**Korean Model of Latecomer Development:**

**Capability-Building and Smart Specialization**

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**1. Introduction**

Korea has been one of the most successful latecomer economies to achieve rapid economic growth and join the ranks of high income economies. While Korea has often been proposed as a role model for other developing countries, there is also some skepticism. Such skepticism seems to stem from the perception that the Korean model involved a great degree of state activism, including targeted protection for some industries or firms—an intervention not acceptable in today’s global environment under the WTO regime. The perception continues to prevail, as early literature tended to focus on the role of the government versus markets in catching up development (Amsden 1989; Chang 1994; World Bank 1993).

This paper intends to propose a ‘(human and private firm) capability-based view’ of the Korean and Asian experience in the catching up development process. This approach can be considered an extension of the technology-based view (such as OECD 1992; Hobday 1995; L. Kim 1997; Dahlman, Westphal and Kim 1985). We are taking this view because the real lesson from Korea is not the role of government in economic development but the fact that the country was able to strengthen the capability of people and firms, thus inducing sustained growth for several decades.

Sustaining long-term growth is not easy. There are numerous cases of macro-oriented reform bringing immediate recovery but without it being sustained, and eventually the economy is faced with another crisis (Lee 2006). The most fundamental barrier to sustained development is local capabilities. Without a certain critical degree of capabilities, growth, which is based on lower wage rates or simple price competitiveness, tends to be short-lived. The Korean success was based on building capabilities in two steps; the first stage was during the 1960 and 1970s where emphasis on enhancing basic human capabilities of health and primary and secondary education while guaranteeing a stable supply of food by agricultural revolution; the second stage was since the 1980s and mid 1990s when Korea has emphasized in-house research and development (R&D) in private sectors, pushing the aggregate R&D/GDP ratio to the threshold level of 1 per cent, and eventually to 2.5 per cent or higher.

One of the most obvious differences between the developed and developing countries is their per capita GDP. But what accounts for the differences in income levels? These result from the varying capabilities of each country, including the capability to produce and sell internationally competitive products for long periods. One core element of the Korean model was its focus on building these capabilities, which enabled the economy to achieve building first human capabilities and then firm’s capabilities which enabled continuous upgrading into higher end segments within the same industries as well as advancing successive entries (another kind of upgrading) into new promising or higher end industries.

But it is not easy to enhance capabilities. Mainstream economics tends to concentrate on macroeconomic stabilization and trade liberalization, but these are only remotely connected to capacity building, if at all. This bias in economics dates back to the intrinsic limitations of mainstream economics when the word ‘capabilities’ (and by implication, ‘learning’) did not exist. Mainstream economics advocates the optimization of resources, but starts from the implicit assumption that all resources (inputs or capabilities) are already in existence and the only task is to find their most efficient utilization. But in reality, most of the developing countries do not have to worry about the optimal usages of resources (capabilities) simply because they are not available. For these countries, the more critical issue is how to strengthen such capabilities.

The importance of capability building in developing countries is uncontested. However, “where (which sectors) to utilize” such capability remains unknown. Given that latecomer firms are not only “resource/capability poor” but also “late entrants” (Mathews 2002a), they have to determine the points of entry in the established international division of labor for their survival; they are late entrants in the sense that when they begin their manufacturing activities, the value chain of production is already well established in their chosen market segment and is already occupied by firms from advanced countries (Ernst and Guerrieri 1998; Sturgeon and Gereffi 2009). Therefore, latecomer firms have no choice but to inherit some, often low-end, segments left by firms from advanced economies or to start from original equipment manufacturing (OEM) or sub-contracting (Amsden 1989; Hobday 1995).

Developing countries, especially low-income ones, have comparative advantages in low-end, often labor-intensive, segments or sectors in which they have to specialize. However, specialization alone will not help these countries catch up or move beyond the middle-income stage. Although OEM and sub-contracting may serve as channels for exporting and earning foreign exchanges, they have limited applications as long-term strategies. Specifically, a successful OEM can lead to increased wage rates, and new, cheaper labor sites in “next tier down” countries will emerge to replace the position of a country in the global value chain. Consequentially, these countries will fall into the “middle-income trap” unless they upgrade themselves into a higher-end segment with higher capabilities.

The middle-income trap results from the pitting of middle-income countries (MICs) between low-wage manufacturers and high-wage innovators; given their very high wage rates and low technological capability, these countries cannot compete with low-wage exporters and advanced countries (Yusuf and Nabeshima 2009;World Bank 2010 and 2012). To free themselves from this trap, these countries must build their innovation capabilities and find a new niche or segment in which they can upgrade their specialization (Lee 2013).

Thus, a latecomer firms and economies need not only capability building but also “smart specialization.” This study thus propose smart specialization for successive upgrading as another essential aspect of the Korean model of latecomer development. Specifically, it argues that Korean industries had specialized into short cycle technology-based sectors since the mid 1980s to the end of 1990s. Cycle time of technologies refers to how fast technologies change or become obsolete over time (Jaffe and Trajtenberg 2002). Based on the country-panel growth regression results obtained by Lee (2013a) using cycle time variables, this study argues that qualified middle income countries (MICs), like Korea in the mid 1980s, have relative advantages in specializing in technological sectors with a short cycle time because short-cycle technologies imply that the dominance of the incumbents is often disrupted and new technologies tend to emerge and offer higher growth prospects. Aside from indicating low entry barriers and high profitability, a minimal reliance on existing technologies is associated with few collisions with the technologies of advanced countries, less royalty payments, and first- or fast-mover advantages (Lee 2013a). The idea of MICs specializing in short-cycle sectors is consistent with the ideas that the mechanisms of economic growth differ across various levels of income, especially in the case of low- and high-income countries, and that a narrow transition path bridges these two country groups. Specialization into short-cycle sectors is a transition strategy that can help MICs go beyond their middle-income levels and reach high-income status. And, such transition happened in Korea during the late 1980, and thereby Korea was able to go beyond the middle income situation.

Next, in section 2, we define capability building and successive upgrading as the essence of the Korean model, and then discuss how the country has overcome the disadvantage of being a latecomer to capability building. Section 3 elaborates the process of capability building over four stages. Section 4 summarizes each capability building phase, highlighting the first half of the 1980s as the critical juncture in the process. Section 5 discusses the issue of sectoral specialization for industrial upgrading. The final section discusses the transferability of the Korean model to other countries and policy ideas for the low income countries.

**2. Capability building and Successive Upgrading as the essence of the Korean model**

**2.1. Development as a process of capability building**

Openness and export promotion have generally been regarded as key policy ingredients for the developing countries. Thus, many countries simply resorted to devaluation or standard trade liberalization, which led to export booms from the price effects and certain stabilization of external balances. However, there are numerous cases of macro-oriented reform bringing immediate, albeit un-sustained, recovery and eventually another round of crisis. For example, the three reform cycles in Indonesia (1983–91, 1994–97, and the post-1998) show that rapid success with macro-reform, if not supported by microeconomic changes, tends to fade fairly soon, triggering another balance-of-payment crisis. A similar pattern is unfolding in Nepal with respect to the 1990s reforms (Lee 2006).

Korea was in the same predicament as the other developing countries, faced with continual external imbalances and persistent trade deficits during the first two decades of industrialization in the 1960s and 1970s. However, since the 1970s the government has put emphasis on technological development by publicly funding and conducting R&D. The results were shared with private firms, private R&D was promoted with tax incentives and in the 1980s a public-private joint R&D was set up for bigger, risky projects. Intensification of R&D expenditure and a focus on higher education laid the basis for knowledge-driven growth. This is apparent in the rise in US patents filed by Koreans. In the early 1980s, approximately 50 US patent applications were instigated by Koreans, similar to the situation of the Latin American countries. The R&D/GDP ratios for East Asian and Latin American countries were also similar, around 0.5 per cent (Table 1). But by 2000, Korea was filing more than 5,000 US patents per year and its R&D/GDP ratio was 2.5 per cent. In contrast, the ratio for most of the Latin American countries had remained around 0.5 to 1.0 per cent, and none of Latin American countries were filing more than 1,000 applications annually.

This often unnoticed policy initiative was successful in strengthening the manufacturing sector, an important factor behind the late 1980s trade surplus, the first in the modern history of Korea. Since then, Korea has been able to overcome the persistent trap of external imbalances or stop-go cycles of crisis and reforms. Countries that followed the Washington consensus, focusing on macroeconomic stabilization and trade liberalization, experienced some improvement but this tended to be short-lived. When the momentum of the initial macro-based reform slowed down and the economy started to show signs of a crisis or recession, bolder economic reforms were tried in the next round. These included financial liberalization or capital market liberalization, which exposed the economy to volatile short-term finance capital. When financial liberalization lacked proper design and management, it often led to a foreign borrowing spree, speculation, a financial bubble, and ultimately another financial crisis. Although Rodrik (1996b) acknowledges the importance of the sequential adoption of the ten policy recommendations of the Washington consensus, he overlooks the fact that East Asia since the mid-1980s had more advanced capabilities already prior to deeper marketization.

[Table 1]

It needs to be noted that one of the most important elements of Korea’s success was the emphasis on capability and technological development, which may lead to a consolidation of private exporting and R&D capacity. Without strengthened R&D capability, sustained export growth is not possible. The difference between the more and less successful Asian economies was the priority given to technology and, in particular, higher education to enhance long-term growth potential. These are missing from the old Washington consensus, even though they can be considered as the distinctive core elements of the approach adopted in North East Asia.

A World Bank assessment of the reform decade of the 1990s concedes that growth entails more than the efficient use of resources and that growth-oriented actions, for example, on technological catch-up or encouragement of risk-taking for faster accumulation may be needed (World Bank 2005). Also, recent ECLAC studies on reform in Latin America find that macroeconomic stability is not a sufficient condition for ensuring long-term growth, which is linked more closely to the dynamics of the production structure. Furthermore, a well-functioning broader institutional context and infrastructure are essential, but these generally do not play a direct role in bringing about changes in the momentum of growth (Ocampo 2005). Then, our point is that microeconomic interventions should be combined with capacity-enhancing elements (technology and education), so that the costs of distortions (rent-seeking) can be offset by growth-generated new additional rents.

