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MANAGEMENT OF TECHNOLOGY IN NEWLY INDUSTRIALISING COUNTRIES:

LESSONS FOR AFRICA

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Executive Summary

Technological development has been recognised as the key driving force in economic development not only in industrially advanced countries but also in Newly Industrialising Countries (NICs). Korea, for instance, suffered from almost all the difficulties facing most poor countries today. But its economy grew at an average rate of almost 9 percent through the mid-1990s, raising its GNP per capita in current prices from $87 in 1962 to over $10,000 by 1995. Korea's export increased from a mere $40 million to over $125 billion during the same period. Korea began exporting primary goods in the 1950s, but semiconductors, automobiles, telecommunications system and industrial plants became major export items in the 1990s. How did Korea and other NICs do it?

This paper first presents four analytical frameworks – technology trajectory, technology policy/strategy, absorptive capacity and technology transfer. These frameworks provide useful analytical tools to discuss technology policies and strategies in developing countries.

Then, using the absorptive capacity framework – knowledge base and the intensity of effort - as a structure for presentation, this paper discusses the Korean experience of technology policies and strategies. At the initial mature technology stage, the three most import sources of building the knowledge base for Korea were education, foreign technology transfer and the mobility of experienced technical people. First, Korea invested heavily in education at all levels. The expansion of education more rapidly than economic progress, however, created a serious unemployment problem of the educated. But the subsequent development of the economy soon absorbed the surplus. Second, Korea heavily imported foreign technologies, mostly through such informal mechanisms as reverse engineering of the existing mature foreign products. Third, the mobility of experienced technical and managerial personnel brought about the effective diffusion of imported technologies throughout the economy.

At the same time, both the Korean government and top management had used four major means to enhance the intensity of effort: export promotion, the hasty creation of heavy and chemical industries (HCIs), technology transfer strategy and crisis construction. First, export promotion forced Korean firms to continuously strengthen their competitiveness in the international market. As a result, export-oriented sectors grew far faster than local market-oriented sectors. Second, the hasty creation of HCIs without adequate preparation in technological capability, more for building a self-reliant national defence capacity than economic purposes, forced local firms to assimilate imported technologies far faster than otherwise in order to increase capacity utilisation, expediting technological learning. Third, Korea restricted foreign direct investment (FDI) but promoted instead technology transfer through other means such as capital goods imports in the 1960s. Such a policy forced Korean firms to expedite learning in order to assimilate and integrate technologies imported from multiple sources into a workable system. Fourth, many Korean firms constructed crises proactively either in response to or in the absence of externally evoke crises by setting ambitious goals as a means to expedite technological learning.

Korea continued to strengthen its technological capability by enhancing its Research and Development (R&D) activities at the intermediate and emerging technology stages. These two subsequent stages, however, are less relevant to Africa than the initial stage is. Nevertheless, the paper briefly discusses the Korean experience at the two stages for future reference.

The Korean experiences are not necessarily Korean idiosyncrasy at the general level. Many studies conducted in other countries provide similar findings. NICs in Asia such as Taiwan and Singapore and in Latin America such as Brazil and Argentine have gone through a similar process. Japan and the United States in their history of early industrialisation had also undergone a similar process. These experiences offer useful lessons for Africa.

African countries may have to launch their industrialisation on the basis of abundant low-cost labour force, maximising comparative advantage in labour-intensive industries at the mature technology stage. At this stage, on the supply side of technology, it is important to introduce public policies and corporate strategies that develop sufficient technological capability to undertake imitative reverse engineering of mature foreign products without infringing intellectual property rights. For this purpose, human resource development, liberal policy on brain drain, management of foreign technology transfer, local efforts to develop capabilities are in order. First, aggressive investments in human resource development not only at the primary education level but also at the secondary and tertiary levels are important prerequisite. Second, a liberal brain drain policy is recommended. Such a policy allows the migration of scarce scientists and engineers to advanced countries but sows important seeds for the future. Korea and Taiwan benefited most from these scientists and engineers abroad at the subsequent stages. Third, foreign technology transfer through foreign direct investment and licensing is an essential source of building knowledge base for developing countries, but does not transfer little more than production technologies. Fourth, it is essential for local firms to develop their own capabilities to strengthen their bargaining power in technology transfer and to expedite the assimilation of the imported technologies.

On the demand side of technology, export promotion, competition policy and crisis construction may be useful tools for the governments in Africa to stimulate the demands for technology and capability. First, export promotion can be the most influential mechanism to stimulate local efforts in building technological capability. For that reason, studies show that countries with export-oriented industrialisation grew far faster than those with import-substituting industrialisation did. Second, infant industry protection is necessary for the initial stage of industrialisation, but it is essential to deploy policy instruments to ensure competition even in the local market. Third, both the government and corporations can construct crises proactively by imposing ambitious goals to expedite technological learning.

Entrepreneurship promotion, balanced industrial structure and effective management of national innovation system are other important lessons Africa could learn from the experiences of other developing countries.

1. Introduction

Technological advance has been recognised as the key driving force in economic development. Technological advance accounted for the lion's share of economic growth in advanced countries. Similarly, the acquisition and progressive mastering of technologies has also been a central aspect of NICs that have grown so rapidly over the past thirty years (Pack and Westphal, 1986; Kim, 1997a).

After the early 1960s, countries such as Republic of Korea (hereafter Korea), Taiwan Province of China (hereafter Taiwan) and Singapore have transformed themselves from technologically backward and poor countries to relatively modern and affluent economies. Each now has a significant collection of industrial firms producing technologically complex products and competing effectively against firms based in advanced countries.

For instance, Korea has transformed itself from a subsistent agrarian economy into a newly industrialising country in one generation. As late as 1961, Korea suffered from almost all the difficulties facing most poor countries today. Korea's per capita GNP was less than that of Sudan and less than one-third that of Mexico in 1961. But beginning in 1962, the Korean economy grew at an average annual rate of almost 9 percent through the mid-1990s, raising GNP per capita in current prices from $87 in 1962 to over $10,000 by 1995, which was almost 20 times that of Sudan and 2.5 times that of Mexico. Korea's export increased from a mere $40 million in 1960 to $125 billion in 1995, with virtually all of the increase in goods that Korea did not know how to produce at the start of the era.

In the mid-1960s, Korea began exporting textiles, apparels, toys, wigs, plywood and other labour-intensive mature products. Ten years later, ships, steel, consumer electronics and construction services from Korea challenged established suppliers from the industrially advanced countries. By the mid-1980s, computers, semiconductor memory chips, videocassette recorders, electronic switching systems, automobiles, industrial plants, and other technology-intensive products became Korea's major export items.

Korea is now working on such next-generation products as multimedia electronics, high-density television, personal communication systems and a new type of nuclear breeder. Vogel (1991) concludes that no nation has tried harder and come so far so quickly than Korea, by moving swiftly from handicrafts to heavy industry, from poverty to prosperity, from inexperienced imitators to modern planners, managers and engineers. Korea, alongside with some other Asian countries is undergoing considerable turmoil due to some macroeconomic mismanagement and insufficient regulation of its financial system. However, it is a temporary problem that will soon be solved, because Korea has a strong technological base and is determined to expand the modern sectors efficiently (Pack, 1999).

The key question is: "How did Korea and other NICs do it?" Many political leaders and economic planners in other developing countries, including African countries have shown keen interest in studying the Korean experience to see if what made Korea successful could be emulated in their own countries. This paper is a response to this keen interest.

This paper first presents four analytical frameworks - technological trajectory, technology policy/strategy, absorptive capacity and technology transfer - that may be used as tools to discuss technology policies and strategies in developing countries. It will then discuss similar evidence in other NICs. Lastly, the paper draws the lessons of technology management in Korea and other countries for Africa. NIC

2. Analytical Frameworks

2.1 Technology Trajectory Framework

This framework analyses and integrates two technological trajectories: one in advanced countries and the other in developing countries. Technological trajectory refers to the evolutionary direction of technological advances that are observable across industries.

