KOREA JOURNAL OF POPULATION AND DEVELOPMENT
Volume 21, Number 1, July 1992

KOREA'S TECHNOLOGY POLICY FOR INDUSTRIALIZATION: IMPORTED TECHNOLOGY FOR ECONOMIC DEVELOPMENT

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This paper examines the ways in which Korea's industrial technology has been developed from imported technology. The major feature of Korean technological policy was the fostering of indigenous technology through research centers established in both public and private sectors. Conspicuous in its policy is the stress on a factor mix in which labor is the dominant element. Having realized a successful industrialization, Korea faces the problems in meeting competition from countries with more efficient industries as well as those with lower labor costs. Korea has to promote its own technological innovation, complemented by imported technology.

INTRODUCTION

Industrialization with imported technology corresponds with the Korean experience, in which the imported technology has resulted in structural change, cost reduction, and indigenous innovation in industrial production. Imported technology is the communication, adaptation, and use of technology passed from industrial countries (ICs) to developing countries (DCs). Technology is imported through foreign direct investments, foreign licensings and foreign consultants, and it is also imported by means of imported capital goods, studies abroad and subcontracting.

This paper examines the ways in which Korea's industrial technology has been developed, absorbed, and internalized from imported technology, an experience which is of relevance to development theories as well as to development policy. Section I presents a theoretical model of economic development derived from a production function associated with technology in a developing economy. Section II centers on Korea's technology policy, and Section III examines imported technology and its effect on industrialization. Section IV deals with present-day constraints and challenges with respect to Korea's technology development.

THEORETICAL MODEL OF TECHNOLOGY AND INDUSTRIALIZATION

A change in technology means producing more goods with the same input or producing the same quantity of output with less input. Figure 1 shows this phenomenon, demonstrating combinations of input necessary to make a given amount of output. Then, imported technology leads to economizing input, the same output with less input, and more output with the same input. A schematic model of imported technology depicts that both isoquants signify the same output over time and with altered input.

Furthermore, imported technology may be accompanied with expanded production through accompanying economies of scale and the learning curve effect, which result in lower cost curves. Figure 2 shows three successive average total cost curves which incorporate economies of scale and learning-curve effect. Their combined effects would result in reduction of unit cost of production, with the minimum points of the three cost curves, q_1, q_2, q_3.

Imported technology, thus, is an important factor in increasing productivity, quality, and output. Diffusion of imported technology takes time and