When we regard catching up growth as a capacity building process, we are considering the capacity of private corporations. The ability of latecomer economies to promote vibrant private companies is the most important fundamental criterion that determines the success or failure of economic development or growth. If the risks for private capital are too high, these may initially be state-owned firms, but they should be steered towards private ownership (i.e. making them ‘public’ through an initial public offering as soon as possible. This is rarely stated explicitly, which is why we are highlighting it as the main element of the Korean model.

Among the various aspects of capacities, technology needs to be singled out because without it, sustained growth is impossible. In this era of open competitive markets, private companies cannot sustain momentum with cheap products; they must move up to higher value added goods through continual upgrading, improvement and technological innovation. Furthermore, whenever possible, private companies, including locally controlled joint ventures (JVs), should be ‘local’ enterprises, not the foreign-controlled subsidiaries of multinational corporations (MNCs). The multinationals are continually on the move around the world, seeking cheaper wages and bigger markets, and cannot be relied upon to generate sustained growth in specific localities or countries. MNCs are, however, useful channels for knowledge transfer and learning.

**2.2. Double upgrading and Diversification: intra- and inter-sector**

Some authors, such as Hobday (2000) and Teece (2000), emphasize the potential in original equipment manufacturing (OEM)-based outward-oriented growth, but we focus on the limitations imposed by these growth strategies as they are contingent on MNC decisions whether or not to relocate to the newly emerging cheap-wage countries.

A close examination of a successful catching up economy, like Korea, indicates that advancement within the same industry (intra-sector) upgrading/diversification as well as successive entries (inter-sector upgrading and diversification) into new promising industries evolved over the course of industrial development. Our argument is that without the development of these two strands of upgrading, the chances for successful catch-up are smaller. There are two reasons for this; one impacting from the latecomer side and the other affecting from the front-runner side (Lee and Mathews 2012).

First, the impact from the latecomer perspective: successful OEM strategy tends to increase their wage rates accordingly, but it is also a fact that new cheaper labour sites continue to emerge in next-tier countries and these can overtake the latecomer position in the global value chains. This forces an upward movement towards higher value added activities within the industries that can accept higher wage rates and towards sectors where the next-tier countries are unable to compete.

Second, in the case of front runners, the innovators in these countries tend to generate new industries that correspond to higher value added and the front runners will turn to the latecomers for outsourcing. As innovations develop (new products and new industries), old industries mature, become obsolete and downgrade to lower value added activities, forcing firms to seek to opportunities in the newly emerging and high value added industries. Firms are forced to travel this road of renewal or be overtaken by the followers.

The necessity for these two types of upgrading extends partly from the international industrial lifecycles wherein new industries tend to be created in the developed world, and the latecomer countries and firms inherit these once they mature and their products become standardized. Given this lifecycle, an important feature of successful catching-up is the ability to enter at earlier (higher value added) stages of the cycle, and this is possible only with enhanced absorption capability. Otherwise, the alternatives are lower wage activities or industries, with limited opportunities for long-term success.

Such a dynamic view of industrial change is clearly contradictory to the traditional emphasis on static comparative advantages; uncritical application of industrial change can lock the world at a stage whereby the developed countries specialize more in the high value added or high-margin products while the developing countries are tied to low value added or low margin products. Furthermore, no guidance is offered on how to manage the transition from marginal profit production to high value added production, which makes the prospects of upgrading development uncertain.

There has been a dramatic change in the export structure of Korea, starting from the labour-intensive goods (apparel) to automobiles and electronic goods. The share of exports in total GDP was less than 2 per cent in the early 1960s or at the beginning of the industrial take-off, reaching 10 per cent in the early 1970s and 30 per cent by the mid-1980s. This growth in exports was first driven by such labour‑intensive goods as apparel and footwear. Their share increased rapidly in the 1960s and 1970s to 10 per cent of total exports by 1965 and almost 30 per cent by the early 1970s. Since then, the share of apparel and footwear dropped to about 10 per cent in 1990 and to less than 3 per cent by 2000, as they were replaced by other higher valued goods, such as electric and electronics goods and automobiles. The share of these latter items increased to about 10 per cent by the mid-1970s, accounting for 20 per cent two decades later, and finally almost 30 per cent by 2005.

Behind this change in export structure is the continuous improvement of firm level capabilities, upgraded from OEM to original design manufacturing and then to original brand manufacturing (Mathews and Cho 2000; Hobday 2000; Lee 2005). This became necessary because the forerunning vendor firms tended to transfer their OEM orders to lower wage sites, and latecomers needed to expand to higher value added orders. There are many instances of upgrading within the same industry in East Asia. For example, semiconductor firms in Korea and Taiwan started from integrated circuit (IC) packaging or testing (low value added activities), then moved to IC-fabrication and eventually to IC-design (highest valued added) (Mathews 2005, 2006).

In Korea, there are also many cases of successive entry into higher value added industries. The Samsung group is well-known for its successive convergence of new industries during its 60-year history. As discussed in Lee and Mathews (2012), Samsung started in light manufacturing industries (textiles) but then expanded into consumer electronics, followed by semiconductors and telecommunications, and finally flat panel displays, etc. In this process, the state had an important role in providing institutional support through joint R&D and technology transfer arrangements, as well as tax and credit concessions for newer industries.

The illustration of upgrading and market entry shows that these two processes are interlinked: successive entry is possible only after latecomer firms first acquire the design capability needed for upgrading in a given industry. In other words, to overcome problems related to the OEM-based growth, latecomer firms should first acquire the necessary design capability, and with these design capabilities, they tend to become late albeit fast-following entrants into new emerging industries. Latecomers cannot afford to languish in any given industry because old industries continue to change, often becoming declining industries, and/or new industries are set up through the initiatives of the forerunners to take advantage of higher profits.

A notable feature here is that new industries in the advanced countries tend to be created by new, different firms, whereas in the latecomer countries, new emerging industries are developed by the same firms diversifying but possibly utilizing different access modes. For example, the Korean firms (Samsung or LG) have become highly diversified through entry into the manufacturing of numerous consumer goods.

Although such a dynamic change in the comparatively advantageous industries could evolve without state intervention, often some co-ordination by state agencies could expedite the process and provide a better chance of success.

**3. The process of catch-up: some elaborations**

**3.1. The Preparing for the Initial Conditions for Catch-up (the 1950s, 1960s and 1970s)**

*First Solving the food shortage problem by the Agricultural Revolution*.

Korean economy suffered food shortage until 1950s and 1960s. This came from low agricultural productivity due to lack of technology, capital, and fertilizer and low farmland per worker. Food shortage in the South Korea was exacerbated by the inﬂux of approximately 2.5 million refugees from North Korea (Hsiao 1981). Due to land reform at 1948 and 1950, Korean farmers became small land owner from tenant, but food shortage problem still remained. Below [table 2] shows that Korea experienced chronic shortage of rice and grain in the 1950s and 1960s.

 [ table 2: food shortage]

Korea usually experienced 2-20% shortage of rice and grain in the 1950s. Especially, production was only 70% of demand in the 1952 and 1953 due to Korean War. Furthermore, due to social unrest from independence in 1945 and Korean War in 1950, production of Korean staple grains, rice and barley, didn’t increase between 1940 and 1960. To solve food shortage problem, the US government started PL480 program in 1954 and provided food aid to Korea from 1956. The PL480 provided both food commodities and agricultural inputs such as fertilizer to increase domestic agricultural productivity (Friedmann and McMichael 1987). Due to these aids, share of food aid among domestic food production was 11% in 1947 and 25.4% in 1953 (Korean Economy Compilation Committee 2010). However, food consumption per capita was low; consumption per capita per year was only 180.9 Kg in 1955 (Ministry of Agriculture and Food and Rural Affairs of Korea, 1978).

Owing to the fast growth of input (fertilizer) and the increase of the size of farmland associated with the large-scale reclamation projects by the new government, rice production increased rapidly in the 1960s. Overall growth of rice production in the 1960s was 29.3%, and rice consumption per capita a day increased from 289g in the 1963 to 373.7g in the 1970. Despite the increases in agricultural output, Korea was still depending on the food aid from the US in the 1960s. It was because demand of food increased very fast due to income growth from industrialization in the 1960s and population growth. Overall growth of demand for grain was 67.4% in the 1960s. In fact, US food aid increased steadily from 669,000 metric tons in 1965 to 3.6 million tons in 1972 or one-fourth of South Korean grain consumption (Hsiao 1981). Furthermore, the PL480 Title II program, which provided direct donations of food aid, also ended in 1970 (Hsiao 1981). So it created a great burden on the balance of payments of Korea. Korean export in 1971 was just 1 billion dollar, but import was 2.4 billion dollar. Import of rice and grain was 0.2 billion dollar, which was about 20% of export. Thus, Korean government tried to achieve self-sufficiency of rice.

President Park Chung Hee who took power in a military coup on 1961 had been interested in new rice variety to overcome food shortage problem and save foreign currency. As a first attempt, agents of Korean central intelligence agency smuggled new rice variety ‘Nahda’ into Korea from Egypt in 1964. Based on some test cultivations, President Park believed this new variety will increase yield and named it after his name. However, it couldn’t adapt Korean climate and soil, so it failed. After this failure, Prof. Heo Mun Hoe developed new rice variety ‘IR667’[[1]](#footnote-1) with the help of International Rice Research Institute (IRRI) in 1966. It was hybrid between Japonica type rice and high yield Indica type rice. He provided Korean Rural Development Administration (KRDA) with many varieties including IR667 to supply these varieties nationwide. After some seed improvement in the KRDA, IR 667 showed very high yield at the test cultivations in 1969. Yield of IR 667 at the test cultivations was about 630 Kg per 10 are[[2]](#footnote-2), which was 80% higher than average yield of Korean farm. Korean government started to support IR667 intensively, and IR 667 was supplied nationwide (Lee 2009). Using IR 667 and its varieties, rice production was 6 million metric tons and Korea achieved self-sufficiency of rice in 1977. National average yield per 10 are in 1977 was 494 Kg, which was greater than the previous world record of Japan (447 Kg/10 are) and 41% greater than typical national average before IR 667 (Moon 2010). Below [figure 1] shows yield of rice per 10 are from 1965 to 2000. It is shown that yield per 10 are increased dramatically from 1972 to 1977 after introduction of IR 667.