<u>Technology trajectory in advanced countries</u>

According to Utterback (1994), industries and firms in advanced countries develop along a technology trajectory made up of three stages - fluid, transition and specific.

- Firms in a new technology area will exhibit a fluid pattern of innovation. The rate of radical (rather than incremental) product innovation is high. The new product technology is often crude, expensive and unreliable, but it fulfils a function in a way that satisfies some market niches. Product changes are as frequent as market changes are, so the production system remains fluid, and the organisation needs a flexible structure to respond quickly and effectively to changes in market and technology (Abernathy and Utterback, 1978; Utterback, 1994).

- As market needs are better understood and alternative product technologies converge or drop out, a transition begins towards a dominant product design and mass production methods, adding competition in price as well as product performance. Cost competition leads to a radical change in processes, driving costs rapidly down. Production capability and scale now assume greater importance to reap scale economies.

- As the industry and its market mature and price competition grows more intense, the production process becomes more automated, integrated, system-like, specific and rigid, turning out a highly standardised product. The focus of innovation shifts to incremental process improvements, seeking greater efficiency.

  When the industry reaches this stage, firms are less likely to undertake R&D aimed at radical innovations, becoming increasingly vulnerable in their competitive position. Industry dynamism may become regenerated through invasions by radical innovations introduced by new entrants (Anderson and Tushman, 1990; Cooper and Schendel, 1976; Utterback and Kim, 1985). Often these are innovations generated elsewhere that migrate into the industry. Some industries, however, are quite successful in extending the life of their products in this specific state with a series of incremental innovations to add new values (Baba, 1985). It is at the later part of this stage that industries are typically relocated to developing countries where production costs are lower. The upper part of Figure 1 depicts the above model. This technology trajectory model may change significantly with a shift in the techno-economic paradigm (Freeman and Perez, 1988). The Utterback model, however, is still useful in analysing technology management issues in developing countries.

Technology trajectory in developing countries

On the basis of research in several different industries in Korea, we developed a three stage model - acquisition, assimilation and improvement - to extend Utterback model (Kim, 1980).

- At the early stage of their industrialisation, developing countries acquire mature (specific state) foreign technologies from industrially advanced countries. Lacking local capability to establish production operations, local entrepreneurs develop production processes through the **acquisition** of "packaged" foreign technology, which includes assembly processes, product specifications, production know-how, technical personnel, and components and parts. Production at this stage is merely an assembly operation of foreign inputs to produce fairly standard, undifferentiated products. For this purpose, only engineering efforts are required.

- Once the implementation task is accomplished, production and product design technologies are quickly diffused within the country. Increased competition from new entrants spurs indigenous technical efforts in the **assimilation** of foreign technologies in order to produce differentiated products. Technical emphasis is placed on engineering and limited development rather than research.

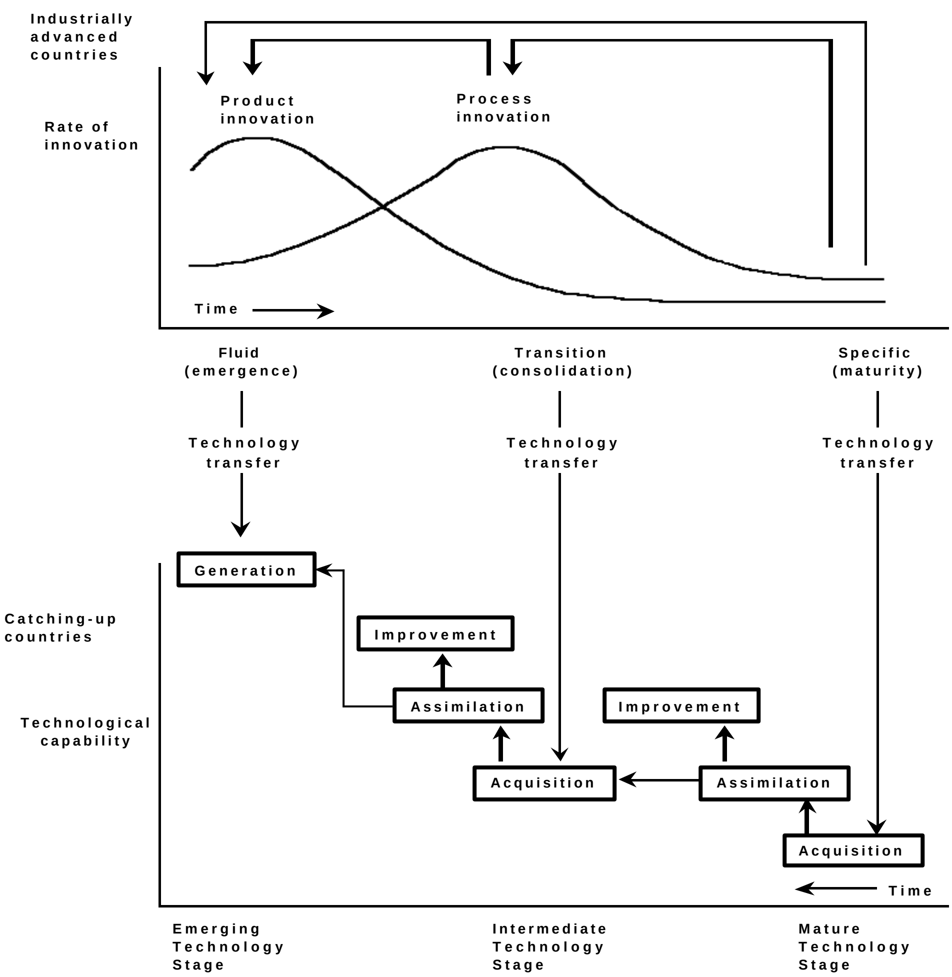
- The relatively successful assimilation of general production technology and increased emphasis upon export promotion, together with the increased capability of local scientific and engineering personnel, lead to the gradual **improvement** of mature technology. Imported technologies are applied to different product lines through local efforts in research, development and engineering.

Integration of the two trajectories

Linking the technology trajectories of Utterback (1994) and Kim (1980), Lee, et al (1988) postulate that the three-stage technology trajectory in developing countries takes place not only in mature technology at the specific stage but also in intermediate technologies at the transition stage.

As shown in Figure 1, firms in developing countries, which have successfully acquired, assimilated and sometimes improved mature foreign technologies, may aim to repeat the process with higher-level technologies at the transition stage in advanced countries. Many industries in the first tier developing countries (e.g., Taiwan Province of China and Korea) have arrived at this stage. Some successful Korean industries have accumulated enough indigenous technological capability to generate emerging technologies at the fluid stage and challenge firms in advanced countries. Innovation is the watchword in these industries. When a substantial number of industries reach this stage, the country may be considered an advanced country.

Figure 1. Technological Trajectories



In other words, as shown in the lower part of Figure 1, developing countries reverse the direction of technology trajectory in advanced countries and evolve from the **mature** technology stage (for duplicative imitation), to the **intermediate** technology stage (for creative imitation) and to the **emerging** technology stage (for innovation).

2.2 Technology Policy/Strategy Framework

What can the government do to facilitate technological learning at individual firms under such a dynamically changing global technology environment? Technology policy may be analysed from three perspectives: market mechanism, technology flow and time (Kim and Dahlman, 1992).

Market mechanism perspective

This perspective emphasises both the demand supply side of technology development. It divides policies related to technological development into three major components: (i) policies designed to strengthen the demand side, creating market needs for technology; (ii) policies designed to strengthen the supply side, increasing science and technology (S&T) capabilities; and (iii) policies designed to provide effective linkages between the demand and supply sides, with a view to making innovation activities both technically and commercially successful.

