domestic product(GDP) is 47.7% in 1986.

Korea's external debt is closely related to its cumulative current account deficit and its accumulation of foreign reserves. As the government begins to allow capital outflows and relax import restrictions, expenditures on foreign investment, spending on imports, and on tourism abroad by Koreans have all jumped in recent years. Even though the relaxation of imports is partly an attempt to promote more efficient domestic production through the introduction of foreign competition, this measure has had some undesirable effects on the economy. For instance, capital flight has increased more than four fold from 1989 to 1990.[1]

These two aspects of the Korean economy: its technological dependence and its trade deficit, have important implications for the recent sluggish economic growth. In response to international pressure to lift import restrictions and the Korean people's desire to experience foreign goods, the expansion of markets for Korean exports is crucial for maintaining economic growth.

The high degree of dependency on foreign technology and the technological gap between industries have resulted as a by-product of the rapid

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[1] Han-kyoreh Shinmun(Daily Newspaper), April 9, 1990.

industrialization and adoption of the Japanese development model and its technology.[2] As we see in the Exhibit 2, Korea imports more than 50% of its imports of technology from Japan.

This strategy follows the recommendation of Adam Smith; emphasis is given to promoting economies of scale for efficient utilization of resources, and then competing on the basis of price in the world market. During the past 25 years of Korea's industrialization, export growth has stimulated the inflow of technology and acquisition of know-how and has had a great effect on the structure of Korean industry.

For example, during Korea's heavy industrialization drive, the steel industry was launched with major equity participation by the government, using the Japanese steel industry as its model, and with participation of Japanese firms in plant development as well as in worker training. At the same time, the number and scale of the major conglomerates expanded and focused on technology, diversification , and establishing their brand names.

Woojung Kim, the chairman of Daewoo, mentioned at a recent MIT seminar that Korean firms had to diversify to minimize their business risk from fluctuations of the world economy. Their business growth had largely depended on exports based on borrowed technology. He indicated that the large firms that dominate Korean industry have followed the directive of the government to attain targeted rates of economic growth.

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[2] Please refer to Exhibit 2.

In 1978, value-added production of the 50 largest firms equalled 43 % of GDP, while this same proportion of GDP was shared by only 30 large firms in 1983. These firms also had access to 48 % of total bank credit -- the top five held 24.2 %. The expansion of large firms and the development of industry, with the majority of technological imports coming from Japan, have created a pattern of dependency and imbalanced trade for Korea vis-a-vis Japan.[3]

Although geographical and cultural similarities between Japan and Korea allowed Japan to provide greater technical assistance for Korean industrialization, this kind of adoption and learning created a heavy dependency on certain intermediate goods, such as, steel ingots, some chemicals, electronics and machinery.[4]

With a poor natural resource endowment and a relatively small domestic market, Korea still has to depend largely on exports for its growth. The share of export of goods and services in GNP rose from 8.5% in 1965 to as high as 41% in 1986. However, the recent Korean growth slow-down to less than 7% in 1989, is the smallest increase since 1981.

According to the Bank of Korea, the slowdown reflected a sharp decline in exports, resulting from appreciation of the won and the impact of labor unrest negatively affecting productivity. This underlines how Korea's future

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[3] Please refer to Exhibit 2.

[4] Korea Industrial Research Institute(KIRI), Industrial Technology White Paper, October 31, 1988.

economic growth will depend largely on how well its exports perform.

Korea, however, faces strong protectionism from the United States which is the largest importing country for Korean goods(40% of Korean exports in 1986). In addition, the potential threat from China and other NICs(newly industrialized countries) in labor intensive export markets, forces Korea to move toward more capital and technology intensive industries.

Korea seems to have an advantage against Japan in labor-intensive consumer goods such as clothing, travel goods, various textiles, and some standardized intermediate goods, while it has disadvantages in technologically advanced capital goods. It appears to be increasingly difficult for Korea to pursue its areas of comparative advantage against Japan. Korea is perceived as a competitor to Japan as well as to the other developed countries. Japan now hesitates to locate its production process in Korea, being afraid of technology outflows, called a "boomerang effect", while Japan now imposes restrictions on Korean textile exports.