 [figure 1: rice yield]

Such increase of agricultural productivity had been supported by the increased investment on rural area. The government quadrupled expenditure on large-scale infrastructure projects such as dams, reservoirs and irrigation (Boyer and Ahn 1991). Irrigation system was improved in 531 thousand hectare from 1970 to 1979, which was 23.8% of arable land. Mechanization of farming was also advanced under 1st five-year plan for agricultural mechanization (1972-1976). Number of mechanic cultivator increased from 11,884 to 289,779 and number of tractor increased from 61 to 2,664 during 1970s (Korean Economy Compilation Committee 2010). Due to these investments, annual growth rate of agricultural fixed capital increased from 1.69% in the 1960s to 11.86% in the 1970s (Hwang and Yoo 2014). Growth of fixed capital offset decrease of labor and farmland from urbanization and labor migration in the 1970s. Finally, Korea achieved self-sufficiency of rice in 1977, although it had to import other grains.

Not only investment in rural infrastructure but also new pricing policies were also introduced to give farmers greater incentives for production. In the 1950, the government used to control the grain market and set price to be low to deal with inflation and poverty. Government purchasing price for grain was very low, sometimes even less than cost of production. It created disincentive for productivity improvement of farmers. The Military government since 1961 changed this low price policy, and increased government purchasing price for grain from 1968.

Beginning in 1969, Korean government began the dual price policy of grain, by which the government purchased grain at high price from the farm and sold them to the consumers at low price. The goal of the program was to subsidize the family economy of urban workers and rural farmers at the same time. In this system, the government purchases grain from farmers at 130 percent of the production cost of marginal paddy land and sells grain to consumers at 70 percent of the government buying price (Ministry for Food, Agriculture, Forestry and Fisheries 1978). It was introduced because of political concerns about the farmers who were becoming increasingly dissatisfied with their economic situation by late 1960s especially compared with urban residents. This program provided farmers with incentive for productivity improvement and introducing new variety of rice such as IR 667. Share of government purchase in the rice production was less than 10% before 1970, but it was greater than 10% in 1971 and it was 23.4% from 1977 to 1979 when use of IR 667-type varieties were at the peak. However, it put a big financial burden on Korean government. Government cost for purchasing and releasing of grains reached to 209 billion Won, which was 4.1% of government expenditure in 1979. It was abolished at 2005 due to international pressure in the WTO.

**3.2. Early Effort for Industrial Catch-up (the 1960s and 1970s)**

*Preparing human capital for catch-up*.

Gross enrolment ratio of primary education was only 47% in 1944, one year before the liberation from the colonial rule by Japan. After liberation in 1945, primary enrolment ratio increased rapidly from 45% in 1945 to 82% in 1949 (Ryu 2002). The number of students of elementary school doubled during this period because the provisional government under the US military office during the period from 1945 to 1948 tried to teach every 6-years-old kids and other age children who wanted to attend schools (Kim 1999). Furthermore, Korean government made primary school education compulsory in June at 1950. Korean government also conducted ‘Compulsory Education Achievement Plan’ from 1954 to 1959. (McGinn et al, 1980) They planned to achieve 96% gross enrolment ratio of primary education and build additional 30,000 classrooms until 1959, but insufficient fund made full attainment of this plan fail. However, the number of students in elementary school increased by 51.6% from 1953 to 1959 and gross enrolment ratio of primary education reached to 91.65% in 1959.

In the 1960s, new government of General Park carried out two ‘Five-Year Plan for Expansion of Facilities of Compulsory Education’. These plans were carried out along with Five-Year Economic Development Plan. First plan was carried out from 1962 to 1966 and second plan was carried out from 1967 to 1971. Due to these two plans, 811 schools and 53,726 classrooms were built from 1962 to 1971(Korean Economy Compilation Committee 2010). Gross enrolment ratio of primary education increased by 12.7% in the 1960s due to these investments and Korea achieved universal primary education in late 1960s.

Gross enrolment ratio of secondary education also increased significantly in the 1960s. As primary education became universal in the 1960s, more children graduated from elementary school and wanted to go to the secondary school (Ryu 2002). Korean government also abolished the entrance exam of middle school in 1968. It was applied to Seoul (capital city) in 1969 and other major cities in 1970. Thus, enrolment ratio of secondary education increased further (Korean Economy Compilation Committee 2010). In contrast, the enrolment ratio of tertiary education remained low at 6~8% in the 1960s.

The catch-up efforts during this period relied mostly on imported turnkey-based technology, and there was a serious shortage of technical personnel able to operate the imported equipment based on on-site instructions or manuals. Thus the main emphasis was on bringing up the general level of human capital, and by the mid-1970s, there was considerable improvement compared to the previous decade. In 1975, primary school enrolment was 106.86 per cent, and secondary and tertiary rates 56.35 per cent and 6.9 per cent, respectively (World Bank 2005).

In the late 1960s, the Korea government also recognized the need for advanced training for scientists and engineers in preparation for developing indigenous technologies. In 1972, the government set up a new graduate school of engineering and applied sciences, the Korea Advanced Institute of Science (KAIS), later renamed KAIST (the Korea Advanced Institute of Science and Technology). KAIS has served as a crucial scientific and technological institute by ensuring, with adequate research funding, elite education for the best minds of the country.

*Low technological capability and technology imports with licensing*

The technology capability of the domestic firms was poor as well, and exported goods were based on OEM production by assembling or processing imported parts and raw materials. The level of technological investment was extremely low; R&D expenditure in 1965 was only 0.26 per cent of the GNP, never exceeding 0.5 per cent of GDP during the 1960s and 1970s. Nevertheless, domestic firms had to make an effort to overcome the poor technological capabilities by investing in learning foreign technology from the advanced countries, which consisted mainly of assembling technology and packaged technology, for example, turnkey-based plants. Further learning efforts were concentrated mainly on operational technology through informal channels such as the purchase of capital goods or reverse engineering (L. Kim 1997). As shown in Table 4, imports of capital goods amounted to US$3,154 million during 1962–71. In contrast, technology imports[[3]](#footnote-3) over the same period were a mere US$21.2 million.

[Table 4]

Although technology imports were low, government policies were established to stimulate the importation of foreign technology. There were laws on capital goods imports, foreign loans and technology imports, including the Foreign Capital Inducement Act (in 1966). For effective control of technology, guidelines were issued (in 1968) to prioritize technologies that promoted exports, developed intermediate capital goods industries or had an awareness-promoting effect. A ceiling on royalties was set at 3 per cent as well as a five-year duration. However, in 1970 and 1978, to encourage the influx of technology, policy changes were introduced to allow for a higher royalty rate (Kim 1997). In 1972, the Technology Development Act was introduced to stimulate technology imports, and a year later, the Foreign Capital Inducement Act was revised to relax the approval criteria and facilitate technology import procedures (OECD 1996). Moreover, key institutions for science and technology infrastructure began to be established. For example, the Korea Institute of Science and Technology, the country’s first multidisciplinary governmental research institute, was founded in 1966, and the Bureau of Science and Technology was set up in 1967.

The Foreign Capital Act certainly contributed to attracting FDI inflows, as export and import procedures for foreign companies were simplified. In the electronics industry, for example, Fairchild Semiconductors, Signetics and Motorola capitalized 100 per cent in Korea and began to produce transistors and IC. In 1969, Toshiba Korea was established and Toshiba (Japan) invested 70 per cent of its capitalization (Bae 1995). However, these FDI-funded operations had been set up to take advantage of Korea’s low wages, as they all used imported intermediate goods, including transistors. Indeed, core technology absorption such as design or wafer processing was not expected. The turning point of the industry began with the founding of Korea Semiconductor, later acquired by Samsung, which aimed at wafer processing. This company was established in January 1974 with investments by both KEMCO (Korea Engineering and Manufacturing Company) and Integrated Circuit International Inc., the US subsidiary of KEMCO. The Korea Semiconductor succeeded in developing the transistor with its own intellectual property rights (IPR)-based technology and contributed to building up the local technological base that was developed further after its acquisition by Samsung.

**3.3. Beginning of the catch-up (mid-1970s to the mid-1980s)**

*Active importation of foreign technology and the beginning of R&D investment*

This stage is characterized by the active importation of foreign technologies by Korean firms for imitative innovation (L. Kim 1997). From the mid-1970s when the economy shifted towards heavy and chemical industries, and large firms emerged, forming the business groups so-called *chaebols*, Korean enterprises invested intensively in learning foreign technology to gain a share of the market in skill-intensive industries. In order to stimulate the technology inflow needed to modernize its heavy industries, Korea had to substantially relax import criteria. This was done, for example, by introducing in 1984 a system of automatic approval for technology imports, which replaced the earlier reporting system (OECD 1996).

Imported technology was unpackaged technology: parts and components and operational technology. Formal channels of learning such as technical licensing became important for securing access to advanced technology. Below, Table 4 shows that technology imports in the 1982–86 period totaled US$1,184.9 million, which is 8.1 times more than in the corresponding period a decade earlier.

Foreign firms from the early 1980s onward were increasingly reluctant to grant technology licenses to Korean enterprises, because the Koreans were attempting to enter the skill-intensive markets dominated by the advanced countries. Thus, investment in R&D was required not only for absorbing advanced technology but also for developing Korea’s own technological capabilities. Consequently, R&D expenditures increased from 42.7 billion *won* in 1975 to 1,237.1 billion *won* in 1985, or as a share of GNP, increasing from 0.42 per cent to 1.41 per cent, respectively. It was the first time since 1983 that the R&D ratio was more than 1 per cent (see Table 4).