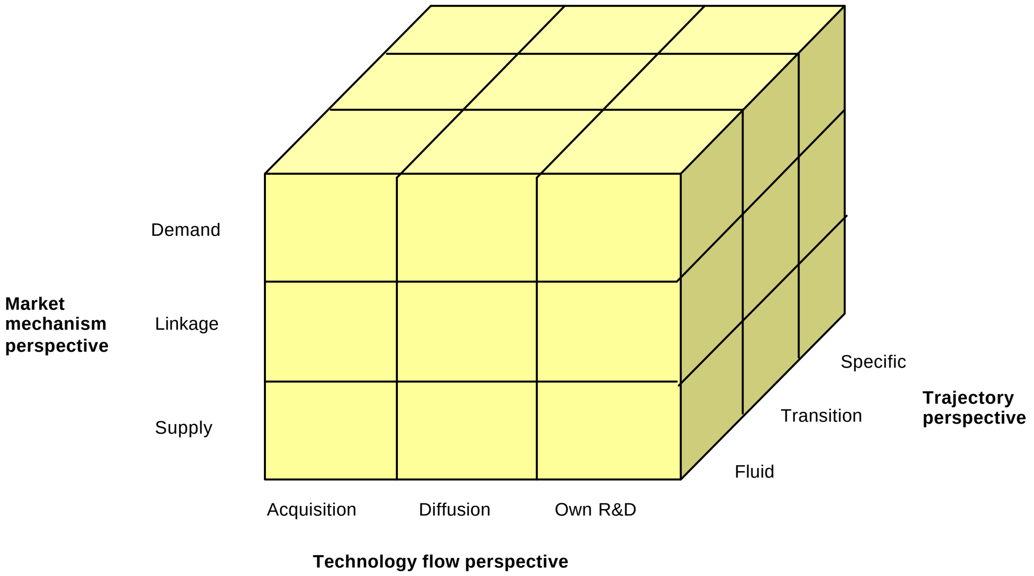
The market mechanism perspective argues that given the uncertain and risky nature of innovation, there will be little investment in innovation activities, unless there is a competitive market. S&T policies therefore need to be an integral part of the overall industrial policies, which shape market structure and industrial development. At the same time, countries without indigenous technological capabilities will not be able to grow industrially, even if the market mechanism calls for the introduction of new products and processes. Then a good management of the research and development (R&D) system is also necessary, which effectively links demand with supply. Few innovations will actually take place with an effective linkage between demand and supply, even in the presence of both demand for innovation and supply of technological capabilities.

Technology flow perspective

Government policies related to technology development may also be assessed from the technology flow perspective. This perspective is mainly concerned with three key sequences in the flow of technology from abroad to developing countries: (a) transfer of foreign technology, (b) diffusion of imported technology and indigenous R&D to assimilate and improve imported technology, and (c) to generate own technology.

The first sequence involves technology transfer from abroad through such formal mechanisms as FDI, the purchase of turnkey plants and machinery, foreign licenses and technical services. Effective diffusion of imported technology within an industry and across industries is a second sequence in upgrading technological capability of an economy. The third sequence involves local efforts to assimilate, adapt and improve imported technology and eventually to develop one's own technology. These efforts are crucial to augmenting technology transfer and expediting the acquisition of technological capability. Technology may be transferred to a firm from abroad or through local diffusion, but the ability to make effective use of it is not easy to transfer. This ability can only be acquired through indigenous technological effort.

Figure 2. An Integrative Model: Technology Policy



<u>Dynamic perspective</u>

The two perspectives outlined here - market mechanisms and technology flow - may be combined as illustrated in Figure 2. The dynamic perspective is added as the third dimension to reflect the technological trajectory framework presented earlier. This dimension is very important. The impact of technology flow and market mechanisms will change as industries in developing countries advances through different stages of development.

The integrative framework presented in Figure 2 can also be applied to technology strategies in the private sector. First, it is important for firms to have effective strategy for the acquisition of foreign technology, the diffusion of imported technology within the firms and in-house R&D. Second, the firms also need to have effective strategy in creating the demand of new technology in the market, developing supply (R&D) capability and coupling the market demand with R&D capability. Finally, such strategies need to change along the reversed evolution from the mature technology stage to the emerging technology stage.

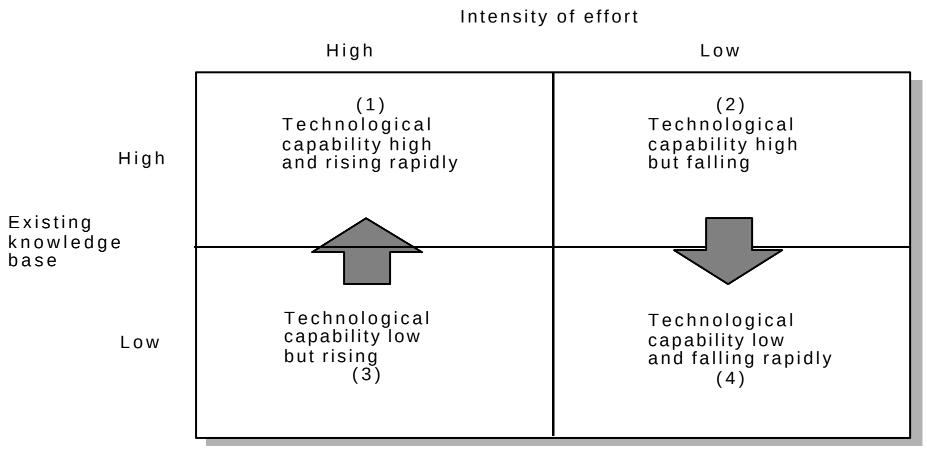
2.3 Absorptive Capacity Framework

Technological capability is acquired through the process of technological learning. And effective technological learning requires absorptive capacity, which has two important elements: existing knowledge base and the intensity of effort (Cohen and Levinthal, 1990).
First, existing knowledge is an essential element in technological learning, as knowledge today influences learning processes and the nature of learning to create increased knowledge tomorrow. Accumulated existing knowledge increases the ability to make sense of, assimilate and use new knowledge. This aspect of absorptive capacity is related to

strengthening the supply of technology. Second, the other important element is the intensity of effort or commitment. The intensity of effort refers to the amount of energy relinquished by the organisational members to solve problems. It is insufficient merely to expose firms to the relevant external knowledge without exerting effort to internalise it. Learning how to solve problems is usually built up over many trials on related problems. Thus, it requires considerable time and effort directed at solving problems early on before moving on to solving the more complex problems. The effort intensifies interaction among the organisational members that in turn facilitates technological learning at the organisational level. This aspect of absorptive capacity is related to creating the demand of technology.

These two variables - existing knowledge base and the intensity of effort - in the organisation constitute, as presented in Figure 3, a 2x2 matrix that indicates the dynamics of technological learning. When both existing knowledge and the intensity of effort are high (Quadrant 1), technological capability is high and rapidly rising. On the contrary, when both elements are low (Quadrant 4), technological capability is low and falling. Organisations with high existing knowledge and low intensity of effort (Quadrant 2) may have high capability now but will gradually lose it, as existing knowledge will become obsolete as technology moves along its trajectory. Those organisations will gradually move down to Quadrant 4. In contrast, organisations with low existing knowledge but with high intensity of effort (Quadrant 3) may have low technological capability now, but will acquire it rapidly, as both continuous and discontinuous learning can take place through significant investment in learning, moving progressively to Quadrant 1. In short, it can be said that the intensity of effort or commitment is a more crucial element than the existing knowledge is for long-term learning and competitiveness of the firm.