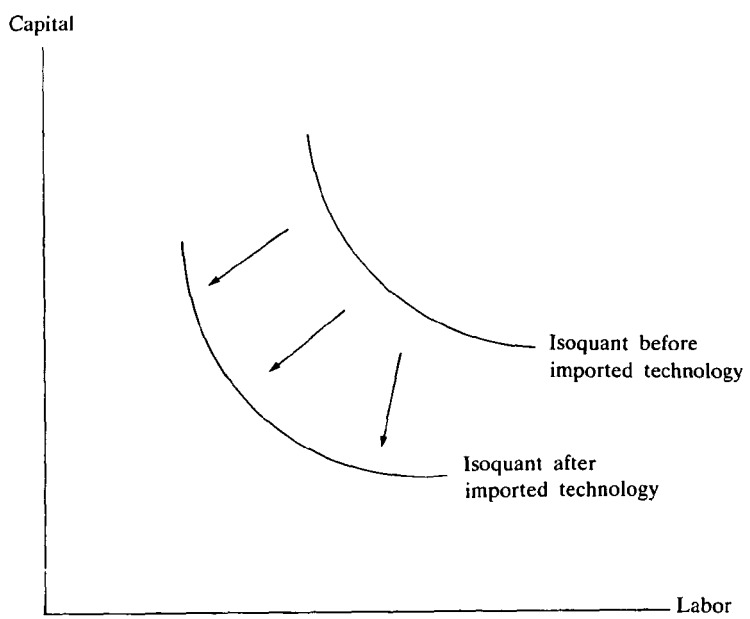

FIGURE 1. PRODUCTION FUNCTION WITH VARYING TECHNOLOGIES

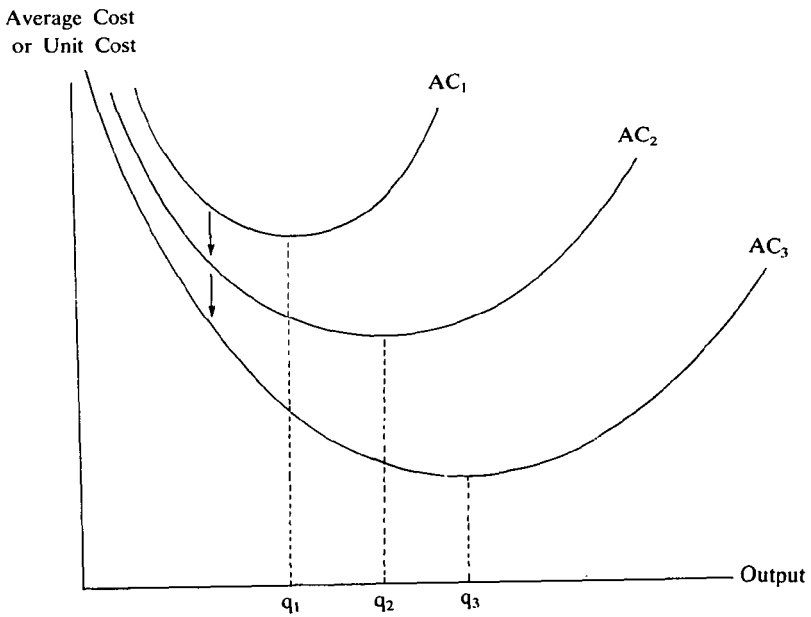

FIGURE 2. TECHNOLOGY IMPACT ON COST CURVE

involves risk and costs. Because of the complexity of the importation process, government may participate in the process with institutional arrangements and strategic (target) industries to provide logistic supports such as introduction of public enterprises, lower rates of interest, and favorable taxation under the rationale of infant industry policy.

Based on the Hecksher-Ohlin theory, a country produces goods for export using intensively its abundant production factor, and conversely, imports products that use intensively its scarce factor, while conventional trade theory assumes free availability of information and given production functions. Vernon's product cycle theory maintains that the flow of technology (information and skill) is restricted, and that products undergo predictable sequences in production and marketing over time.[1] Conspicuous in contemporary technological development, particularly as regards product cycle, new products are theories of product growth and product maturity.

[1]The product cycle implies that a series of shifts in major trading commodities of ICs influences the product composition of other trading countries (Vernon 1966, pp. 190-207; Chiang 1989, pp. 339-349). And in similar vein, "Flying Geese" paradigm is a Japanese version of product cycle, which implies Japan with its larger economy and higher technological level is the lead position (Akamatsu 1961, pp. 196-215; Yamazawa 1990, pp. 27-48).

Accordingly, development economists argue that DCs find it cheaper to purchase new technology rather than develop it, since R & D costs have already been incurred. Futhermore, by the time a specific technology is made available to DCs, industries in ICs are likely to have recovered the major portion of the fixed costs and thus DCs may be able to buy the technology at a reduced price, based on its much smaller marginal cost. For example, Edwin Mansfield's study on technological progress in the American economy over 30 years showed that imitators can on average make a new product for two-thirds of the cost and time that it took the innovators.[2]

In addition there might be ample room for negotiation, realizing the gains from technology transfer for both ICs and DCs. The decision to select a given technology from an IC must be based on a clear understanding of the country's potential and the constraints to which it is subject. The successful transmission of technology to DCs requires that they have adequate technological absorptive capacity. Empirical studies show macroeconomic policy has played a significant role in establishing the required level of absorptive capacity.[3]

KOREA'S TECHNOLOGY POLICY

Korea's way of acquiring foreign technology was to maximize its own uniqueness (idiosyncracies) by encouraging the development of 'native' technology at the same time that it acquired imported technology.

Korea has encouraged the development of indigenous technology and has acquired those technological elements that have not been developed at home. The major result has been to give Korea a strong bargaining position vis-à-vis ICs. Furthermore, as ICs move to higher technological level, Korea has picked up existing machinery and technology at bargain prices. In this way it was able to secure favorable terms from industrial countries crucial to Korea's bid for technology. In implementing this policy the government took various measures to improve the position of technology transfer negotiations and its technological capability. These measures involved coordination and planning for its international search efforts for suitable technology.

The imported technologies made Korea attain efficiency and effectiveness through the operation of the learning curve and economies of scale. As Korea undertook production associated with imported technology, the learning curve was realized as production workers' skill level became enhanced

[2]Besides the returns on technological investment, Mansfield (1990, pp. 17-30) also analyzed social implications.