Also, the science and technology promotion law was enacted, providing a legal basis for various promotion measures. The Special National R&D Program was launched in 1982 with a total investment of 334 billion *won*, of which the government invested 194 billion *won* and private sector 140 billion *won* (Branscomb and Choi 1996). Overall, during this period, the role of the government was greater than that of the private sector.

**3.4. The rapid catch-up (the mid-1980s to the mid-1990s)**

*The establishment of in-house R&D centres of Korean firms*

The third phase from the mid-1980s to the mid-1990s is the period of rapid catch-up led by the major Korean businesses. Firms were increasing production of knowledge-intensive products in the major manufacturing industries such as the electronics, automobile, and mechanical engineering industries. Large firms became internationalized, extending outward foreign investment into cheaper wage sites in South East Asia, expanding into the early stages of becoming multinational companies. After accumulating capability for process improvement, firms started to initiate product innovation (OECD 1996). Domestic firms imported technology related to materials, control, design as well as high-quality product technology (ibid.). Exported goods were produced with both OEM and own brand names, with brand name exports becoming more common (ibid.).

From the mid-1980s, the Korean firms, realizing the limitation of the licensing and embodied technology transfer, started to establish their own in-house R&D centres (OECD 1996). R&D expenditures rose rapidly, as indicated by their increased share in GNP, from 1.4 per cent in 1985 to 2.32 per cent in 1994. In order to encourage R&D activities by private firms, the government eased the prior approval criterion needed for R&D institutes, and a large number of institutes were set up. When the system for registering private research institutes was first introduced in 1981, the scheme had provided tax waivers for private research institutes, military service exemption for research personnel, and tariff exemption for research equipment (OECD 1996). In 1985, to encourage the establishment of research institutes in small firms, the government reduced the required number of research personnel from 10 to 5 (ibid.). Large domestic firms eventually began to recognize the importance of in-house R&D for accumulating the technology development capability needed to gain a share of the market in skill-intensive industries, and established R&D centres during the late 1970s and early 1980s, bringing the number up from 65 institutes to 183 by the year 1985. Overseas branches of private R&D institutes were also set up in order to access foreign sources of knowledge and to be aware of recent technology development; by 1994 there were 51 overseas R&D centres (ibid.).

Such active engagement of private R&D activities enabled Korea eventually to absorb the newly emerging technology. The best example is the mobile digital communication technology code division multiple access (CDMA). Although analogue mobile communication systems were still dominant in most advanced countries, Korea moved forward and started R&D on a digital system in 1989. On the basis of R&D conducted in governmental and private research institutes, domestic firms and governmental research institutes were in a position to absorb knowledge of the mobile digital telecommunication systems through their cooperation with Qualcomm, an American venture company (Lee and Lim 2001). The R&D focused on absorbing emerging technology is linked R&D geared to commercialization.

**3.5. Maturing of the catching up phase (the mid-1990s to the present)**

This is the period when Korea joined the club of the advanced countries, namely the Organization of Economic Cooperation and Development (OECD). But it was also the period when the country suffered a financial crisis, and was faced with a comprehensive economic reform imposed by IMF conditionality.

Partly because of his desire to leave a lasting imprint on the modern history of Korea, President Kim Young-sam in 1993 endorsed the plan to join the OECD, setting December 1996 as the entry date. Without attempting serious labour, financial, and *chaebol* reform, Korea confronted the borderless global capital markets as a country characterized by a real sector that survived on bank subsidies, plagued by labour market rigidities, and entrapped in an opaque corporate governance structure (Lee et al. 2008). In 1997, exactly one year after OECD entry, Korea was faced with a financial crisis.

The post-crisis reform package for Korea was one of the most comprehensive and decisively implemented set of reforms undertaken by any country following a major crisis. Korea became an almost totally open economy in every respect, including capital market liberalization, foreign direct investment (FDI), and importation of foreign goods. In consequence, there was a massive influx of FDI, rising from US$6,971 million in 1997 to US$8,852 million in 1998, and to US$15,541 million in 1999. This influx is, without a doubt, related to the new foreign investment promotion act enforced on 17 November 1998 that provided foreign investors with improved supporting services and increased incentives in efforts to attract foreign investments.

Ten years later, many observers are concerned that the reforms have jeopardized the long-run sustainability of economic growth, as there is increasing recognition of both the benefits and costs of the reforms (Lee and Lee 2008). While the reforms have thrust Korean firms into a more stable and transparent business environment, major economic indicators have been less robust, with a downward shift of 5 percentage points in gross investment rates relative to GDP. Some critics—for example, Chang and Shin (2002)—argue that this is the price that must be paid for transferring to an economic model (the Anglo-Saxon model) that is not suitable for a country just graduating to developed status.

The big business sector is the one that went through substantial reforms, because the *chaebols* and the related excessive investment and foreign borrowing were criticized as one of the important causes of the crisis. Radical restructuring was inevitable, as approximate one-third of the top 30 *chaebols* went bankrupt. According to Choo et al. (2009), investment inefficiency was a critical factor in the productive inefficiency of the 1990s or the pre-crisis period, and that the post-crisis turnaround of the surviving *chaebols* was based on correcting the source of this ineffectiveness. But more importantly, this study confirms that technological capabilities are an important factor in explaining the post-crisis performance of the surviving *chaebols*. This implies that the only enterprises that succeeded in building a degree of capability survived the crisis. Through post-crisis restructuring, the remaining *chaebols* re-emerged as attractive, profitable global players with very low debt ratios and very high foreign shareholdings.

**4. Summary of the process in terms of the capability building and learning**

**4.1. Stages of capability building**

Development is considered to be a process of learning and capability. Thus, securing access to existing knowledge bases determines the success of catching-up because latecomer firms do not command sufficient capability to generate knowledge by themselves. While it is natural for advanced economies to create most of this knowledge stock, and non-advanced economies try to tap into this stock, they are constrained by the limited channels of knowledge diffusion and their abilities to absorb and adapt new knowledge. In this way, the knowledge from advanced countries has the function of facilitating technological development in catch-up economies. Hence, the extent of knowledge diffusion from advanced countries to developing economies in each sector is a critical element for the catching up process. Industry case studies, such as Lee and Lim (2001) and Mu and Lee (2005) as well as the econometric studies by Park and Lee (2006), confirm the importance of gaining access to an external knowledge base, and the high probability of failure of isolated attempts to indigenously develop imported technology.

In arranging access and learning opportunities for foreign knowledge acquisition, it is important to note that there are quite diverse channels of knowledge diffusion, and these vary across industries or at different stages of economic development. Alternative channels include informal learning, learning from OEM, licensing, FDI, strategic alliance, co-development, and so on. The experience of Korea allows us to identify a sequential pattern in the evolution of the channels of access to foreign knowledge.

In the earliest stage of capability-building, as in Korea in the 1960s and early 1970s, the primary channel of learning is technical guidance from foreign OEM buyers or learning by working in FDI firms. Key technology is embodied in imported machinery and equipment. It is basically learning-by-doing with no capacity nor intention of technological development.

During the next stage, when the latecomer firms recognize the need for more systemic learning and technological development, such firms tend to resort to technological licensing, which was Korea’s main form of acquisition of foreign technology in the mid-1970s and the 1980s, or they actively seek knowledge transfer from any FDI partner. During this stage, the critical factor for effective learning would be the absorptive capacity of the latecomer firms, which also depends on the country’s education system and other elements of the national innovation system.

During the third stage, corresponding to the mid-1980s in Korea, the latecomer firms establish a certain degree of in-house R&D capacity with a clear idea of what should be done and how much resources are to be allocated.

The fourth stage concerns the period when licensing or learning from foreign partners has reached its limits. Latecomer firms should now rely on public-private R&D consortia, research of the existing literature, overseas R&D outposts, co-development contracts with foreign R&D or technology specialist firms, and/or international mergers and acquisitions (M&As). It was also from the early 1990s that a small number of Korean firms began to establish overseas R&D posts, mainly in order to obtain easy and faster access to foreign technology that was difficult to acquire through licensed imports. These overseas posts also served as a window on recent trends in technological development (OECD 1996).

The final stage, characterizing Korea since the late 1990s, is the horizontal collaboration or alliance based on complementary assets. Some firms, such as Samsung, have reached this stage, and are now engaged with Intel, Sony, Toshiba, and Microsoft in diverse modes of alliances. .

**4.2. The first half of the 1980s as the critical juncture**

Rodrik (2006: 974) contents that while the lessons drawn by proponents and sceptics may differ, it is fair to say that nobody really believes in the Washington consensus anymore, and that the question is not whether the consensus is dead or alive but what will replace it. After the credibility of the Washington consensus faded, it has been augmented by a long list of the so-called ‘second generation’ reforms that are heavily institutional in nature (Rodrik 2006). Also, an important work by the Growth Commission (Spence 2008) was made public, which acknowledged the importance of government activism and industrial policy, while expressing caution for hasty liberalization and privatization.

However, it is striking to see that both the augmented list and the 2008 Growth Commission report still consider the building of technological capabilities by private firms as a marginal issue. In our view, the East Asian evidence indicates that this is a genuine, binding constraint that can limit sustained growth. Rodrik (2006) points to the importance of inhibiting constraints, but does not attempt to identify what exactly these constraints might be. Lee and Kim (2009) prove with cross-national regressions that for middle-income countries, limited R&D and college education have been the obstacles for long-run growth, whereas for low-income countries, these are the scanty basic political institutions and primary/secondary education.

The discussion so far suggests that in the early to mid-1980s, Korea based its transition from a middle- to a high-income country by enhancing its technological capabilities. At that time, the R&D/GDP ratio was close to the threshold level of 1 per cent, the share of private R&D exceeded 70 per cent, and the share of corporate patents surpassed those by individual inventors. Based on these capabilities, Korea evolved into a high-income country with per capita GDP in the 1980s of approximately US$1,673 in nominal terms and US$3,223 in 2000 dollar terms. By the year 2000, this had increased to US$10,890 (Lee and Kim 2009: table 1).