Figure 3. Absorptive Capacity



2.4 Technology Transfer Framework

How then can firms build the level of the existing knowledge base? Technology transfer from foreign firms in advanced countries can be a very important source of new knowledge for firms in developing countries. Such transfer has two dimensions for analysis: market-mediation and the role of foreign suppliers. In the first dimension, technology transfer may or may not be mediated through the market. In market-mediated technology transfer, the supplier and the buyer negotiate payment for technology transfer, which may be either embodied in or disembodied from the physical equipment. Foreign technology may also be transferred to local users without the mediation of market; in this case the technology transfer usually takes place informally without written agreements and payments (Fransman, 1985).

In the second dimension, the foreign supplier may take an active role, exercising significant control over the way, in which the technology is transferred to and used by the local recipient. Alternatively, the supplier may take a passive role, having almost nothing to do with the way the user takes advantage of available technical know-how either embodied in or disembodied from the physical items. These two dimensions - the mediation of market and the role of foreign suppliers - offer a useful 2x2 matrix, as shown in Figure 4, to identify and evaluate different mechanisms of international technology transfer (Kim, 1991).

In other words, firms in developing countries have many alternative mechanisms for acquiring foreign technology. Foreign direct investment, foreign licensing and turnkey plants are major sources of formal technology transfer in Quadrant 1. Contract research with local universities and government research institutes becomes an important source of Quadrant 1, as industrialisation progresses in developing countries. The purchase of capital goods transfers machine-embodied technology (Quadrant 2). Foreign suppliers and original equipment manufacturer (OEM) buyers often transfer critical knowledge to producers to ensure that the producers’ products meet the buyers' technical specifications (Quadrant 3) (Kim, 1991). Printed information such as sales catalogues, blueprints, technical specifications, trade journals and other publications, together with observation of foreign plants, serve as important informal sources of new knowledge for firms in developing countries (Quadrant 4) (Kim and Kim, 1985). In addition, reverse brain-drain or return of native foreign-trained professionals and moonlighting foreign engineers give significant rise to technological learning of the firm in developing countries (Kim, 1993). If firms in developing countries have absorptive capability, they can effectively acquire foreign technology informally without any transaction costs (Quadrants 3 and 4).

Figure 4. Technology Transfer Framework

The role of foreign suppliers

	Active	Passive
Market mediated	Foreign direct investment, foreign licensing, turnkey plants, technical consultancy, made-order machinery (Cell 1)	Standard(serial) machinery (Cell 2)
Non-market mediated	Technical assistance by foreign buyers, technical assistance by foreign vendors (Cell 4)	Imitation, (reverse engineering) observation, trade journals, technological information service (Cell 3)

3. Technology Management in Korea

Most developing countries have tried to industrialise their economies. Yet, the majority of them have made little progress; only a few have managed to make a significant stride in catching-up. Korea is one of them. How has Korea managed to achieve such a phenomenal growth in building technological capability in only three decades? This section first presents Korea's initial setting in the 1960s, which is relevant to Africa. It then discusses Korea's experience as a case in point, using the absorptive capacity framework as a structure of presentation.

3.1 Initial Setting

After the fall of Japanese colonial rule, arbitrary division of the nation into North and South and the ensuing civil war between 1945 and 1953 flattened Korea as `a nation with little left of its past and facing a bleak future' (Mason, et al., 1980). In spite of U.S. aid, which brought Korea back to the pre-war economic level, Korea suffered from almost all the problems facing most resource-poor, low-income countries today. Korea began as the poorest country among NICs today with a far lower technical base but has achieved phenomenal industrial development in a generation.

3.2 Technology Management in the Mature Technology Stage

The mature technology stage did not necessarily take place at the same time in all mature industries in Korea. Duplicative imitation began in such light industries as textiles, toys, plywood and consumer electronics in the 1960s and in such heavy industries as automobile, steel, shipbuilding and machinery in the 1970s. How then have Korean firms acquired the existing knowledge base (the supply side of technology) and enhanced the intensity of effort (the demand side of technology) to expedite technological learning in these industries?

Existing knowledge base

The three most important sources of building the existing knowledge base for Korea at the mature technology stage were education, foreign technology transfer and the mobility of experienced technical people.

First, Korea's first major move towards building the knowledge base was in education. This can be seen in the growth of government investment. The share of education in the total government budget rose from 2.5 percent in 1951 to over 17 percent by 1966. Government expenditures, however, accounted for only one-third of the total expenditures in education, the remainder being borne by the private sector and parents, reflecting the high commitment for education within Korean society. This commitment was the strongest in Korea among eight industrialised countries (Denmark, Germany, Italy, Japan, Sweden, Switzerland, the United Kingdom and the United States) and two developing countries (Singapore and Korea), as Porter (1990) found.

Enrolment at the various levels of the formal education system has increased rapidly since 1953. Elementary school enrolment has grown more than five times. Even faster growth is seen in the secondary and tertiary education levels. School enrolment as a percentage of the corresponding age group rose to over 100 percent by 1970 for the elementary school level. Although secondary and tertiary education was not free, the enrolment ratio rose from 21 percent in 1953 to almost 99 percent in 1994 for the middle school level and from 12 percent to almost 89 percent for the high school level during the same period. University enrolment has also expanded rapidly from 38.4 thousand in 1953 to 1.15 million in 1994. The enrolment at junior colleges and universities as percentage of corresponding age group grew from 3.1 in 1953 to 48.8 percent in 1994. As a result, the illiteracy rate dropped to 27.9 percent by 1960, to 10.6 percent by 1970 and to an insignificant level by 1980.

Several other developing countries attained as an equally rapid growth rate in elementary education as did Korea. But what was unique in Korea was the well-balanced expansion at all levels of education early enough to support its economic development. Using data from the late 1950s for seventy-three developing countries, Harbison and Myers (1964) found three nations – Korea, Taiwan and Yugoslavia – with levels of educational achievements far above what would be expected, given their levels of economic development, reflecting the high commitment for education within the Korean society.

The more rapid expansion of education more rapidly than economic progress, however, created a serious unemployment problem of the educated. But the formation of educated human resources laid an important tacit knowledge base for the subsequent development of the economy, which soon absorbed the surplus.

Second, lacking technological capability at the outset of its economic development, Korea’s second major move to build knowledge base was to rely on foreign technology imports. Korea's policies on foreign licensing were gradually relaxed in 1970 and 1978. As a result, royalty payments for foreign licensing significantly increased from $0.8 million during the first five-year economic development plan period (1962-1966) to $451.4 million in the 4th five-year economic development plan period (1977-1981). This increase is insignificant compared to foreign licensing in the subsequent periods in the 1980s. Most foreign licensing in early years was associated with technical assistance needed to train local engineers to run turnkey plants.

In contrast to the gradual relaxation of government control on foreign licensing, Korea was one of the few countries with very restrictive regulations on FDI, when technology was not a critical element and mature technologies needed could be easily acquired through mechanisms other than FDI or foreign licensing (e.g., reverse engineering). Consequently, the size of FDI and its proportion to total external borrowing were significantly lower in Korea than in other NICs. For example, Korea's stock of FDI in 1983 was only 7 percent of that in Brazil, 23 percent of that in Singapore, and less than a half of that in Taiwan and Hong Kong. The proportion of FDI to total external borrowing was only 6.1 percent in Korea compared with 91.9 percent in Singapore, 45 percent in Taiwan, and 21.8 percent in Brazil. The comparative figure reflects Korea's explicit policy of promoting its "independence" from the Transnational Corporations (TNCs) in management control. As a result, unlike these other countries, FDI had a minimal effect on the Korean economy. For example, FDI's contribution to the growth of GNP in Korea in the 1972-1980 period amounted only to 1.3 percent, while its contribution to total and manufacturing value added was only 1.1 percent and 4.8 percent, respectively, in l971, and 4.5 percent and 14.2 percent, respectively, in 1980.