In response to this measure, Korea has launched a five-year program to reduce the bilateral trade deficit with Japan, with localization of previously imported components and switching imports from Japan to the United States.

The inability to resist pressure to import exerted by the United States and European countries, along with people's desire to taste foreign goods and services domestically, and the threat from other developing countries in its current export markets, implies that competitiveness through technological

progress is a crucial component of Korea's future economic growth.

4.3: THE POTENTIAL CONTRIBUTION OF SMALL FIRMS

In the context of technological independence, efficient technological transfer to small and medium-size firms should be considered an important factor. These firms also should be considered as complementary sources acting as component suppliers for big firms in production rather than a competing agent for the allocation of capital investment.

As we previously mentioned, the biased support of large firms during past Korean industrialization, with its emphasis on the efficient utilization of resources, have left small firms largely neglected.

Since 1980, the small firms's contribution to the Korean economy has improved.[5] Small firms are 97.6% by number of firms, 57.4% in employment, 39.1% in value-added, and 37.% in GNP.[6] Although, as the data indicate, small firms' contribution to the number of firms and employment in the Korean economy is reasonably large, the share of value-added and GNP have been relatively small. One of the major reasons is the lack of organizational capability in production, in terms of technical

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[5] Small firm is defined as a firm with fewer than 300 employees.

[6] 1988 Industrial Technology White Paper, KIRI, Korea, October 31, 1988.

knowledge, size, and financial resources as they try to change their production from light manufacturing to intermediate products.

According to a European case study done by Hans Corsten and Otmar Lang, small and medium sized firms have inherited structural disadvantages stemming from size, including:

- Lacking financial resources
- Lacking information with regards to: potential technology suppliers, solutions towards technical problems, market structure.
- Staff restrictions: lack of qualified personnel, lack of staff, non-acceptance of technical change.

These kinds of problems are also shared by Korean small firms. How these factors have affected these firms in adopting new and sophisticated technology and knowledge should be examined in the particular Korean case.

In the summer of 1989, when I visited the Association for small and medium size firms in Korea, it was mentioned that employers of these firms generally lack information to advance their production capacity and face a shortage of qualified employees in several important managerial sectors. For example, tax breaks given to these firms were mostly left unused, because the costs of hiring an accountant to file for the tax break exceeded the size of the benefit itself. Thus, access to outside information and assistance are very limited for small and medium-size firms.

4.4: TECHNOLOGY TRANSFER AND DIFFUSION

Although small firms face many difficulties in their operation, an European study done by the IFO Institute shows their positive impact on technological progress. A high proportion of European patents(52%) are taken out by this sector. The major sectors of patents applied for in the last five years by small firms until 1986 were in steel construction and mechanical engineering, electrical engineering, and information technology.

The study also found relatively little technology transfer. The sale of know-how is the main method of technology transfer, as well as through the issue of licenses. University-linked technology transfer agencies are also of importance. The bodies most frequently consulted are chambers of industry and commerce, and trade associations, because collaboration with them has proved efficient in the past.

The enterprises regard the following as significant obstacles:

- Lack of information about potential partners
- Lack of confidence in partners
- Lack of staff time

This indicates that technology transfer as part of an innovation policy depends less on direct financial support than on the availability of an information structure. Therefore, the lack of financial resource seems to be less problematic than the lack of information flow to small firms. At the same time, this study shows that small firms certainly have advantages in the

act of technological innovation itself. In addition, two major requirements are essential in improving the efficiency of the process of technology transfer: personal support within the framework of the development of technology transfer, and the availability of an infrastructure that on the one hand takes technical aspects into consideration, and that disposes information about relevant technology suppliers on the other.

Higher transparency of the technology market and the set up of a information infrastructure appear to be the major ingredients for successful technology transfer.

On the other hand, a study of technological diffusion in U.S. biotechnology by Alice M. Sapienza suggests that market forces and established pharmaceutical companies(bureaucratic stolidity) - put pressure on managers for short-term payoffs. Managers tend to adopt marketing efficiency and managerial risk aversion strategies rather than depending on the quality of human resources and investment in R&D.