[3]Government approach is typified with the case of Korea (Ranis 1990, pp. 157-178; Gereffi 1990, pp. 90-109).

over time. And, as observed in most manufacturing industries, economies of scale came about with unit cost reduction as fixed cost spread over larger volumes of production along with an "S"-shaped path of imported technology.

Granted that the diffusion followed an "S"-shaped path, and that the initial cost of production associated with imported technology was high, it was reduced drastically at the next stage. The "S" path meant that the innovation took place slowly at first, then the adaptation came about with improvement engineering.[4]

Korea instituted drastic economic measures after 1961, which constituted a new track of industrial and trade policy. Korea's policy was to utilize its endowed resources and abundant labor supply for industrialization with imported technology. The government took initial steps to organize national policy for imported technology. However, as industrialization had to be undertaken from scratch, serious constraints existed everywhere in the form of insufficient capital, inferior technology, inadequate demand for industrial products, and poorly developed infrastructure.

Korea's imported technology is characterized by modification and adaptation; the country develops its own way of using technology and capital goods including reverse engineering. Machinery and technological application are handled in simpler ways than originally designed to better suit the workers were in the early stage of industrialization. As long as simpler ways have resulted in the desired production, not only have output goals been reached, but Korean management and workers have gained confidence and have undertaken further improvement and adaptation from sophisticated technology transfer. Korean industries have husbanded their supplies of capital while utilizing abundant labor supplies. Obsolete machinery has been purchased for producing goods for the home market and for training workers to be employed in export-oriented industries.[5]

However, the Fourth Five Year Plan (1977-1981) was a turning point toward a heavy and chemical industrialization drive. To meet growing requirements for higher levels of technology, the government introduced various new devices and incentives for importing technology and promoting domestic R & D activities.

[4]Technology diffusion is the effective use of technological knowledge, through continuous technological effects to assimilate, adapt and create technology including improvement engineering (Sharif 1988, pp. 201-208; Kim, Y. 1978, pp. 34-38).

[5]By modifying imported technology and implementing reverse engineering, Korean industries husbanded their supplies of capital while utilizing abundant labor supplies (Magaziner and Partinkin 1989, pp. 83-92; Kim, Y. 1989, pp. 217-223).

Korea was technologically undeveloped and capital-poor in the 1960s. Its technology policy was conditioned on the acquisition of technology from abroad. During the period 1962-1976 Korea implemented two types of technology policy. First, industries such as fertilizer, petroleum refining, and cement were selected to produce materials for the infrastructure and to provide basic input. Second, Korea imported standardized technology for promoting labor-intensive light industries in order to increase employment and to expand exports.

In the 1970s the policy focused on the development of heavy and chemical industries with imported technology. During the period 1973-1983, imported technology increased 19.2 percent annually in terms of number of contracts (see Table 1). Imported technologies were classified based on type of channels, whether they were obtained through private business sources such as firms, or government, international organization, or universities.

TABLE 1: CONTRACTS AND PAYMENTS FOR KOREA'S IMPORTED TECHNOLOGY

	Licensing Argeements		Engineering Consultancy		Imported Technology	
	Number of Contracts	(US$ millions)	Number of Contracts	(US$ millions)	Number of Contracts	(US$ millions)
1973	67	11.5	28	5.3	95	16.8
1974	86	17.8	44	4.1	130	21.9
1975	99	26.5	57	2.2	156	28.7
1976	131	30.4	61	6.1	192	36.5
1977	168	58.1	94	9.2	262	67.3
1978	296	85.1	105	9.7	401	94.8
1979	288	93.9	131	14.3	419	108.2
1980	222	107.1	120	9.1	342	116.3
1981	247	107.1	101	12.4	348	119.5
1982	308	115.7	125	19.6	433	135.3
1983	360	149.5	190	73.3	550	222.8
			Growth Rates (in perentages)			
1973-83	25.9	29.2	21.1	30.0	19.2	29.5
1984	437	213.2				
1985	454	295.5				
1986	517	411.0				
1987	637	523.7				
1988	751	676.3				
1989	763	930.3				

Source: Ministry of Science and Technology (Seoul, Korea), *Science and Technology Annual*, 1984; Ministry of Finance (Seoul, Korea), *Imported Technology Annual*, 1989.