Tertiary school enrolment jumped from around 10 per cent in 1980 to more than 30 per cent five years later, and finally surpassed 70 per cent in 2000 (Lee 2006: table 5). The R&D/GDP ratio was around 0.7 per cent in 1980, 1.5 per cent in 1985 and almost 2 per cent in 2000. In contrast, trade/GDP ratio was 70 per cent already in 1980 and has stayed around that level until 2000. These figures clearly indicate that the transition was made possible not by better opportunities, but by capability building associated with tertiary education and private R&D.

**5. Smart Specialization and Avoiding the both Target ad Design failure**

**51. Theoretical Criteria for Specialization and Leapfrogging**

Besides building innovation capabilities, a thorny issue for developing countries is how to choose the right sectors or businesses. This is because capability building does not take place in a vacuum but in specific areas of business and sectors. The nature and criterion of sectorial specialization has been a classic issue in economics, in particular for unbalanced growth theories. The established answer for low-income groups is specialization based on initial endowments, such as labor and natural resources or comparative advantages associated with resource endowments (Lin, 2012). These industries usually produce low-value-added or low-end goods in the global division of labor, which means that they essentially resemble trade-based specialization.

A more intriguing issue is how to identify a criterion of specialization that can be applied to the group of middle-income countries that strive to upgrade their industrial structure from lower to higher value-added. Value-added per worker or labor productivity might be a criterion, but it is too general and there are too many sectors with similar levels of labor productivity for it to function well. Lin’s structural economics (2012) point out the need for dynamic comparative advantage, suggesting that latecomers should target the industries with latent comparative advantage or mature industries from the countries slightly ahead of them. Nevertheless, though this is a good practical guideline, a more theoretically grounded criterion is still needed, or a more specific, differentiating criterion for middle- income countries attempting to mobilize new tools of technology policy.

For example, suppose that a country is ready to form a private-public R&D consortium to develop certain technologies or products. In this case, one challenging issue is identifying which technologies or products to target. This question of specialization has also been raised by Greenwald and Stiglitz (2014), who suggest that an economy should choose a sector with the greatest learning possibility and capacity, without providing further specifications. Some scholars, such as Hausman et al. (2007), argue that developing countries should diversify their export products into more sophisticated products, which should be a way for sustained growth. Hausman et al. (2007) developed a measure of the sophistication of tradable products using income level as the weighting factor. However, this definition has made the measure somewhat tautological. That is, the measure suggests that, if a country wants to be rich, it has to move [its production] into goods currently being produced by richer countries. In other words, the gradual nature of diversification begs the question of which sectors diversification should encompass first.

Another criterion that has been suggested by other scholars is technological opportunity, as measured by the growth rate of patents per field. This opportunity variable has been used in the literature as an indicator of ‘good’ technological specialization, yet Meliciani (2002) failed to confirm any significant relationship between such specialization and economic growth. Lee (2013: Ch. 4) also confirms the absence of a significant relationship between the variable of technological opportunity and technological catch-up in the cases of Korea and Taiwan. From a latecomer’s perspective, specialization in high-opportunity sectors is desirable, but involves a greater risk because such sectors are more crowded with already-established companies.

As an alternative to these measures, this paper suggests using the cycle time of technology as a criterion for the specialization of middle-income countries. Conceptually, the length of cycle time of technologies refers to the speed by which technologies change or become obsolete over time, causing new technologies to emerge more often. A long cycle time indicates greater importance of old knowledge, hence the greater need for latecomers to study such knowledge, as is the case of medicine, pharmaceuticals and machineries. When knowledge in the field changes quickly (i.e., essentially meaning of short cycle time), as in typical IT products, the disadvantages for the latecomer might not be substantial. Thus, it is advantageous for qualified latecomers to target and specialize in these sectors.

Technologies based on short cycle time possess two key properties, namely, the sector has less reliance on existing technologies, and it also offers a greater opportunity for the continued emergence of new technologies. New opportunities indicate more growth prospects, and less reliance on existing technologies may lead to faster localization of knowledge creation mechanisms. Additionally, this criterion satisfies the condition of viable profitability and competitiveness because it carries with it lower entry barriers and the possibility of higher profitability due to fewer collisions with advanced countries’ technologies, less royalty payments, and even first- or fast-mover advantages or product differentiation.

The validity of this argument and the criterion for specialization has been verified by extensive econometric analysis conducted by Lee (2013) at the firm, sector, and country levels. Lee’s book show that Korea and Taiwan were similar to other typical developing countries specializing in low-end, long-cycle sectors (such as apparels), but increasingly have turned to shorter and shorter cycle technology-based sectors (such as ITs) from the mid-1980s onwards in order to seek their own niche away from the incumbent high income countries. Table 3.7 of Lee (2013) shows that there are no overlaps at all between the top 10 technological fields where the largest number of US patents are filed by G5 countries and those of two Asian latecomers (Korea and Taiwan), indicating the completely different specialization of these two groups. In contrast, there were several overlaps between the G5 and other middle income countries. Now recently in the 2000s have these two catching-up economies tried to enter into industries similar to those of the advanced countries, including more hard science-based sectors, such as bio and medical products. This long journey, or a ‘detour’ as called by Lee (2013), is described in Figure 1.

 [ Figure 1 ]

Typical research in this area, such as the diversification thesis, tends to focus on how quickly a developing country’s economic activity can become similar to that of a rich country. For instance, scholars have pointed out that the industrial structure of advanced economies is highly diversified and thus recommend that developing countries should also try to diversify. However, these studies do not explain how latecomers can maintain competitiveness and succeed against the incumbents in the same industries. Furthermore, they do not describe how to diversify or what direction should be taken first. In comparison, we suggests that latecomers should avoid the immediate emulation of rich countries, as well as direct market competition with them. Instead, they should look for their own niches in short-cycle sectors, where they can enjoy a certain level of profitability. In sum, rather than telling a developing country to become more similar to a rich country, we argue the opposite: a developing country’s transition strategy should involve entering into sectors with short-cycle technologies instead of entering into sectors that are already being dominated by rich countries, namely those with long-cycle technologies.

Given that the specialization in short-cycle sectors and diversification proceed together, it is unclear which factor ‘causes’ which. The cycle times of technologies are a better policy-guide variable because they indicate in which direction an economy should diversify. In other words, developing countries should diversify by moving into short-cycle, technology-based sectors.

Lastly, it is to be noted that specializing in short-cycle technologies does not entail a fixed list of technologies. Instead, the implication in sectors with short-cycle technologies is that new technologies always emerge to replace existing ones. In other words, the criterion for technological specialization is less about the cycle length itself, but more about entry barriers, such that the latercomers are to choose the technological sectors that rely less on existing technologies dominated by the incumbents. Also, continuous technological emergence suggests the availability to new entrants of fresh windows of opportunity that are not confined to the old, dominant technologies. This concept is the exact opposite of the product life cycle concept of Vernon (1966), in which latecomers merely inherit old or mature industries (or segments thereof) from the incumbent economies (Lee 2013).

Until now, we have often used Korean firms and industries as examples of successful catch-up, leaving us with an intriguing question: Did policy makers in these countries consider the criterion of short cycle time as they planned their economic development? While the answer to this question is no, they were in fact always asking themselves, ‘What’s next?’ They looked keenly at which industries and businesses were likely to emerge in the immediate future and thought carefully about how to enter into emerging ones. New or emerging industries or businesses are often the ones with short-cycle technologies because they rely less on existing technologies. Therefore, without specifically planning to do so, in effect, the policy makers were always pursing the short-cycle industries.

According to Lin’s framework, if policy makers choose to target an industry that is new to a latecomer country but mature in the forerunning countries, the industry must offer a latent comparative advantage (Lin 2012b). After a certain amount of technological capability is built up in the latecomer economy, it can then target another industry that is new to both the latecomer and forerunning economies. This is an effort at leapfrogging, and China is already doing this in various industries. Its efforts to this end are exemplified in particular by its solar power and wind power initiatives. Korea also succeeded in leapfrogging in the 1990s into mobile phones and digital TV for which they used to be a latecomer without solid experiences and knowledge (Ch. 7 of Lee 2013). In general, a leapfrogging strategy has a higher chance of success when it is conducted during a time of shifts in technological paradigms or generations (Perez and Soete 1988), and such shifts happen with higher frequency in short-cycle technology sectors.

**5. 2. The First Case of Moving into Short cycle Technology-based Sectors**

Gerschenkron, the great Russian economic historian, analysed the industrialization of Germany and Russia and introduced the notion of the ‘latecomer effect’ in the 1950s and 1960s (Lee and Mathews 2012). Gerschenkron (1962) notes that relative economic backwardness plays a role in inducing systematic substitution for the assumed prerequisites of industrial growth, and regards state intervention as necessary to compensate for the deficiencies. He points out that England, the locus of the industrial revolution, could advance with free market guidance along the lines of Adam Smith, but that France, beginning later, would have needed greater intervention to compensate for its limitations, and that in Germany, the key innovation would have been the formation of large banks to provide access to the capital needed for industrialization, just as Russia’s greater backwardness required larger and more direct compensatory role by the state. The situation confronted today by the developing world is worse than that faced by Germany or Russia, because many of these countries lag behind the leaders. Thus it is understandable if the developing countries seek special or more radical ways to compensate for their latecomer deficiencies.

Therefore, while the ultimate goal of development is to raise the capabilities of local private companies, pilot agencies are needed to guide and co-ordinate the whole process. Such needs exist because key resources are scarce, and should be mobilized for sectors or projects with the greatest externalities. As was understood by Gerschenkron who identified latecomer agencies—such as large state-owned investment banks—as the engines of process in Germany and Russia, it is such agencies that can compensate for gaps in a country seeking to industrialize.