Sharps also mentions the absence of creativity among large pharmaceutical companies:

> "The flexibility of the small CBSs(commercial biotechnology companies) not only fostered the application of new techniques, but also the conception, design and development of products addressed to markets that were previously nonexistent. It is very likely the environment of a large pharmaceutical company might diminish this creative spirit."

Thus this study shows that the pharmaceutical companies, after rapid expansion and globalization, have transformed into more efficient marketing

organizations than discovery organizations. For instance, R&D expenditure is generally one-quarter of marketing and sales expenses.[7] Therefore, large firms do not necessary contribute their resources for R&D development in the industry, although they have advantages over small firms, in terms of their capacity for seeking finance and easier access to valuable information.

4.5: SUBSIDY

Indicators of technological performance would include the numbers of patents granted, the level of productivity, the shares of new products in sales and the export-import ratio in high-technology products. A study by Henning Klodt in 1987 suggests that Japan's exports of high-tech products are more than four times as high as its imports of high-technology intensive products. At the same time, the most successful exporter of high-technology products has the lowest level of government subsidies. For example, the share of public funds for instrument and motor vehicles, that are the major exports of Japan, is less than 1 %, whereas their share in private funds amounts to 18 %.[8]

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[7] Industry Analysis Division of the U.S. Department of Commerce, "A Competitive Assessment of the U.S. Pharmaceutical Industry," Washington, DC, 1984.

[8] Henning Klodt, "R&D Subsides and Export Performance of Manufacturing Industries," Thechnovation, 7, 1987.

It seems that there is an inverse relationship between direct government R&D support and export-import ratios in high-technology products(aerospace, electrical equipment, machinery, chemicals, instruments,and motor vehicles). He found that one reason for this poor performance is the concentration of governments' R&D subsidies on a few industries.

In the case of developing countries, the major aims of the government to spend, in most cases, is to catch up with other developed countries' technologies. Korea is in the position of defending its world market share by switching its exports from low technology intensive products to high technology intensive products. In the early period of Korean industrialization, subsidies on heavy industry failed somewhat to achieve their initial goal. During the late 1970s, the shipbuilding industry experienced overcapacity. Although government subsidies are an important resource for R&D and technological progress, inefficient use of funds in certain industries should be avoided.

4.6: THE RECENT DEVELOPMENT OF SMALL FIRMS IN KOREA

Small firms in Korea tend to rely heavily on technological acquisition through informal channels such as technical assistance from local R&D institutions, buyers & suppliers of equipment or materials, and technical

journals to raise technological capability, and personnel experience.

This kind of technology transfer has some advantages in terms of low cost, new product development without technological dependence, and the possibility of developing locally-appropriate technology, but there are shortcomings such as a technology gap.[9] A recent study done for 66 firms out of a sample of 90 innovative small firms also shows that these firms achieved technological progress without formal collaboration.[10]

The recently established small firms, however, appear to have better prepared for dealing with this technological gap. For new small technology-based firms, the employment generation tends to be higher than existing firms. These new firms also have invested more in R&D than have the existing ones. The R&D expenditure for the new firms is 24.5 % of sales and 5.1 % for the existing firms. At the same time, the contents of sales of innovative products is 77.1 % for the new small firms and 19.3 % for the existing small firms.[11]

In the meantime, the majority of these enterprises are established by younger entrepreneurs than existing ones and 65 % of these new entrepreneurs formerly held top management positions in large firms. They

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[9] Zong-tae Bae and Jinjoo Lee, "Technology Development Patterns of Small and Medium Sized Companies in the Korean Machinery Industry", Technovation 4, 1986.

[10] Linsu Kim and Youngbae kim, "Innovation in a Newly Industrializing Country: a Multiple Discriminant Analysis," Management Science, Vol. 31, No. 3, 1985.

[11] Korea Economic Research Institute.

had gained manufacturing know-how through their experience prior to operating their own firms. At the same time, 90 % of these entrepreneurs hold a college degree and 15 % of them hold graduate degrees. It is logical that they are mostly engaged in high-technology intensive industries such as microelectronics and computers.[12]

It seems that Korea has begun to undertake an innovative approach to production at the small firm level as society requires more complex technology and sophisticated products. It is also viewed as a positive development as the need for technological independence increases in the face of protectionism of intellectual property rights from other industrialized countries.