The government played an indispensable role in importing technology and its application in targeted industries. In order to achieve this objective, the government exercised substantial powers so as to encourage industries which undertook risk ventures of technology transfer and its application to production. Industrial policy was shaped by technology policy. For example, the government set up public ventures in targeted industries, but later on transferred them to private control, supported by special loans and tax incentives. In 1973, the government announced six target industries: steel, petrochemicals, nonferrous metals, machinery, shipbuilding, and electronics. Pohang Iron & Steel Company and Korea Petrochemical Company were established as public enterprises; both were later sold to the private sector.[6]

The technology policy was designed to efficiently implement imported technology so as to coordinate and stimulate domestic R & D activities. The Ministry of Science and Technology in 1967 was established as the central government policy making, planning, coordinating, and promotional body, as an umbrella organization which supervises overall technology policy.[7]

The Korea Institute of Science and Technology was established in 1966 as an autonomous multidisciplinary industrial research institute. Its function is to bolster the industrial sector, eliminating bottlenecks which hinder planned industrial growth. Subsequently, the Korea Advanced Institute of Science (KAIS) was established in 1971. It is a mission-oriented post-graduate school in selected fields of applied sciences and engineering. One of the functions of KAIS was to educate a sufficient number of high calibre scientists and engineers to meet the emerging needs of industries.

These agencies have been typical of government bodies established to facilitate technology policy by initiating, planning, and coordinating the targeted research, both public and private. The agencies have also contributed to form human capital, thereby upgrading training to overcome bottlenecks in manpower supply as industrialization progressed. They have participated in selecting and administering imported technology so as to facilitate suitable licensing and foreign consultants for industries.

For example, the Korea Institute of Electronics Technology (KIET) was established in 1976. It was responsible for coordinating and planning semiconductor research and development; for importing, assimilating, and disseminating imported technology; and for market research. Operating with close consultation with private companies, KIET took part in all imported technology

[6]Korea, with its involvement with Japan and the U.S., offers a very vivid example of adapting imported technology (Eros and Park 1989, pp. 56-58; Kim, Y. 1991, pp. 31-51).

[7]The necessary technology was not simply bought from ICs. Careful local technological support nets of native technology were developed at the same time (Arnold 1989, pp. 440-444).

negotiations between Korean firms and foreign firms, and as an example of a public enterprise, accomodated itself to the need of the private sector.

As big firms (*chaebols*) expanded their in-house research and development capacity, KIET changed its role from applied technology research to basic research focused on the technology frontier. In the process it changed its name to Electronics and Telecommunications Research Institute (ERSO). The KIET may be characterized as having a "big followership" and ERSO may be viewed as having a "big leadership" role.

The government introduced a law for the Promotion of Technology Development in 1972 in order to encourage industries to finance their own R & D activities. It also financed R & D activities jointly with private enterprises. Moreover, the Law for the Korean Science and Engineering Foundation of 1976 provides encouragement of research centers around universities and supports science and engineering for planned industrialization. The government designated targeted industries as monopolists or oligopolists in its drive for technology acquisition so as to restrict competition by foreign firms that might threaten domestic industries.

In summary, since the 1970s, Korea has built up considerable technological capability through continued expansion of investment in indigenous R & D and imported technology. The major feature of Korean policy for imported technology was the fostering of indigenous technology through research institutions established in both private and public sectors. Most conspicuous in its policy was the emphasis placed on the factor mix in which labor was the dominant element in its initial industrialization drive.

This policy might well foreshadow a contribution to policy makers of DCs.[8] The critical feature of imported technology is its modification, adaptation and diffusion; the country develops its own way of using imported technology and capital goods so as to realize indigenous production engineering and reverse engineering capability. Machinery and technological application were handled in Korea's own unique ways than originally designed since workers were poorly equipped with skill and production know-how. As learning curve, management know-how and economies scale were realized with government involvement, it moved forward a lower level of production cost and a higher level of absorbing imported technologies, since the various mission-oriented institutions were designed to encourage and enhance the utilization and application of imported technology to domestic industries.

[8]The crucial problem DCs face is what to choose and how to select technology suitable to their endogenous resources (Kim, L. 1991, pp. 223-283).

IMPORTED TECHNOLOGY AND INDUSTRIALIZATION

Korea faces an international technology market that is typically oligopolistic and imperfect. While some technologies are available at low cost, many are expensive and subject to tight control. In addition, the ability to make use of imported technology depends on an industry's absorptive capacity. A country or an industry which possesses sufficient absorptive capacity is able to dispense with imported technology once it has internalized imported technology.