All the East Asian countries set up specific state agencies that played a role in guiding the industrialization process. In Korea, the institutions established in the 1960s under the Park regime included the economic planning board to set economic plans; the Ministry of Trade and Industry to support industrial policy and export; and the Ministry of Finance to fund the economic plans. These government agencies were important in targeting and promoting key industries and technologies in Korea, as is explained below.

The development process concerns growing industries, where firms can flourish and develop enhanced capabilities. But industries cannot be chosen randomly, or left to the whim of the multinational corporations. Enhancing the capabilities of private firms requires giving them the assurance of initial rents (profits) and learning opportunities until they mature enough to compete successfully in world markets. One effective way of assuring such opportunities is to target certain industries or technologies, such as those that exhibit externalities or market failure in terms of the gap between private and social return. While mainstream economics would focus only on such industries, we can go deeper than this and contend that there are more justified targets in the catching up context. One obvious target might be those industries or technologies that are being imported or purchased at prices monopolized by foreign companies. In this situation, targeted import-substitution transfers the rents from the foreign to local companies. With such a strategy of targeted import-substitution, local operations face less uncertainty or risk because the targeted technology often constitutes mature inventions that are possible to emulate through the concentrated efforts of local indigenous R&D centres. Many successful examples abound in East Asia, including the development by the local R&D consortium, TDX (digital telephone switches) in Korea in the early 1980s (Lee, Mani, and Mu 2012). On the one hand, this case of telephone switch in Korea was a case of localization of imported products, and, on the other hands, it is one of the first move by the Korean firms into shorter-cycle technology-based sectors.

Korea in the 1970s and 1980s faced a telephone service bottleneck. But the country had neither its own telecommunications equipment manufacturing industry nor an R&D program until the late 1970s. As a result, most of the equipment and related technologies were imported, and Korean technicians merely installed foreign switching systems into the nation’s telephone networks.

With rapid development of its industrial and commercial bases and in population growth (approaching 36 million), telecommunications services in the late 1970s fell far behind the demand. After prudent consideration, Korea decided to build its own manufacturing capability and the R&D infrastructure needed for the creation of state-of-the art digital phone switching systems.

In collaboration with a national network of switching system manufacturers and distributors, the Korean consortium and the Korean Electronics and Telecommunications Research Institute, ETRI, developed in 1981–83 a proprietary digital switching system called the TDX (time-division exchange) series. Thus development of the Korean system was phased through manual switch, step-by-step switch, skipping the crossbar switch to leapfrog to the analogue electronic switch and the digital electronic switch. This indigenous product took over markets previously dominated by imports and the MNCs. Korea’s experience, accumulated and enhanced over the preceding decades, led to the growth of indigenous capabilities in wireless telecommunications in the 1990s. A similar takeover of the mobile phone market from Motorola to local Samsung and LG occurred around the millennium (Lee and Lim 2001).

These cases are indicative of how the Koreans, with the support of the government, were able to successfully overtake the markets previously held by the MNCs or JVs to become exporters. The preparation and cultivation of new industries necessitate state-led efforts by a variety of agencies, offering support ranging from the acquisition of land for firms destined in the designated industry, the acquisition of technology and the securing of finance including credit rationing, the adoption of nurturing strategies including tax concessions and R&D subsidies, initial control of excessive competition to allow companies time to develop their products and markets, and a phased opening up to the full force of international competition. But, this state activism should be phased out at later stages because the costs of local production and risks of entering new markets will have been reduced due to the dynamic learning effects that result from the cumulative output produced.

* 1. **Avoiding the Design Failure**

Another issue is the identification of the sector or business items that correspond to shorter cycle technologies than do the current businesses. A method that is consistent with the idea of entrepreneurial discovery suggested by the ‘Smart Specialization’ framework (Foray 2015) can be adopted. Policy makers should organize a private–public joint taskforce, which includes representatives from private sectors, and conduct a survey to existing private firms and entrepreneurs to ask the nature of business items or technological areas where they see near-future potentials, opportunities, risks, and bottlenecks when entering or starting in these future areas. The business areas to be identified by surveys are those areas where private sectors see certain market potentials and short cycle times but with some technological, financial, and other related environmental (regulation) uncertainties. Private firms may know better where the next markets are, but cannot be sure whether they will be able to develop the necessary and right technologies and whether they will be able to raise funds for such R&D and initial marketing. That is, new business/technology areas with more certain market potentials but uncertain technological, financial, and regulatory uncertainty will be targetable areas. Policy intervention promotes these identified areas by mobilizing public and private resources and competencies that correct market and coordination failures.

An example is the Korean electronics industry in the early 1990s. The TV industry was a short cycle technology-based sector and also a fast-growing market globally, and new technologies, such as high-definition (HD) TVs, emerged. HD TV technologies has two alternatives: the analogue HD technologies pioneered by Japanese firms and the digital technology-based HD TVs by western firms. Thus, the Korean latecomer firms knew that the market was with certainty, but they were facing three choices: to keep making the old (non-HD) analogue TV, follow the Japan firms to license analog HD TV technologies, or leapfrog into digital TV technologies. Lee et al. (2005) explained that the public–private R&D consortium chose the third option to develop their own digital TV technologies. Japanese firms were locked in for a while with their own analog HD TVs. Thus, Korean firms became the leader in digital TV, which was the turning point for the Korean firms (i.e., Samsung), and surpassed Japanese firms (i.e., Sony) in the display industry.

The above case in Korea can be contrasted with the case in South Africa, where they developed their own electric cars called “Joule.” Swart (2015) explained that the South African government provided the initial funding and established Optimal Energy in 2005. Optimal Energy is a start‐up business with the objective of “establishing and leading the Electric Vehicle industry in South Africa and expanding globally.” The company initially succeeded and had four road-worthy prototypes by December 2010. The Joule Electric Vehicle was a “born electric” five‐seater passenger car that sported a totally new vehicle design, which incorporated locally developed battery, motor, and software technologies. However, the company closed in June 2012 despite the technical success and an impressive network of partners and suppliers. The government, who was the major shareholder, decided to stop the funding required to start large-scale production of the electric cars because of uncertainties in marketing success.

The failure was caused by the lack of involvement of private companies who would take the role in volume production and sales. Thus, existing foreign MNCs and local auto companies did not want this new “disruptive innovation,” state-owned company to grow as another rival that sells cars. The government should have formed a private-public consortium with the plan that volume production would be carried out by private actors after the consortium developed the prototype. Thus, this case of the South African trial can be considered a case of “design failure” and not a “targeting failure.”[[4]](#footnote-4)

The reason that the process should involve private firms in terms of design is twofold: they know where market demand is, and they eventually run the show. However, public sector agents have improved capabilities to deal with technological and financial uncertainty. The situation could have been good if the South African project involved private firms throughout the stages. Caution against government activism often does not distinguish whether the sources of failure is from the targeting or design failure. The sources are often mixed together. While one might expect more cases of targeting failure, this is not always the case. Uncertainty is less if targeting is seen in terms of identifying the potential or existing markets as long as private sectors who know about the markets are involved. If not on the frontier, the targets may be obvious because there often exists a clear benchmark case, and then you may attempt to identify niches between existing firms and projects. Numerous public initiatives fail because of design or capability failure, where the latter means low execution capabilities.

6**. Transferability and Lessons of the Korean Model: Policy Suggestions**

**6.1 Transferability of the Model**

One of the first lessons from the Korean experience would be the emphasis on human condictions, such as basic food and education. As discussed in section 3.1, Korea was too poor and starved in the 1950s to start any kind of industrial upgrading, and thus the initial emphasis was on the solving the food shortage by agricultural revolution, as well as providing universal education to the whole population. These well-feed and educated population had served as an effective initial conditions for industrialization at later stages. Later industrialization itself is the work of human beings, given the importance of higher education and R&D. In this light, the Korean model of development can be termed as a human-centered development.

Next, given our emphasis on promoting capabilities of private companies as the engine of growth, one might ask whether more or less independent and indigenously owned companies are necessary for successful catch-up, and whether it is feasible to rely on foreign MNCs or FDI. As is known, MNCs are the places for learning and the sources of knowledge diffusion for local firms as these try continuously to move upward for higher value added activities in the global chain. But we would like to point out that in order to succeed with a strategy of more involvement with the MNCs, several other elements identified in the Korean model are required in addition to the generally high level of educational attainment. They include: creating and relying upon the pilot (coordinating) state agencies to guide industrialization, targeting industries/technologies for (mixing import-substituting and export-promotion) development, and sequential upgrading for changing/dynamic comparative advantages. Together, these elements mean some role by the government. The Taiwan SMEs are an example. The Taiwan SMEs were set-up as suppliers to the MNCs or joint ventures, but more and more of these eventually developed into firms with greater local ownership and control, as noted by Amsden and Chu (2003). This was possible because the disadvantages of ‘smallness’ were overcome by the government’s more active support (Mathews 2002). In particular, the SMEs in sectors with greater capital requirements or more risk were helped by government research institutes which provided sources of new knowledge in the form of joint R&D consortia and/or new spinoff firms from the government sector.

In term of specialization strategy, one possible policy idea for some developing countries is to utilize resource-based development as a starting point for these countries to leapfrog into emerging technologies that combine renewable energies, nanotechnology, bioelectronics, and new materials. Experts on innovation in Latin America, such as Perez (2008), have also described resource-based development as offering only a short window of opportunity. However, such development can also serve as the basis for a self-funded developmental leap, possibly into new emerging industries. Perez (2008) makes the following analogy between East Asia and Latin America: East Asian tigers acquired their initial capability in the fabrication industries of the 1960s and 1970s, and they used this capability to place themselves at an advantageous position within the emerging paradigms of the information and communication technologies (ICT) industries of the 1990s. Latin American economies can similarly use their current resource exports as both a platform for and source of funding with which to begin to enhance their capabilities in preparation for entering the next technological revolution.