In developing small firms' technological capability, the Korean experience shows that creation of markets for these firms is the most important factor, in addition to financial support. This fact reflects that a demand side strategy is more effective than a supply side strategy, because top management is more committed when there are market opportunities and not just the simple availability of R&D subsides.[13] Therefore, the development strategy should be linked between these two stimuli: supply side strategy of financial supports and a demand side strategy of creating market opportunity

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[12] Source: Korea Economic Research Institute.

[13] Linsu Kim et al, "Korea's Entry into the Computer Industry and Its Acquisition of Technological Capability," Technovation, Vol. 6, 1987.

4.7: ALLIANCES BETWEEN SMALL AND LARGE FIRMS

As an alternative strategy for technological progress, it is useful to look at "strategic alliances" and the managing of complementary assets. Reflecting Joseph Schumpeter's idea of the need for radical technological innovation in the vulnerability of established firms to technological discontinuity that inevitably results in their obsolescence, many large firms have tried to pioneer new industries and numerous established firms have been at the forefront in the effort to generate radically new technologies.

These accomplishment are relatively minimal compared to the size of their investments, in the case of semiconductor technology, robotics, personal computers, and new materials. This may explain the arguments of Abernathy and Utterback that the price of product maturity and the quest for efficiency is decreasing receptiveness to radical improvements.

Strategic alliances provide alternatives for collaboration between firms with minimal contamination of the pioneering and entrepreneurial spirit of new technology-based firms. For instance, it may be preferable to ride the dynamics of the environment rather than fight them. Many firms have managed these dynamics through strategic alliances between the large established firm and small firms launched to exploit a new technology. The large firm can supply its accumulated resources, while the small firm supplies its intense efforts focussed on the new technology.

As Michael Porter argues, a disadvantage in a static model of competition can become an advantage in a dynamic one. For example, when there is an ample supply of cheap materials or abundant labor, companies can rest on these advantages and often deploy them inefficiently yet survive; but companies in a nation where these factors do not exist must innovate and upgrade to compete. The absence of competitive supplier industries and other related industries lead to difficulties in international competition.[14]

In addition, internationally competitive home-based suppliers create advantages for down stream industries in several ways. First, they deliver the most cost-effective inputs in an efficient and rapid way. They provide an advantage in innovation and upgrading based on close working relationships. Suppliers and end-users located near each other make the quick and constant flow of communication easier.

Therefore, the interaction between large firms and small firms through subcontracting, supported by technical assistance, would reinforce the industry's ability to compete in world markets. In particular, in technology intensive industries like the automobile industry, large firms can benefit from the complementarity of small firms by economizing capital expenditure in producing components, and in easing the task of managing a huge vertically integrated structure.

At the same time, small firms' flexibility makes it easier for them to

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[14] Michael Porter E., "The Competitive Advantage of Nations," Harvard Business Review, March-April, 1990, No. 2.

adopt changes, and competitive home-based suppliers would certainly provide complementarity for large firms. Therefore, isolated support of large firms through subsidies, cheap loans, and other mechanisms would not desirable. For example, large firms merely depending on cheap labor, a favorable exchange rate, and government supports will not sustain competitiveness in the dynamic and complex world market. Static efficiency is less critical than the need for dynamic improvements in the face of global competition.

Therefore, in Korea, the linkage between large and small firms is crucial in promoting technological innovation and progress. Well equipped and competitive small firms could be instrumental to large firms' growth and their ability to compete in global markets by providing quality and lower priced components to these large firms.

4.8: SUMMARY

Throughout Chapter Four, we have examined the complementarity between small and large firms. First we have observed the emerging need for developing indigenous technology by looking at the trade pattern with Japan. Next, we investigated other means for developing technology; these examples underline the fact that subsidies and direct financial support tend to have less beneficial effect on technological development, as exemplified by the experience

of small firms in Korea.

Therefore, the linkage between small firms and large firms will enhance effective technological transfer from large firms to small firms, while large firms provide markets and technical assistance for small firms, and small firms supply quality components essential to domestic producers at lower prices. Market creation for small firms is also highlighted as the most crucial factor in enhancing the technological capability of small firms. As mentioned earlier, the commitment of top management is a key factor for technological progress. Competition for market opportunities among these small firms will play a great role in the improvement of production.