The experience of Korea's industrialization indicates that imported technology may be highly efficient. As rising labor costs in electronics, automobiles and machinery threaten competitiveness in world markets, Korean industries are launching an overall restructuring of industry toward more technology intensive, higher value-added products. Korea's technology takes into account not only economies of scale but also dynamic dimensions of the learning curve. In order to realize technology-intensive industrial structure, Korea has sufficiently promoted the development of targeted industries and reduction of costs to compete in world markets. As to specific examples, during the 1980s electronic equipment and automobiles made in Korea began to be exported. Korean industry now stands at the threshold of transition from labor-intensive to technology-intensive manufacturing. Advances in Korea's electronic industry, for example, although it dates back to the 1970s, did not begin large scale production until the 1980s. Korea's electronic industries are attributable not only to the enormous capital invested, but also to heavy reliance on imported technology.[9]

Korea needs to invest heavily in industrial technologies in order to support the capabilities of the target industries, to improve productivity, and to bring forth a continuing stream of new products. To encourage private investment, the government has put in place investment inducement plans that reward research and development and new venture activities in this sector. In response, investment in technology development has accelerated. In 1987, the nation's total technology investment was 2.12 percent of the GNP; it improved to 2.40 percent in 1988.

Private initiative in R & D more than tripled from 1982 to 1986. Private firms' R & D expenditures as a percentage of total sales revenue have risen to 1.87 percent in 1988. The largest R & D investments have been made in electric and electronics, precision instruments, machinery, chemistry, and

[9]The Korean economy has now become so sophisticated and complex, and it has moved to high value-added industries (Kim, Y. 1991, pp. 87-100).

transportation equipment industries.

These statistics seem impressive, but the rate of R & D investment of 1.93 percent of the Korean GNP in 1987 is still far below the normal range of rates of 2.57 to 2.81 percent of the GNP prevailing in ICs. According to the comparisons made by Korea Industrial Technology Promotion Association, the total amount of Korea's R & D investment in 1987, $2.37 billion, is a paltry sum. It amounts to a mere 1/50 of the US R & D investment and 1/26 of Japan's investment in the same period. The most serious impediment to Korea's technology development is the shortage of high quality research workers. In order to continue its industrial expansion Korea has to undertake substantial investment in higher education. What is necessary, hereby, is government support of scientific education.

The most tangible results of Korea's recent emphasis on technology development are improvement in manufacturing technologies and concurrent improvement in both quality and productivity in existing product lines. Labor productivity in the mining and manufacturing sector made a healthy recovery since the last quarter of 1986. Improvement continued also in the manufacturing sector. The Korea Productivity Center reports that the primary cause of the improvement is the widespread application of automation. The overall success of Korea's development of new technologies and the burgeoning of its high technology industries remains to be seen. Korea's industrial policy fosters industrialization through science and technological application in accordance with imported technology. This policy can be broadly viewed as a form of government sponsorship in order to implement targeted industrialization.

From the mid-1970s on, the government has served principally as a coordinator for the business sector, encouraging entrepreneurs through incentives and administrative guidance by signaling certain priorities to the business sector. In other words, Korea's technology policy was shaped to implement imported technology as an important vehicle of its industrial transformation. Through effective monitoring institutions Korea has been able to speed up the absorption of imported or generic technology which enhanced productivity and domestic R & D.

CONSTRAINTS AND NEW CHALLENGE

The necessary technology was not simply bought from ICs, but careful domestic support networks of indigenous technology were developed at the same time. A country cannot rely on imported technology without evolving its own research and development institutions.[10]

[10]Korea's success was costly and effortful (Byun and Kim 1992).

Korea geared closely to the needs of big business whose export expansion was linked with imported parts and components. The availability of Japanese parts and components allowed Korea's big business to expand their production and export, further repressing the growth of small- and medium-size producers of parts and components. This phenomenon led to structural weakness in trade and industries.

The government support of big business has resulted in increasing domination of conglomerates in manufacturing (referred to in Table 2). This policy has served as an impediment of the growth of small- and medium-size businesses. Diffusion of imported technology from big business to smaller business has not occurred, because this was not in big business's interest. Korean industries have heavily increased export volume, but in doing so they were dependent on imported parts and components, mainly from Japan.

This precarious situation has not been generally realized. To export, Korea must import intermediate goods from Japan, thereby incurring further trade deficits with Japan.[11] This structural weakness creates the imbalance of bilateral trade. For example, Hyundai Motor Company's exports grew more than tenfold during 1984-87; Hyundai's Excel was highly successful in Canada and the United States. But many parts of the Excel's components were Japanese, including the Mitsubishi-made engine and transmission. Korean automobile producers are not fully independent of Japan, as shown most recently by another Hyundai model, Sonata, which has many components from Japan.