Instead, Korea promoted technology transfer in the early years through the procurement of turnkey plants and capital goods. The rapid growth of the Korean economy required commensurate growth in investment for production facilities. Government policy had, however, been biased in favour of the importation of turnkey plants and foreign capital goods as a way to strengthen international competitiveness of the capital goods using industries. Such a policy led to massive imports of foreign capital goods at the cost of retarding the development of the local capital goods industry. Protection of the machinery industry was relatively low until the first half of 1971, giving capital goods user almost free access to foreign capital goods. For example, chemical, cement, steel and paper industries, established in the 1960s and early 1970s, all resorted to the purchase of turnkey plants and foreign capital goods for their initial set-up.

Under such a policy environment, Korean firms relied heavily on foreign sources for both explicit and tacit knowledge. The majority of important or crucial tacit and explicit knowledge needed to solve technical problems at the mature technology stage could, however, be obtained free of charge through non-market mediated informal mechanisms (Quadrants 3 and 4 in Figure 4). This mode of technology transfer has clearly prevailed in innovative small firms. Large Korean firms, however, resorted to turnkey plant transfer or technical licensing agreements with foreign suppliers (Quadrant 1 in Figure 4). Given the scale of the large investment required and the lack of technological capability and experience in the early years, large firms relied on foreign suppliers to ensure swift construction, smooth start-up of their production processes and manufacturing of goods to meet stringent OEM specifications (Kim and Lee, 1987). Informal technology transfer has, however, been most significant in further broadening the capabilities of both large and small firms (Westphal, et. al, 1985; Kim, 1997a).

Third, the mobility of experienced technical people was one of the most effective ways for late-entrants to acquire the necessary tacit knowledge base. The majority of consumer electronics producers in the 1970s entered the industry by poaching experienced managerial and technical people from existing firms. For instance, the first four large black and white television set producers entered foreign licensing to acquire the initial knowledge base, but the remaining eleven relied on the mobility of experienced personnel from the first four firms (Kim, 1980). State-owned large chemical and machinery companies in the 1950s and 1960s relied completely on turnkey transplant and foreign engineers for the initial knowledge base, but engineers who accumulated modern production experience in these firms spun-off later to private enterprises to provide the crucial knowledge base there. Many studies show that a quantum leap in technological capability in small firms is commonly associated with the arrival of technical personnel recruited from other firms (Kim and Kim, 1985; Kim, 1997a). The intensity of effort

Both the Korean government and top management had used four major means to enhance the intensity of effort: export promotion, the hasty creation of heavy and chemical industries (HCIs), technology transfer strategy and crisis construction.
First, the most influential way to give rise to the intensity of effort was the export drive. The Korean government made exports a matter of life and death in order to achieve economic growth goals. The Korean government designated so-called "strategic" industries for import substitution and export promotion. Plywood, textiles, consumer electronics and automobiles in the 1960s and steel, shipbuilding, construction services and machinery in the 1970s are examples.

The government pushed firms with ambitious goals. It instituted the export-targeting system in the 1960s as a regular instrument to assess the industrial success. Annual targets were assigned to major commodity groups, which were allocated to related industrial associations. They were also assigned by destinations, which were allocated to Korean embassies in respective countries. The Ministry of Trade and Industry maintained a "situation room" to monitor export performance. The performance was then reported to the Monthly Trade Promotion Conference attended by the President of the nation, cabinet members, heads of major financial institutions, business association leaders and representatives of major export firms. The conference served to solve many problems encountered by exporting firms through administrative guidance and the President's final decisions.

The Korean government used "sticks" in the form of administrative guidance (a euphemism for governmental orders) to force firms to reach the government goals. If a firm does not respond to particular goals, programs or incentives as satisfactory as expected, its tax returns are subject to careful examination, its application for a bank credit is deliberately ignored, or that its outstanding bank loans are not renewed. Government agencies often showed no hesitation in resorting to command backed by compulsion. In short, the role of the government was much stronger in Korea than in Japan and Taiwan, especially during the 1960s and 1970s. And it worked.

The government also cajoled firms with incentives, by borrowing heavily from abroad and channelling these funds into export-oriented investments at below-market interest rates. Firms were granted unrestricted and tariff-free import of intermediate inputs. Firms were also granted automatic access to bank loans for all export activities, even when the domestic money supply was being tightened. These firms also had unrestricted access to foreign capital goods and were encouraged to integrate vertically in order to sustain international competitiveness. These automatic incentives constituted the crux of the Korean system of export promotion.

In particular, the rationing of longer-term bank loans was used as a carrot to draw firms to new paths of exporting, to encourage diversification and to export more. These incentives were applied to all exporting firms, but they were particularly effective, when combined with the greater organisational, financial and political leverage of the *chaebols*, the Korean version of Japanese *zaibatsu* (Kim, 1993). Exporters also benefited from a variety of tariff exemptions, accelerated depreciation, exemptions from value-added taxes, and duty-free imports of raw materials and spare parts. Tax holidays and reduced rates on public utilities further boosted corporate profitability. Assignment of lucrative import licenses was linked to export performance.

The fact that the Korean economy was primarily export-oriented seems to have enabled its fast acquisition of technological capability many different ways:

1) Lump-sum investments for a production capacity well beyond the local market size to bring about the economy of scale forced the Korean producers to quickly acquire technological capability, so as to maximise their capacity utilisation. Second, in the face of the strong international competition, as soon as they entered the global export market, they were forced to invest greatly in technological efforts, mainly in learning by doing and reverse engineering, so as to become competitive in both quality and price. Third, informal technical assistance of foreign OEM buyers to ensure Korea-made products meeting their technical specifications provided invaluable help to Korean firms in acquiring necessary capability.

2) The Korean government also imposed an externally evoked crisis on firms by the hasty creation of HCIs without adequate preparation of technological capability. Korean government launched the HCI program at a far greater intensity and in a far shorter time than previously envisioned. This hasty move was motivated by the desire to build a self-reliant national defence capability in the wake of the U.S. move to withdraw its forces from Korea rather than for the economic purpose. Such a hasty promotion resulted in a rapid increase in foreign debts, problem of resource misallocation, inflation and further concentration of economic power in the a few *chaebols* involved in HCIs.

   These problems notwithstanding, the hasty HCI promotion policy greatly helped expedite Korean firms', in particular, *chaebols*' technological learning process. Lacking capability, *chaebols* had to rely almost entirely on foreign sources for technology. The HCI program, however, presented a major crisis for these firms. In order to survive, firms were forced to assimilate technology very rapidly through a quick knowledge conversion and creation, hence upgrading their capacity utilisation ratio. It all resulted in a rapid transition of the industrial structure in Korea. It took only fifteen years for the ratio of value added in light industries over HCIs to fall from four to one in Korea; whereas, the same shift took twenty-five years in Japan and fifty years in the U.S..

3) Government policy and corporate strategy on foreign technology transfer also led to the intensification of firms' technological learning effort. The Korean government restricted FDI but promoted technology transfer through other means such as import of capital goods in the 1960s. Unlike other developing countries, FDI therefore had a minimal effect on the Korean economy. Such a policy forced Korean firms to maintain their managerial independence from foreign companies and TNCs. Even in the case that some equity participation was allowed, managerial independence was still maintained. This created a crisis, inducing Korean firms to invest aggressively for a quick technological learning, hence accumulating quickly their technological capability. Unlike those foreign subsidiaries which can depend upon parent firms' s technology supply, these independent Korean firms had to take initiatives and play the key role in acquiring, assimilating and improving mature foreign technology.

4) Many Korean firms constructed crises proactively by setting ambitious goals as a means to expedite their technological learning process. Constructed crises often increase the intensity of effort at the individual and organisational level in search of alternative courses of action to make the crises creative rather than destructive. Crisis construction and expeditious learning were widespread in Korean manufacturing. Firms in automobiles (Kim, 1998), shipbuilding (Amsden and Kim, 1985; Amsden, 1989), steel (Amsden and Kim, 1985; Amsden, 1989), electronics (Kim, 1997a) and machinery (Amsden and Kim, 1986) have undergone a similar process of crisis construction and expeditious learning at the mature technology stage.