This kind of alliance is crucial to Korea, due to the business environment it faces in the global market: increasing protectionism for its exports, the potential threat from other developing countries in the existing export markets, and increasing demands for quality products by domestic customers with the relaxation of import restrictions.

In Korea, it seems that the firms already have taken substantial efforts in R&D investment and in development of indigenous technology among different levels of firms and sectors of industry. Future study will consider the following issues: how Korea can serve its own economic development by enhancing its technological capability, as well as serving other developing countries in their economic development.

CONCLUSION

Throughout the thesis, I have discussed technological development from the perspective of developing countries. These countries tend to develop their technological capability through adaptation of foreign technology in the beginning of their industrialization, through informal and formal channels of technology acquisition.

First, the Korean case suggests that a less developed country progresses in its technological capability through three stages of development: acquisition/implementation, assimilation, and improvement. In each stage, accumulation of knowledge and skills occur and this eventually enables the creation of indigenous technology and product.

In order to achieve technological progress, there are some critical elements. For example, the educational level of labor, the industrial infrastructure, the receptiveness of management skills, entrepreneurship, and government industrial policy appear to be important factors in contributing to technological progress.

At the same time, this pattern of technological progress is distinct from the experience of developed countries. The major reasons are that developing countries lack knowledge and skills in basic and applied science and technology, including lack of financial resources. In that sense, I have tried to examine how less developed countries are able to develop their technological capability in enhancing economic growth through examining the

Korean case. Therefore, the Korean case shows that analyzing technological development from the perspective of developed countries can be misleading, considering less developed countries, when they gradually improve their ability to develop new technologies and products.

Second, in observing the process of technology transfer, I have considered joint ventures, licensing agreements, and the role of multinational firms, including government policy toward technology adaptation. It was shown that the joint venture and licensing agreements have some limitations as the economy matures, and at the firm level they put constraints on flexibility for creativity and expansion of production.

Although these channels of technology transfer are efficient on grounds of cost and speed, they tend to be less effective means of technology transfer in the later stages of economic development. I hope to consider specific Korea case studies in later research to document this claim.

Third, I have addressed the technological independence issue when facing increasing international protectionism and intense global competition. Hyundai's example is presented in evaluating the need for technological "self-reliance." In Hyundai's early experience, technological dependency created severe constraints on management and on production ability, and technology transfer tends to be less efficient when the technologically superior partner is not fully committed to the joint project. Since adopting an independent strategy, Hyundai has been the most successful auto producer in Korea.

Finally, I have suggested alternative ways to enhance the competitiveness of local firms in Korea. In doing that, I have attributed the bilateral trade deficit with Japan to the import of industrial components. Therefore, the narrowing of this deficit will reflect changes in technological independence, to some degree.

I have provided an overview of the effects of R&D policy in other countries, in addition to the case of Korean small firms. The results show that the demand side of policy, enhancing market opportunities, is the major incentive for small firms to innovate. At the same time, direct public subsidies and financial support tend to be less effective.

This study has undertaken research based more on a theoretical framework rather than on actual experience. In a way, it lacks some relevant evidence, which would enhance my findings for technological progress in less developed countries, but it provides a conceptual understanding for technological development from the perspective of less developed countries. I hope, in later research, to make clearer findings to assist technological development in less developed countries, not for merely its own sake, but so that it may be used to better people's lives.