Other than manufacturing-based leapfrogging, IT service may also be a promising sector for other developing countries to consider, as it also depends on short-cycle technology and thus leapfrogging into service bypassing manufacturing. The advantages of IT services, such as low entry barriers, have already been taken advantage of by Indians in their promotion of IT services, which were really an example of them leapfrogging over IT manufacturing (Lee 2013; Ch. 8 on India). Furthermore, there are already successful cases of public-private collaboration in Latin America, such as the software company, ARTech Consultores in Uruguay (Sabel et al 2012; Ch. 10).

Finally, there is an issue of the role of government. We are all aware about the costs of the ‘visible foot’ or government failure, which often leads to rent-seeking behaviour. We can point to two elements in the Korean model that could curb the potential for rent-seeking. The first is outward or export orientation where any preferential resource allocation has to be based on the performance of the exporting firms. As explained above, export orientation imposes a market discipline that cannot be offered by the domestic market to protected producers, and thereby poses a set of constraints on domestic economic policies (C. Lee 1992). The second element is the fact that the Korean model is strongly biased towards generating new sources of growth, new rents as well as taking rents away from foreign firms, and these tend to lighten any potential burden. In other words, the rules of game are not so much about the redistribution of rent among domestic agents, as about the creation and generation of new rents. For example, in Korea the preferential and targeted public and private R&D consortium for indigenously developing the digital telephone switches was to create new sources of rent for local products competing against foreign goods.

A remaining issue concerns the new environment created by general global trading conditions and those by WTO, such as the new rules for intellectual property protection, for trade-related investment measures, and the general agreement on trade in services. These codes impose stringent restrictions on the rights of the developing countries to deploy many of the institutions and policy settings that were available to Korea, such as infant industry protective tariffs and restraints on inward FDI and foreign exchanges.

But enterprising countries may find ways to work around these restrictions, particularly in areas that can be considered ‘innovation’, rather than trade or development. As is well-known, the WTO rules allow substantial room for state subsidies for R&D expenditure. The US conducts considerable state-led R&D in the name of defense-related research, and innovative developing countries will follow its example. Developing countries can pay more attention to their ‘national systems of innovation’, not only because R&D conducted through government research institutes is important in developing domestic technological capabilities, but also because this provides a path through the tangle of WTO rules and restrictions. The WTO allows some discretion in policies to support the small and medium enterprises (SMEs).

Specifically, the following can be said, based on Lee et al. (2015b). First, the latecomer economies are advised not to take the WTO restriction on industrial policies as an excuse for not trying the industrial policy. Members can deviate from WTO disciplines, provided that no other member initiates legal action (and makes the case) against that measure, a situation that is likely to happen only when industrial policies become significantly successful. Second, R&D subsidies have not been restricted or classified as green light subsidies. Subsidies on exports are prohibited. However, those on production for domestic markets are “green light subsidies” or have not been prohibited unless they are deemed as specific and causing adverse effects on other member countries (UNIDO/UNCTAD, 2011). Moreover, SCM does not prevent governments from subsidizing activities, particularly through regional, technological, and environmental policies, provided that governments have sufficient ingenuity to present such subsidies as WTO compatible (United Nations, 2006). The developing countries may attempt to take advantage of the fact that many rules in the WTO SCM have loopholes or room for flexible interpretation, as the term “yellow” light for certain types of subsidies are classified. The lengthy process and enforcement are sometimes dubious even if a country is brought into the WTO process. Third, the south may be able to use some “non-specific” subsidies because these subsidies are not prohibited by the WTO. That is, subsidiaries are regarded as not specific when they are not limited to “certain enterprises or industries” but are available on the basis of “objective criteria or conditions.”

**6.2 Two Modes of Building Productive Capacities in LICs**

In general, we can conceive of two modes of productive capacity development in LICs (low income countries), depending upon whether abundant resource of a country is labor or natural resources. The first happens in mostly manufacturing sector which involves the so-called OEM (own- equipment manufacturing) where LDC firms make products to the foreign buyers’s specification under diverse forms of contractural arrangement including FDI (Hobday 2000). The second mode typically involves resource-based (such as mining) sectors which evolves to be an extension and upgrading into backward or forward linkage sectors as a part of the global value chains led usually by foreign companies (Morris et al 2012). What follows is a brief discussion of each mode in sequence.

The first mode: Manufacturing mode.

One of the most conventional modes for developing productive capacity in LICs may be through contractural arrangement with foreign countries, in the form of the OEM or FDI. It is a specific form of subcontracting under which a complete, finished product is made to the exact buyer’s specifications. Examples of the OEM or FDI-based assembly-type products include consumer electronics, automobiles, and telecommunication equipment. These arrangements are typical of low-income or middle-income countries who tend to specialize in mature industries. From the 1970s to the early 1990s, OEM accounted for a significant share of the electronic exports of Taiwan and Korea, and served to facilitate technological learning (Hobday 2000). An example is textile products where latecomers produce for export markets via an OEM arrangement with firms from advanced countries.

OEM does not simply mean production and job creation in the host countries, but it naturally involves learning and building certain capabilities. Learning with the OEM mode can be discussed in the two stages. During the first and earliest stage of development, the latecomer firms learns skills or operational know-how while they produce the final products according to the foreign-supplied manual on foreign-made plants or production lines. In other words, there is a manual to follow during operation, and tacit knowledge (know-how and skills) is created during the process. Thus, the process can be called skill formation which leads to increase in productivity. This productivity increase through learning by doing is the main sources for the catching-up during this stage. In terms of catching-up patterns, this stage corresponds to path-following catching-up (Lee and Lim 2001). In this stage, being a simple assembly production, the responsibility taken by local or late-comer firms or entrepreneurs for production tend to be small.

The second stage, which can be regarded as an advanced form of the OEM, is to acquire processing technology, such that the late-comer firms now take the responsibility for production. In this stage, the late-comer firms acquire processing technology while they produce goods according to designs provided by foreigners, usually final producers. The designs can be either those of the products or those of production facility or both. In any case, acquisition of processing technology means that the late-comer firms become capable of *setting up their own production facility and takes responsibility for production*. Foreigners provide not only designs but often dispatch personnel to provide technical guidance in setting-up production facility and/or in producing the goods. In terms of the catching pattern, the stage still corresponds to a path-following catching-up as it basically tries to imitate the fore-running firms. Thus it can be basically "duplicative imitation" in terms of the framework by L. Kim (1997).

In this mode of OEM based learning-by-doing or exporting, the by-products are job creation and foreign exchange earnings, and the policy tools often include tariffs and undervaluation of currencies that are less sector-specific or horizontal. A desirable structure of tariff may be asymmetric structure, such as higher tariffs for sectors that are being promoted and lower tariffs for imported capital goods. Such asymmetric tariffs increased the world market share of Korean products (Shin and Lee 2012). Other forms of horizontal interventions are needed to build physical infrastructure.

The second mode: resource-based development and upgrading. In this mode, the LICs are initially engaged in resource (minerals) –based simple production under the foreign leadership (Morris et al 2012). Then, the essential task is to build productive capacities in related segments while participating the GVC. There have emerged new perspectives which argue that LICs may escape the resource-curse under certain conditions. In particular, changing strategies of industrial organization, such as importance of the efficiency of GVCs, have led lead commodity firms to emphasize the virtues of external supply of inputs into their operations, initially from the lowest cost global supplier, but also over time to lowest cost local suppliers. The linkages and upgrading transformation may emerge from lead commodity producers in the commodities sector to input suppliers (backward linkages) and to commodity processors (forward linkages or downstream activities).

Couple of promising examples are already out there. In the case of Botswana, its rise from low income to middle income country has been possible owing to its diamond sector where local firms have emerged from simple commodity producer to diamond cutting and polishing processor since the 1980s. It has taken a long time and the progress has been very slow until 2005 when there was a big deal between the government and De Beers (global diamond jewelry company) to promote local processing industries. Because 2005 was the year when De Beers‟ 25 year mining license was due for renewal, the government had a great deal of bargaining power. The government insisted that in order for De Beers to renew its mining license for another 25 years it should help Botswana to create a viable and globally-competitive cutting and polishing industry. Until then, De Beers used to say that Botswana had no comparative advantage in processing sector, however, after the new contract, the Government invited the world's leading cutting and polishing companies (16 in total) to establish factories in Botswana and in the process to transfer cutting and polishing skills to local citizens. While the situation in Botswana is much better than before, longer term challenge is to keep moving up the value chain, currently from crude diamond production and cutting & polishing to polished dealing, jewelry manufacturing, and marketing & sales which take up the bigger pie in the chain.

 Similar challenge of upgrading exists in the mode starting from OEM. While the OEM is an effective way of catching up at the early stage of economic growth, it is somewhat uncertain as a long-term strategy because foreign vendor firms may move their production orders to other lower-wage production sites (Lee 2005; Lee and Mathews 2013). Currently, a similar trend is underway among flower producers in East Africa as foreign vendor firms buy flowers not only from Kenya but also from neighbouring countries catching up with Kenya. In this respect, OEM firms should prepare longer term plans to transition to original design manufacturing (ODM) and finally to original brand manufacturing (OBM).

 ODM firms carry out most of the detailed product design, and the customer firms of ODM companies continue with marketing functions. Meanwhile OBM undertake manufacturing, design of new products, R&D for materials, processing of products, as well as sales and distribution for their own brand. The path from OEM to ODM to OBM has become the standard upgrading process for the latecomer firms. Modified examples of such upgrading in flower firms in Africa would be producing flowers that can last longer, have specific smells, and use less pesticides. All these require innovation. A transition to OBM in the flower industry would require African firms to enter into marketing and set up their own outlets with their own brands in Europe. Such a transition to ODM or OBM is not easy but serves as a narrow path to the middle- or even higher-income status. Another model available for African countries, endowed with rich resources, is a combination of ‘black’ and ‘green’ development, where cash from exports of natural resources can be used to finance entry into green industries (Lee and Mathews 2013). In general, transition to the middle-income stage calls for more sector-specific or vertical intervention policies. This is because the country must identify its niche between low-income countries with cost advantages in low-end goods, and high-income countries with quality advantages in high-end goods. For instance, Botswana is trying to find a niche, by targeting a mid-level quality of cutting and polishing, above the small stones produced in China and India, and below the highly specialised stones produced in Belgium and Israel (Morris et al 2012).