The availability of imported parts and components has caused big business to bypass small- and medium-size firms which otherwise might have become a dependable source of components of export products. *Chaebol* industries

TABLE 2. CONGLOMERATES' SHARE IN MANUFACTURING (in Percentage)

	Sales			Employment		
	1978	1980	1982	1978	1980	1982
Top 5 firms	15.7	16.9	22.6	9.5	9.1	8.4
10 firms	21.1	23.8	30.2	13.9	12.8	12.2
20 firms	29.3	31.4	36.6	18.2	17.9	16.0
30 firms	34.1	36.0	40.7	22.2	22.4	18.6

Source: World Bank, *A World Bank Country Study: Korea,* Volume 2, 1987, p. 32.

[11]Korean electronic producers also depend on Japan for the bulk of their technology, including key components and parts. For example, Samsung and Goldstar have long standing relationship of technology imports from Japanese producers (Kim, Y. 1990, pp. 79-87; Cronin 1990, pp. 484-498).

dominate all levels of the Korean economy, in contrast to the industrial organization of ICs and Japan especially.

This presents yet another problem. The industrial structure resulting from "big push" policy is inflexible. The *cheabols* are unable to respond quickly to changes in market demand in ICs market due to scale constraints in existing operating facilities.

Further growth in Korea is challenged as well by rising labor costs, a 40% increase in 1988 and a 43% increase in 1989 (see Tables 3 and 4). The government, formerly repressive to labor, has assumed a more neutral posi-

TABLE 3. WAGE LEVEL BY COUNTRIES: HOURLY LABOR COSTS (in US$)

Country	Year			
	1987	1988	1989	1990
Korea	1.78	2.50	3.57	4.16
Taiwan	2.26	2.82	3.53	3.98
Hong Kong	2.09	2.40	2.79	3.20
Singapore	2.31	2.67	3.15	3.78
Japan	10.83	12.80	12.63	12.84
USA	13.40	13.85	14.28	14.83

Source: U.S. Department of Labor, quoted by *Korea Trade Focus*, Vol. 13, July 25, 1991, p. 3.

TABLE 4. ANNUAL CHANGES IN WAGE LEVEL BY COUNTRIES (in Percentage)

Country	Year			Average Annual Growth Rate	
	1988	1989	1990	1980-85	1985-90
Korea	40.4	42.8	16.5	5.6	25.2
Taiwan	24.8	25.2	12.7	8.4	21.6
Hong Kong	14.8	18.0	20.0	2.8	13.1
Singapore	15.6	18.0	20.0	10.6	8.9
Japan	18.2	−1.3	1.7	2.8	14.8
USA	3.4	3.1	3.9	5.7	2.7

Source: The same as Table 3.

tion, so that labor has pressed for and achieved higher wages and improved working condition. Big business has been able to accommodate most of the workers' demands. But small- and medium-size firms' production is more labor intensive, and these firms have been injured by rising labor costs. Given their limited resources, many of these small- and medium-size firms were unable to resist long strikes and thus had to capitulate to high cost labor contracts. This situation contrasts markedly with that of Japan, with its long tradition of docile labor force.

CONCLUSION

For most DCs which have not built necessary technology support networks, Korea represents the right paradigm. This vast technological strategic unpreparedness stems from the simplistic view of technology as a simple hardware/software item, while in fact, technology is a complex social relationship tying together workers, institutions and their skills. In this context Korea appears to be one of the refreshing examples of achieving industrialization.

Having realized a successful industrialization, however, Korea now faces formidable constraints in the export-led economy. Because of Korea's rising labor costs, such countries as China and Thailand have become challenges in labor-intensive industrial exports, and other more advanced DCs such as Taiwan and Mexico present stiffer competition in the world market.

Korea is seriously hampered in obtaining technology from ICs. Fearful of boomerang effects, ICs are reluctant to transfer technology and Korea finds itself in the crossroad at the cutting edge of technology. At the same time, Korea's big industries are situated in economic inflexibility in the face of changing world demand.

In conclusion, it faces the problems in meeting competition from countries with more efficient industries as well as those with lower labor costs. Korea is now finding itself increasingly difficult to rely on imported technology for product innovation and process technologies which it must have for meeting challenges in global competition.

Korea must muster the human capital, financial and other resources for domestic R & D needed to maintain a continued industrial growth path, complemented by imported technology. Korea has to promote its own technological innovations that are essential in meeting the constraints imposed on her in the changing world economy.

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