LIST OF EXHIBITS

EXHIBIT 1

Foreign Technology Allowances by Field and Year

	'67-'71	'72-'76	'77-'81	'82	'83	'84	'85	'86	'87	Total
Agriculture & Livestock	6	-	55	3	4	5	1	2	3	79
Food	6	7	30	21	21	24	19	16	23	167
Pulp & Paper	4	3	7			1			2	17
Textile	2	10	12	7	7	2	1	7	8	56
Chemical Textile	5	14	29	23	23	29	14	17	29	183
Ceramic & Cement	11	9	34	6	6	10	14	11	25	126
Oil Refine & Chemical Industry	59	85	195	50	50	64	64	95	128	790
Drug	17	8	31	6	6	19	5	13	8	113
Metal	28	45	105	22	22	21	24	21	31	319
Electronic & Electrical Equip.	65	84	205	79	79	78	125	131	163	1009
Machinery	58	116	403	82	82	123	126	153	146	1289
Shipbuilding	1	10	45	21	21	17	25	17	13	170
Communication	13	10	21	7	7		3	6	2	69
Electricity	2	7	37	5	5	4	5	2	7	74
Construction	3	4	25	9	9	14	5	5	5	79
Others	5	22	42	20	20	26	23	21	44	223
Total	285	434	1276	361	362	437	454	517	637	4763

Note: All units are number of cases

Source: 1988 Science and Technology Annual, Ministry of Science and Technology, Seoul, Korea, March 15, 1989.

EXHIBIT 2

Foreign Technology Allowances by Nation

	1962-81	1982	1983	1984	1985	1986	1987	Total	Percentage
U. S.	466	68	77	99	114	157	180	1161	25%
Japan	1125	164	201	217	228	264	307	2506	53%
Germany	93	14	20	36	29	23	35	250	5%
France	46	16	10	23	14	19	40	168	4%
U. K.	14	14	13	14	21	11	21	164	3%
Other	177	32	41	48	48	43	54	443	9%
Total	1977	308	362	437	454	517	637	4692	100%

Note: All units are number of cases

Source: 1987 Report for Technology Imports, Korea Industrial Research Institute, Seoul, Korea, March 1988.

EXHIBIT 3 - a

GNP & INVESTMENT 1962-1986
(in billion won at 1975 market price)

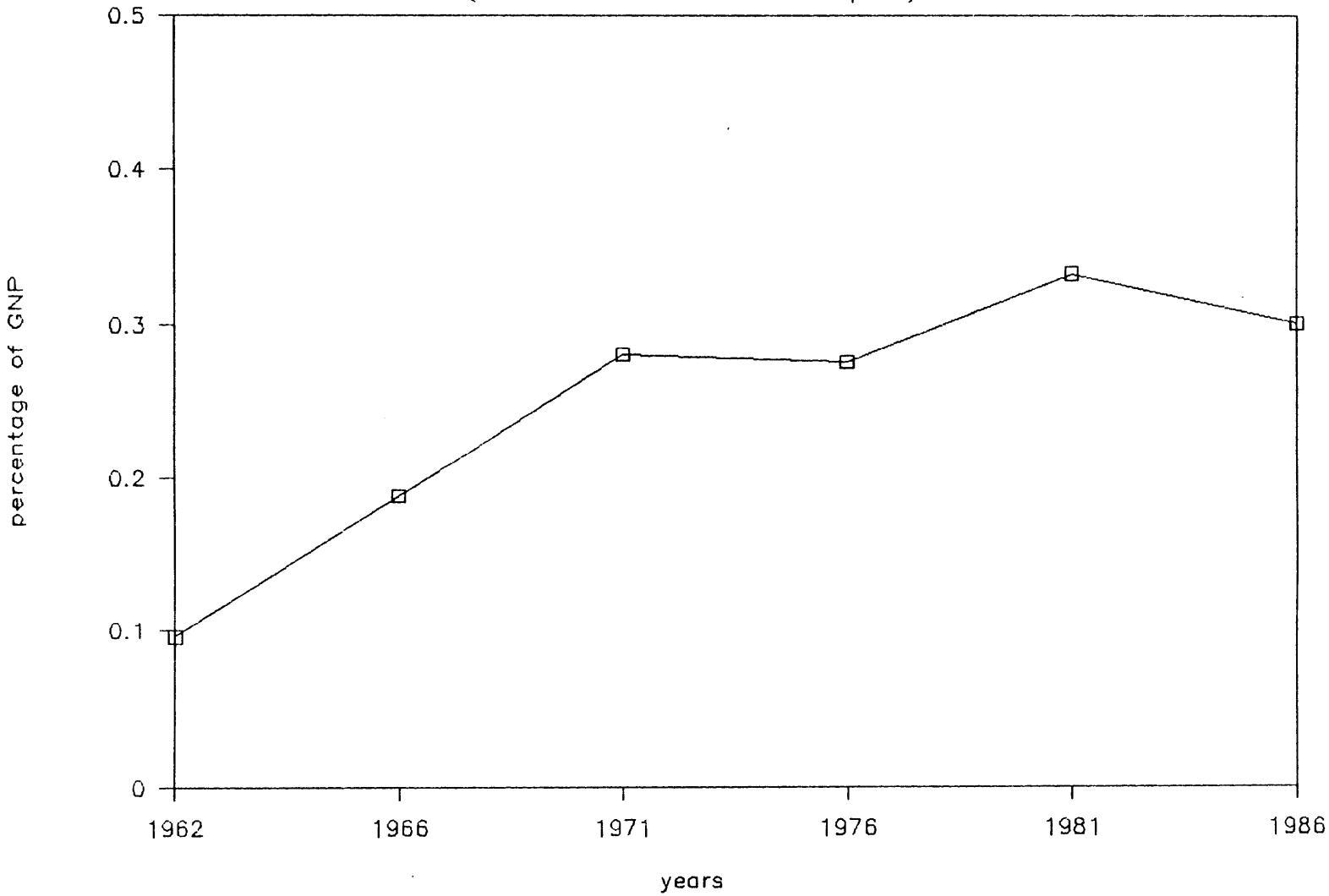
	1962	1966	1971	1976	1981	1986
GNP	3071	4378	6962	11276	14724	22600
Investment	295	824	1955	3112	4892	6800
Investment/GNP	9.61%	18.82%	28.08%	27.60%	33.22%	30.09%