3.3 Technology Management at the Intermediate Stage

The erosion of international competitiveness in low wage, mature technology industries forced Korean firms in the 1980s to shift their emphasis onto intermediate technology products and industries as depicted in the lower part of Figure 1.

This required a significantly higher level of knowledge base than that at the previous stage in order to bring about a creative imitation rather than a duplicative imitation. Since this and the subsequent stages are less relevant to Africa, we will keep the discussion of these two stages relatively short.

<u>Existing knowledge base</u>

At the intermediate technology stage, there are apparently five major sources of building the existing knowledge base. First, foreign technology transfer continued to serve as a major source of building the existing knowledge base in Korean firms. However, sophisticated technologies could be obtained only through formal mechanisms, making it increasingly expensive for Korean firms to obtain the much-needed technologies. Second, another important source of external knowledge was the reverse brain drain of high-calibre Korean manpower pool abroad.

In the course of a rapid industrialisation in the 1970s, the Korean government made systematic efforts to repatriate Korean scientists and engineers from abroad. Third, the emergence and increasing intensity of corporate R&D activities of Korean firms gave rise to their bargaining power in formal technology transfer, also enabling assimilation of imported technologies and generation of new knowledge through knowledge conversion and creation by research. Fourth, the intermediate technology stage necessitates well-educated and trained scientists and engineers. It also requires more sophisticated basic capabilities. However, the poor quality of university education and research was a major bottleneck. Fifth, in the absence of adequate university research, the government took the initiative in establishing several Government Research Institutes (GRIs) by recruiting overseas-trained Korean scientists and engineers. These GRIs produced many experienced researchers, who spun-off to corporate R&D centres.

The intensity of effort

First, in the course of Korea's transition from mature technology to intermediate technology industries, the competition in more technology-intensive industries was tough, and advanced countries were reluctant to share their technologies. Given this situation, Korean firms had no alternative but to intensify their own R&D efforts, hence enhancing their "learning by research". Second, at the intermediate technology stage, crisis construction continued to function as a useful strategic tool, which made Korean firms put more and more effort into their technological learning.

3.4 Technology Management at the Emerging Technology Stage

Having mastered intermediate technologies, some *chaebols* began to challenge emerging technologies. The questions, which arise, are for example: What made these Korean firms possible to do that? What are problems they face now?

Existing knowledge base

Four mechanisms may be worth mentioning. First, after recognising the importance of basic research at universities, the Korean government began to move to transform a dozen or so of universities into research-oriented graduate schools. Most Korean universities, however, are still not well equipped to effectively support Korean economy and industries. Second, while investment in university research was on the increase, GRIs produced some significant research results and then would pass them on to the private sector. This contribution notwithstanding, GRI's reform and redefinition of their roles are now urgently needed. This is important, especially in the face of the rapidly expanding private R&D activities and intensifying university R&D efforts. Third, the private sector drastically stepped up its R&D efforts for their innovation. Fourth, R&D investments of Korean firms abroad has become an important means for their further technology development. C*haebols* established a number of R&D outposts in the U.S.A., Japan and Europe to monitor technological change and also to undertake frontier R&D activities. Fifth, reverse brain drain becomes even more important for Korean *chaebols* to upgrade their existing knowledge base in the 1990s to "leapfrog" into state-of-the-art technologies.

The intensity of effort

A few points deserve mentioning. First, heightening market competition constitutes a major source of stimulus for Korean firms. In addition to its export-orientation, Korea's increasing import liberalisation policy under the World Trade Organisation regime became a new source of stimulus. Second, crisis construction was an effective means to expedite Korean firms' technological learning process in their catching-up period. Though, the problem is that it is no longer the case in the pioneering period. Now the pioneering firms must work with a strategic ambiguity that provides only a broad direction (Nonaka, 1988). Third, Koreans in the 1990s are no longer as hard working as in the previous decades. Democratisation and the labour movement have resulted in a significant social climate change; workers have become far less submissive than previously. The new generation, which grew up in affluence, is not willing to work so hard as the old generation. This makes it more and more difficult even for the catching-up firms to use crisis construction as a means of intensifying learning effort.

4. Evidence in Other Newly Industrialising Countries

The above-described patterns are not necessarily Korean idiosyncrasy. Many studies conducted in other Asian NICs provide similar findings.

For example, Taiwan has many similarities with Korea, as far as technology management is concerned, despite their significant differences in many other respects.[1]

First, Taiwan based its industrialisation largely on human resources. It invested heavily in developing human resources. Second, Taiwan introduced a series of incentives to promote exports and used exports as a major mechanism to stimulate its technological learning and industrialisation. Third, the contribution of TNCs was a relatively small in Taiwan; it accounted only for 2.2 percent of total domestic capital formation in the 1960s and 2.5 percent in the 1980s. Explosive growth in industry is largely attributed to the local small and medium-sized Enterprises (SMEs). Fourth, Taiwan initially entered labour-intensive mature technology areas and gradually moved towards more intermediate technology areas, while reversing the evolutionary direction of advanced countries, as postulated by Utterback (1994). Fifth, Taiwanese firms relied heavily on foreign technology for their technological learning. Foreign direct investment and foreign licensing enabled Taiwanese SMEs to acquire the initial production capability, producing OEM products. OEM production experiences helped Taiwanese SMEs acquire design capability, enabling them to move from OEM-to ODM (original design manufacture)-stage. Sixth, as wages rose significantly in the late 1980s, Taiwan

[1] First, Taiwan's initial condition was far better than that of Korea; economic and social development in Taiwan during the Japanese colony far surpassed those in Korea. Second, Taiwan's industrial development relied heavily on a large number of small and medium-sized enterprises, while Korea relied mainly on the scale and financial power of large *chaebols*. Third, unlike Korean government, Taiwanese government intervened selectively in scale-intensive areas such as semiconductors, but left most business activities to private sector decisions.

intensified its own R&D to produce high-quality engineering products. Seventh, reverse brain drain became Taiwan's major source of innovation capability in the 1990s, enabling Taiwanese firms to crack close-to-the-frontier technologies, especially in non-memory semiconductors and industrial electronics.

Singapore, a small city-state, differs from Korea in its policy towards TNCs and provides a highly conducive environment for TNCs' operation on its soil. TNCs dominated Singaporean industries, accounting for a lion's share of production. In 1991, local firms accounted for only 16 percent of manufacturing investment. It is important to note that TNCs' FDI strategies were however very different from those in most other developing countries. Given Singapore's small local market size, FDI activities in Singapore were directed more towards exports markets than the exploitation of the local market.

Notwithstanding the differences regarding their policies towards TNCs, Singapore's experience in technology management is quite similar to Korea's experience in many respects. For example, the Singaporean government played a leading role in business through its direct and indirect interventions. It also invested heavily in education to provide competitive human resources to sustain Singapore as a production locale for exports. It used export promotion as a major means to stimulate firms' technological learning. Furthermore, technological learning process took place from simple to complex tasks: TNC subsidiaries in Singapore began at the standard mature end of the product cycle and then progressed progressively moved towards more complex products, reversing advanced countries' usual direction of technology development trajectory.

5. Lessons for Africa

African countries may have to launch their industrialisation on the basis of their abundant low-cost labour, maximising their comparative advantage in labour-intensive industries at the mature technology stage. At this stage, on the technology supply side (to give rise to existing knowledge base), it is important to introduce adequate public policies and corporate strategies that develop sufficient technological capability to undertake imitative reverse engineering of mature foreign products without infringing intellectual property rights. On the technology demand side, it is imperative to introduce market competition in order to expedite technological learning and augment the technological learning effort. Lessons of the Korean experience with regard to these two points will be discussed below.