Source: Bank of Korea

EXHIBIT 3 - b

INVESTMENT/GNP 1962–1986

(in billion won at 1975 market price)



Source: Bank of Korea

EXHIBIT 4 - a

R&D INVESTMENT
(in billion won at 1975 market price)

	1980	1981	1982	1983	1984	1985	1986	1987
Public Funds	2155	2385	2886	2767	3065	3601	4332	5776
Percentage	68	59	52	38	32	28	26	28
Private Funds	1014	1658	2664	4515	6512	9261	12331	14853
Percentage	32	41	48	62	68	72	74	72
Total	3169	4043	5550	7282	9577	12862	16663	20629

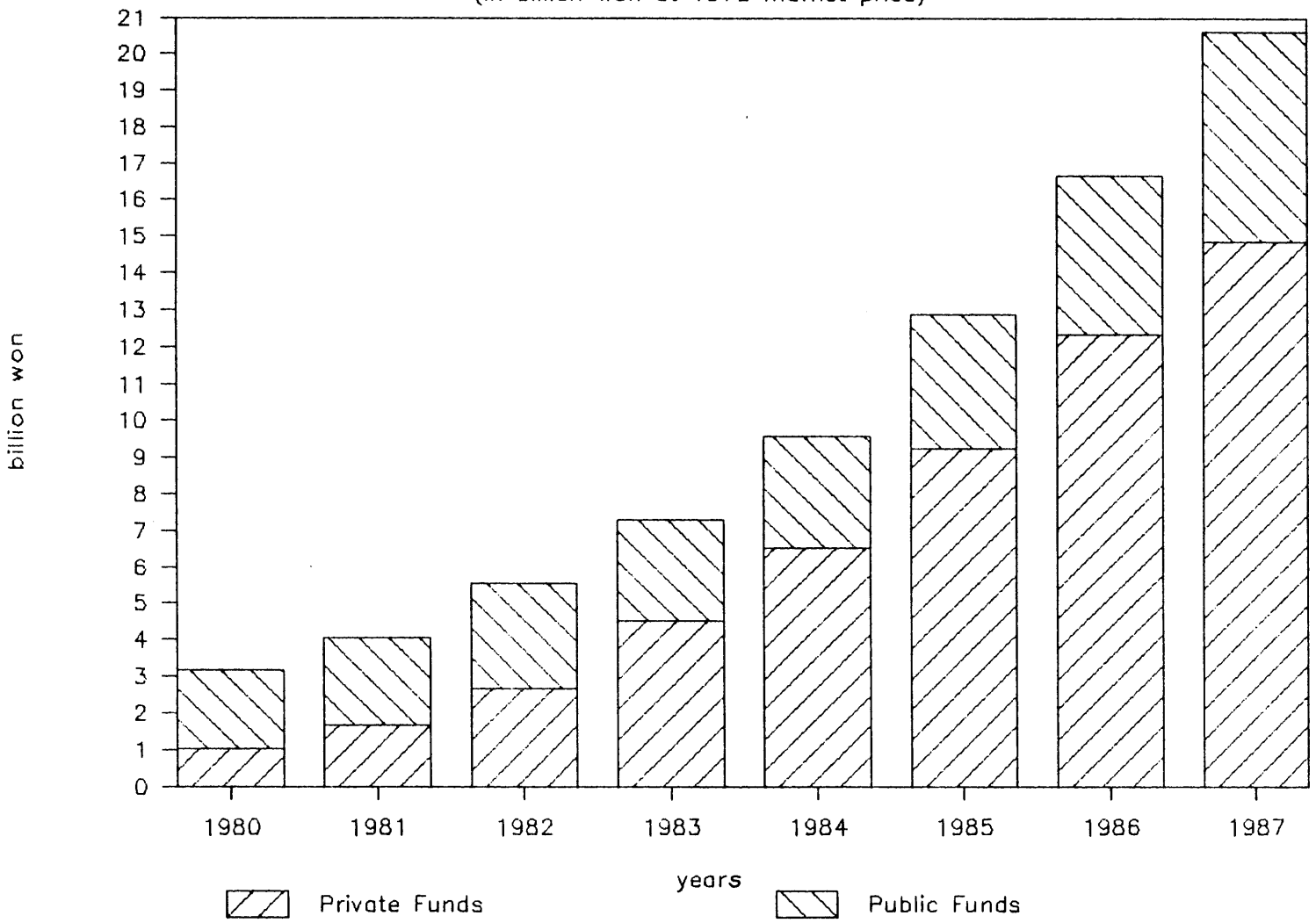
Note: Investment in social science excluded

Source: Science and Technology Annual

EXHIBIT 4 - b

R&D INVESTMENT

(in billion won at 1975 market price)



Source: '88 Science and Technology Annual

EXHIBIT 5

Patents Granted by Nationality and Year

Nationality	1982	Percentage	1983	1984	1985	1986	1987	Percentage
Total	2609		2448	2365	2268	1894	2330	
Korean	274	11%	245	297	349	458	596	26%
Foreigner	2335	89%	2203	2068	1919	1436	1734	74%

Source: The Office of Patents Administration, Seoul, Korea, 1988

EXHIBIT 6

Korea Automobile Production

		1986	Percentage	1987	Percentage
Passenger car	Production	457383		793125	
	Domestic Sales	156464	34%	249319	31%
	Exports	298878	65%	535231	67%
Bus	Production	36386		58431	
	Domestic Sales	34880	96%	54010	92%
	Exports	605	2%	2312	4%
Truck & other	Production	107777		128800	
	Domestic Sales	96907	90%	117092	91%
	Exports	6886	7%	8767	7%
Total	Production	601546		980356	
	Domestic Sales	288251	48%	420421	43%
	Exports	306369	51%	546310	56%

Note: The discrepency between production and sales is inventory.

Source: Korea Automobile Association.

EXHIBIT 7

Foreign Technology Allowances by Large and Small Firms

	'62-'66	'67-'71	'72-'76	'77-'81	'82-'86	1987	Total
Large Firms	26	178	293	796	1042	264	2599
(Percentage)	78.79%	62.46%	67.51%	64.98%	50.14%	41.38%	55.39%
Small Firms	7.00	107.00	141.00	425.00	1030.00	367.00	2077.00
(Percentage)	21.21%	37.54%	32.49%	34.69%	49.57%	57.52%	44.27%
Others	0.00	0.00	0.00	4.00	6.00	6.00	16.00
(Percentage)				0.33%	0.29%	0.94%	0.34%
Total	33	285	434	1225	2078	638	4692

Note: All units are number of cases.

Source: 1987 Report for Foreign Technology Allowances, Korea Industrial Research Institute, March 1988.

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