5.1 Lessons Related to the Supply Side of Technology

<u>Human resources</u>

Experiences of NICs indicate that the first and foremost important lesson for Africa is expanded investment in education even before launching an industrialisation program. What was unique in Asian NICs was the well-balanced expansion in all levels of education early enough to support its economic development. This contrasts with other developing countries that attained an equally rapid growth in elementary education. Whereas the former countries have achieved a phenomenal industrial growth, many African countries (e.g., Somalia, Ethiopia, Congo, Uganda, Nigeria, Sudan and Kenya) with the least educational achievement in the 1950s (Harbison and Myers, 1964) still belong to the Least Developed Countries (LDCs) in the 1990s.

Most essential to building and strengthening of African countries' indigenous, lasting technological capability is to commit themselves definitely to the expansion of good quality tertiary education systems. Building first-rate educational institutions requires an enormous investment over a decade. This is one of the several major mistakes made by Korea. Korea expanded its tertiary educational program but failed to invest sufficiently to upgrade its quality. The Korean government belatedly recognised this mistake and attempted to introduce a major reform in recent years, but it will take a decade or more before its effects can be seen. In fact, many studies confirm the existence of a strong correlation between education and industrialisation. For instance, according to Baumol, et al (1991), the quantity and quality of education is one of the key determinants of developing countries' rapid catching-up industrialisation process. Provision of secondary and higher education explains differences in national wealth.

Brain drain

Brain drain is clearly an important concern for many developing countries. However, Asian NICs' experience shows the importance of adopting a liberal policy on this brain drain issue, allowing scarce scientists and engineers to migrate to advanced countries. Otherwise, many of them will not find suitable jobs. Brain drain was a serious problem also for Korea throughout the 1960s. As of 1967, 96.7 percent of Korean scientists and 87.7 percent of Korean engineers educated abroad remained abroad, mainly in the U.S. This is a very high ratio, when compared with 35 and 30.2 percent for all countries in the world. However, these scientists and engineers later turned out to be an important source of an overseas technology network and a high calibre manpower pool essential to Korea's subsequent economic development.

Important is also an active reverse brain drain policy to attract these scientists and engineers back to home, once industrialisation level has reached certain level of progress. The Korean government launched an ambitious repatriation programme of overseas Korean scientists and engineers in the 1960s and 1970s. It also set a model for the private sector, which aggressively recruited high-calibre scientists and engineers in the 1980s and 1990s. The recruitment of Korean scientists and engineers in the United States enabled Korean firms to build up the local capability essential to mastering of new technologies. In other words, brain drain in earlier years provided an important pool of high calibre human resources for Korean firms to draw competent manpower from. As discussed earlier, Taiwan also implemented a similar program to lure overseas Chinese scientists and engineers.

Foreign investment and technology transfer

Foreign technology transfer is a critically important source of learning for developing countries.

Foreign technology transfer can provide add new dimensions to raise existing the knowledge level. It may function as a catalyst of technological change and enable developing countries' firms to make a quantum jump in their indigenous technological learning.

However, Korea's experience shows that FDI or joint venture is not necessarily an effective way to acquire foreign technology. Rather, the procurement of turnkey plants (in the case of continuous process industries such as chemicals) and capital goods can be more effective. SMEs usually have neither the financial resources nor the organisational capability to identify and negotiate collaborative agreements with foreign suppliers. The least expensive and relatively effective way to tackle mature technology for these SMEs is to take an imitative approach by developing the capability to make sense of the available blueprints, manuals, technical specifications and machinery. Such capability may be acquired most effectively by poaching experienced personnel from existing large firms (Kim and Kim, 1985). Well-trained, hard working Koreans were motivated to maximise technological learning from readily available foreign goods and were equipped with sufficient tacit knowledge to reverse-engineer them successfully. Most innovative SMEs in Korea and Taiwan invaded mature industries this way.

For SMEs, informal mechanisms of foreign technology acquisition are usually more important than the formal ones. Experiences of Asian NICs show that firms in developing countries can benefit greatly from an informal technology transfer. As for the effect of an informal technology transfer to Korea, many studies clearly indicate that it has played a very important role for Korea's acquisition of technological capability. Most important information at the early stage of industrialisation can be obtained freely through the non-market mediated, informal mechanisms, if firms in LDCs have the local capability to undertake reverse engineering.

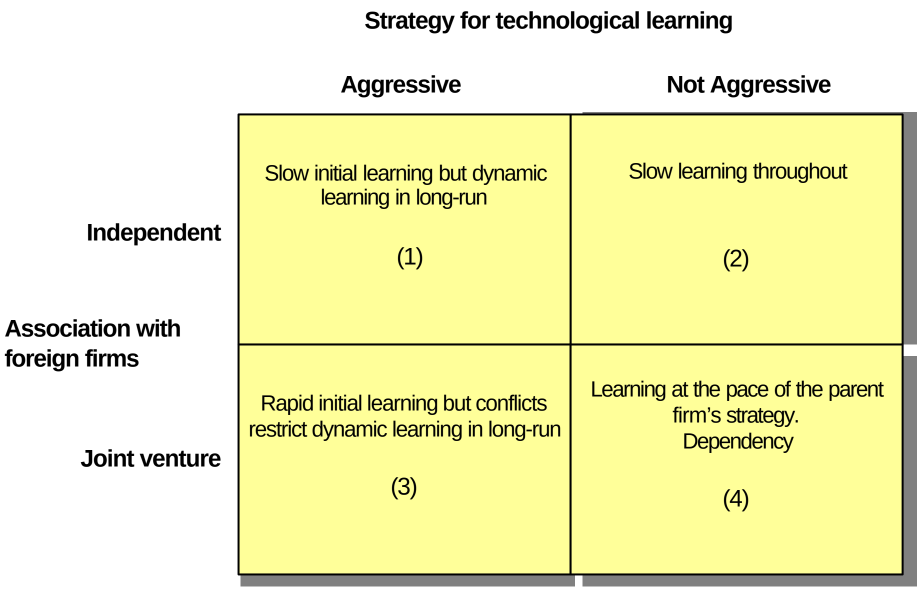
For large firms with a financial and organisational capability to negotiate with foreign suppliers for a large-scale mature technology, the most effective way is to purchase a turnkey plant with a foreign license. Large local firms had better to look to the experienced foreign firms for their help with the start-up of their production process, especially, given the large investment scale and their lack of technological capability and experience. Such an arrangement will also help them acquire the relevant technical information and receive training (Kim and Lee, 1987).

What is then the best way to do the foreign licensing? The best way to use it as a tool to stimulate and expedite the technological learning process is to unpackage it. Foreign license in a packaged form from a single source entails little risk for the technology recipient, as the supplier guarantees the performance of the transferred technology. However, it induces a passive attitude of the recipient and little learning. By comparison, in cases of unpackaged technologies from multiple sources, the recipient needs to integrate them into a workable system, hence taking a big risk. This causes a crisis situation, in which the recipient is motivated and forced to expedite its own technological learning process. When the recipient firm has relevant tacit knowledge, it had better to be charged with the integration of technologies to expedite its own learning (Kim, 1997b). For this approach to be effective, though, it is important to have a sufficient number of quality manpower at the recipient's disposal

Under the World Trade Organisation regime, it is not easy to restrict foreign investment activities. However, LDCs still have the choice. The question then arises: Is a fully owned FDI or joint venture a good strategy to acquire foreign technology? The problem is though that fully owned FDI or a joint venture as a mechanism of technology transfer may cause foreign dependency or conflicts. These mechanisms will certainly transfer production capability, but not necessarily the investment or innovation capability. This is particularly the case, when the main purpose of the parent company's FDI or joint venture is to exploit the local market in developing countries. It will be the parent company, which often sets the pace for the learning process of the local subsidiary

When should firms in developing countries go independent or enter joint venture with technology suppliers then? When they decide to invest aggressively into their technological learning so as to accumulate their technological capability, it is better for them to go independent of the foreign equity participation (Quadrant 1 in Figure 5). Even in cases of some equity participation for any reason, the managerial independence should be maintained. When technology recipients do not decide for an aggressive technological learning, then a joint venture arrangement will be useful (Quadrant 4). However, their learning process will be paced by the parent company, resulting in the recipient firm's technological dependence on the parent company.

Figure 5. Recipients' Strategy



But then again, how is Singapore's successful technology management to be explained? After all, Singapore is a small city-state, of which local market is too small for TNCs to exploit. TNCs therefore used Singapore initially as a production locale for labour-intensive industries. As Singapore however managed to supply increasingly more skilled labour and advanced infrastructure to make it an attractive production locale for more technologically sophisticated industries, TNCs increasingly shifted their production operations away from the labour-intensive ones to more technology-intensive ones. But their TNC subsidiaries are not R&D intensive with most design activities conducted at the parent headquarters. All in all, most developing countries can hardly emulate Singapore's city-state experience, as they have different national characteristics and also because TNCs might have different strategies.

Local effort

Although sophisticated R&D activities are not required for LDCs at the mature technology stage, it is still important to invest in S&T infrastructure such as GRIs at the early stage of industrialisation. For it takes a decade or more to develop an effective S&T infrastructure. However, GRIs should be established in close connection with universities, so that research results, whether successful or not, may be embodied in the head of graduates, who may then spin off to different industries. After all, this type of spin-off is one of the best technology diffusion mechanisms.
At the early stage of industrialisation, S&T infrastructure, particularly GRIs, suffer from poor linkages with industries. For instance, in case of Korea, most of the scientists and engineers recruited by the government to build the S&T infrastructure came from either academic institutions or R&D organisations that undertook advanced research. There was however no demand from industries for the kind of expertise that GRIs offered. The GRI researchers lacked the actual manufacturing know-how and the ability to develop prototypes, which were in great demand in early years. They were unable to assist industries in solving teething problems at the crucial initial stage and were no match for the foreign licensors when supplying detailed blueprints and other manufacturing know-how.

Nevertheless, they played several important roles. First, successful imitative R&D activities at GRIs resulted in a drastic reduction of the import price of similar, related foreign products. Second, joint R&D activities helped local firms have sufficient prior knowledge to strengthen their bargaining power vis-à-vis foreign technology suppliers. Third, GRIs generated a large number of experienced researchers, especially when the private sector's R&D investment faltered. By the time, when local firms were ready to actively undertake their own R&D activities in response to the heightening market competition, these experienced researchers could spin out of the GRIs to assume a pivotal role in private R&D centres.
It is also imperative for firms in LDCs to make their in-house assimilation efforts to acquire indigenous technological capability. Such capability will enable them to reverse-engineer readily available mature products and to expedite the assimilation of imported technologies. Korean experience shows that the technologically most dynamic firm is neither the firm that relied solely on foreign technological inputs, nor the one that relied exclusively on its own technological efforts: It was the firm that combined both.

5.2 Lessons Related to the Demand Side of Technology

Export promotion

The most powerful mechanism for intensifying the technological learning effort is an active export promotion policy. It creates business opportunities, while at the same time imposing crises on firms and thereby forcing them to compete fiercely for their own survival in the highly competitive world market. In order to survive the crises, firms in Asian NICs had to accelerate their learning-by-importing process, while rapidly assimilating foreign production technology. As the export promotion policy continually put pressure on them to remain competitive in the changing international technology and market environment, export-oriented firms tend to acquire more foreign technologies than import-substituting firms do.

In fact, export-oriented industries were those, which accounted for most foreign licensing and capital goods imports in Korea. And firms in export-oriented industries learned much more rapidly and also grew faster than firms in import substituting industries. Export-oriented countries such as Asian NICs tend to grow faster than countries with an import-substituting industrialisation process, e.g., Latin American countries. The average annual economic growth rate for the former was 9.5 per cent for 1963-1973 and 7.7 per cent and 1973-1985 periods, as compared to 4.1 per cent and 2.5 per cent for the latter.

Competition policy

Another important mechanism for creating competition for local firms is to introduce various means to make the local market competitive. It is important to protect local infant industries for sometime, but a prolonged protection of the local market will retard the healthy growth of local firms. Import liberalisation and fair trade legislation may become important at a certain point in the industrialisation process.

Crisis construction

Both the government and corporate management can use crisis construction as a strategic tool to induce local firms' expeditious technological learning. The Korean experience shows that the government often imposed ambitious goals on local firms. It then forced local firms to expedite their foreign technology import and assimilation efforts, in order to achieve the goals. In addition, whenever dynamic firms were challenged by a new technology, their top management regularly created crises as a deliberate tool to expedite technological learning (Kim, 1997b, 1998).

5.3 Lessons Related to Other Issues

Government structure

One of many questions raised by policy makers of developing countries is whether they should establish a separate ministry for Science and technology to consolidate their technology management policies.

There is no doubt some advantages in establishing a separate ministry of science and technology to focus on key S&T issues, especially when other ministries have little interest in a long-term technology development. Korea established its Ministry of Science and Technology in 1967. The Ministry made important contributions for the initial development of S&T infrastructure and promoted public R&D activities, paving the way for the private sector's subsequent entry.

Though, the separate ministry is not necessarily the best way at the later industrialisation stage, when other major ministries consider technology development issue more seriously. Japanese and Korean experience indicate that the existence of a separate ministry of science and technology helps little to bring about an effective co-ordination among different government ministries. What is really needed is an overarching organisation directly under the President or the Prime Minister, which sets up the goals and co-ordinates science and technology activities of many different ministries. Now the Korean and Japanese governments are seriously contemplating the abolition of their science and technology ministries. However, existing bureaucratic rigidity and inertia make it extremely difficult to implement such a governmental restructuring.

Entrepreneurship

It is important for the governments in LDCs to foster local entrepreneurs. Most LDCs have a good number of competent economists, scientists and engineers as well as enough literate manpower to promote industrialisation programs. Capital and technology may be acquired from abroad. What some LDCs really lack are the entrepreneurs, who could bring these resources together and manage them effectively to meet existing and potential market needs.

In the case of Korea, the government privatised Japanese properties and state-owned enterprises and transferred them to selected local entrepreneurs on favourable terms, helping them build the necessary capital. The government then managed these entrepreneurs relatively effectively by penalising poor performers and rewarding only good ones. Good performers were rewarded with further licenses to expand. The government also encouraged these entrepreneurs to enter risky businesses by offering them industrial licenses in more lucrative sectors in return (Amsden, 1989). It is important, though, to note that only competent and clean governments can play such a role.

Industrial structure

It is important to develop a balanced industrial structure. Korea's competitive advantage lies in the strength of its big businesses, whereas Taiwan's advantage lies in the strength of its dynamic SMEs (Gereffi and Wyman, 1990). Though, these advantages carry certain problems. Korea lacks dynamic SMEs' strong support, which can make its large-scale assemblers innovative. Korean large firms therefore had to rely heavily, for example, on Japanese SMEs for their supply of critical components for automobiles and electronics. In contrast, Taiwan lacks large firms to challenge scale-intensive industries. As a result, Taiwan is lagging behind Korea in such industries as steel, automobile and memory semiconductors.

The origin of such a skewed industrial structure is mainly both governments' biased policies. Korea deliberately promoted the formation and growth of large firms in order to bring about scale economy in the labour-intensive light industries, while Taiwan kept large businesses under the state- ownership for political reasons. These two economies belatedly recognised the importance of having a balanced industrial structure to sustain a healthy growth.

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