At this stage, public policy should focus on two kinds of upgrading: entry into new industries, and upgrading to higher value-segment in existing industries, which is to upgrade the overall industrial structure (Lee and Mathews 2012). Short-cycle, technology-based sectors are candidate niches for latecomers (Lee 2013). The main issue is how to break into medium short-cycle technology-based products or into the higher-valued segment of the existing sectors. Good targets for such an (import substitution) entry are those products that latecomers have to import at higher prices due to oligopolistic market structure, dominated by incumbent countries or firms. A best existing example is China’s telephone switch development in the 1980s and 1990s (Lee et al. 2012). The lessons have implications for African countries which produce oil but export it as crude oil without refining it. They can build more oil refineries based on mature or medium short-cycle technologies. The task is possible since the technology needed to build oil refineries is old, mature, and easily available at cost. The process would be similar to the Korean entry into steel-making through a state-owned enterprise (POSCO) in the early 1970s.

**6.3. Role of the Public Sector in Productive Capacity Development in LICs**

The stage-based mode of productive capacity development described in the above can be further elaborated with focus on the changing roles of government research institutes (GRI) or public research organizations (PRO). The essence of such a latecomer model of productive and technological development is the tripartite cooperation involving government research institutes, private firms, and government ministries (GPG) which played a key role in such countries in the past as Korea (Lee and Mathews 2013).. Under this model the actors have different roles depending on the stage of development. A typical division of labor in the past examples from east Asia was that government research laboratories are in charge of R&D, private firms of undertaking production, and government ministries of marketing in the form of direct procurement or protection by tariffs and exclusive standards. The case of the telephone switch in Korea and China would be the most typical representation of this model. Under this model, R&D is mainly done by GRIs or public research organs, and private firms are in charge of manufacturing and the government helps marketing through procurement of the domestically-made products.

The above GPG model can be modified as the model of international technology assistance for LICs. This can involve cooperation between foreign actors (F), local firms (L), and government (G) in the so-called FLG model. A simple idea of this is to put foreign actors (foreign research organizations invited by the donor government or the United Nations) in the place of the GRI/PRO in the GPG model so that foreign actors (cooperating partner) conduct R&D to transfer the results to local (private or state-owned) firms in African countries (stage FLG0). Then, in the next stage or FLPG, foreign partners conduct joint R&D with local R&D organizations or firms. Then, in the third stage, the aid-receiving LICs is able to conduct R&D locally through private-public partnerships. The final stage is, of course, where all functions are performed by private actors.

The Green Revolution of the 1960s and 1970s and the System of Rice Intensification (SRI) are examples of the FLG model (Lee et al 2014). The Green Revolution involved the introduction of packages of high-yielding varieties of: rice, wheat, and maize; fertilizers; pesticides; new management practices; and irrigation. The packages brought about a dramatic increase in productivity and production. The Green Revolution, initiated with support from the Ford and Rockefeller Foundations and led by Norman Borlaug, is regarded as having saved over a billion people from starvation. Much of the initial research on rice and wheat has already been done in American universities but needed to be adapted to local conditions. This required the creation of new international research institutes, initially the International Maize and Wheat Improvement Center (CIMMYT) in Mexico and the International Rice Research Institute (IRRI) in the Philippines (Juma 2011). These institutions were later brought under the auspices of the Consultative Group on International Agricultural Research (CGIAR). Today the CGIAR is a consortium of 15 research institutes working on agroforestry, biodiversity, dry areas, food policy, fish, forestry, livestock, maize and wheat, potato, rice, semi-arid tropics, tropical agriculture, and water. As part of this international initiative, local authorities expanded roads, improved irrigation systems, and provided electrical power to support farmers to adopt the new technology. International lending was also made available to promote the package. Research collaboration at the international level also led to the birth and expansion of national agricultural research institutes. These centres were to adapt the internationally developed varieties of rice and wheat to local conditions.

In the Indian case, the government played a key role in the diffusion of new seed varieties (Lee et al 2014). The government, with the financial support from the World Bank and technical assistance from the Rockefeller Foundation, established state seed corporations in most major states in the 1960s which led to the creation of the seed industry in India (Juma 2011). SRI was started in the early 1980s after participating groups from 40 countries first assembled in Madagascar in 1983. Then, it rapidly spread to more countries with the assistance of Cornell University. India is regarded as one of the biggest beneficiaries of this initiative.

In certain context and on certain conditions, such as availability of foreign assistance and access to knowledge and funding, the latecomers may try leapfrogging into newly emerging sectors, such as renewable energies. An example is the use of solar power in desert grasslands rural areas in Jigawa State of Nigeria (Lee and Mathews 2013). Given no water supply in this semi-desert area, a traditional option was to open wells with rope and bucket, hand pumps, or government supplied diesel-powered pumps that work only until they break down or until villagers run out of money to buy the expensive diesel. Now, solar-powered pumps have solved the problem as they are designed to run maintenance-free for eight to ten years or more.

Another example is the O&L Groups in Namibia (Lee et al 2014). Established by Mr. Shilongo, this company started from retail and brewery, and then diversified into dairy and even solar energy. Owing to government support (against a South African company’s price dumping to kill this company), they survived, grew big and quickly, with their sales reaching about 4 per cent of GDP of that country. Given that Namibia imports electricity from South Africa and Angola, this company plans to enter more into energy business, including wind power, although they have first to solve the hurdle imposed by grid monopoly by the government.

Some example cases in LICs are really more about adoption of new technologies than local innovations. But adoption is a beginning or stepping stone for learning and eventual innovation. Without adopting, you cannot learn. Manufacturing in East Asia, such as Samsung and Hyundai Motors in Korea, all started from the adoption of foreign technology for production, learning from using it, finding a way to enhance productivity by mastering production technologies, and finally even acquiring design technology (Lee 2005, Lee 2013a). More recent examples can be found in the renewable energy markets of China, Brazil, and India which involve the transition toward low-carbon economies. Options for LICs in low-carbon technologies include wind, solar, biogas, and geothermal energy sources. In this case, coordinated initiatives and incentives for early adopters are essential in reducing the risks associated with weak initial markets.

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[Table 1] R&D/GDP ratios in selected countries

|  |  |  |  |
| --- | --- | --- | --- |
|  | 1965 | 1980 | 2000 |
| Korea |  0.5 |  0.56 | 2.65 |
| Taiwan |  |  0.71 | 2.05 |
| Philippines |  0.2 |  0.2 |  |
| Thailand |  0.3 (1969) |  0.3 (1985) | 0.25 |
| Malaysia |  |  0.10 (1988) | 0.49 |
| China |  |  0.68 (1985) | 1.00 |
| India |  0.4 (1968) |  0.7 (1982) | 0.85 |
| Brazil |  0.3 (1974) |  0.6 (1982) | 1.04 |
| Argentina |  0.2 (1969) |  0.5 | 0.44 |
| Chile |  |  0.4 | 0.53 |
| Mexico |  0.1 (1970) |  0.6 (1984) | 0.37 |
| Ghana |  0.2 (1966) |  0.9 (1976) |  |
| Nigeria |  0.5 (1969) |  0.3 (1977) |  |
| South Africa |  |  0.89 (1985) | 0.62(avg. of 1988 & 2002) |

Source: Authors’ database explained in Appendix on the data sources in Lee and Kim (2009); also Lee (2006).

[Table 2] Shortage of rice and grain in Korea, 1946-1962

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  |  |  | (unit : thousand Suk\*) |
| Year | Domestic Production | Demand | Shortage | Production/Demand(%) |
| 1946 | 19,878  | 21,070  | -1,192  | 94.34  |
| 1950 | 23,359  | 23,687  | -328  | 98.62  |
| 1952 | 17,010  | 23,946  | -6,936  | 71.03  |
| 1953 | 16,503  | 23,599  | -7,096  | 69.93  |
| 1955 | 26,451  | 27,013  | -562  | 97.92  |
| 1958 | 31,574  | 38,509  | -6,935  | 81.99  |
| 1960 | 35,373  | 37,491  | -2,118  | 94.35  |
| 1962 | 38,540  | 42,706  | -4,166  | 90.24  |
| Source : Korean Ministry of Agriculture and Food and Rural Affairs, Korean History of Food Policy, 1978 |
| \* Suk is Korean unit for rice and grain. 1 Suk is about 144Kg.  |

|  |  |
| --- | --- |
| [Table 3]. Gross School Enrolment Ratio (%) in Korea |  |
| Year | Primary | Secondary | Tertiary |
| 1956 | 85.29  | 23.15  | 5.12  |
| 1957 | 89.20  | 22.49  | 4.42  |
| 1958 | 87.59  | 21.88  | n.a. |
| 1959 | 91.65  | 22.44  | n.a. |
| 1960 | 90.02  | 24.62  | 3.75  |
| 1961 | 91.14  | 27.39  | 7.58  |
| 1962 | 92.18  | 29.24  | 6.66  |
| 1963 | 95.23  | 30.19  | 6.48  |
| 1964 | 97.46  | 30.67  | 7.04  |
| 1965 | 97.72  | 33.27  | 6.91  |
| 1966 | 98.14  | 34.86  | 8.49  |
| 1967 | 100.69  | 35.38  | 8.10  |
| 1968 | 102.21  | 36.94  | 7.11  |
| 1969 | 102.03  | 39.30  | 7.40  |
| 1970 | 102.78  | 42.53  | 7.85  |
| \* Source : Korean Statistical Information Service, Statistic Yearbook of Education, Korean Population Census |
| \* Gross enrolment ratio is the ratio of total enrolment in each level of educations to the population of official education age (primary(6-11), secondary(12-17), tertiary(18-21)) |
| \* Total enrolment data is from Korean Statistical Information Service (~1961) and Statistic Yearbook of Education (1962~) |
|  |
|  |  |  |  |

[Table 4] Technology Transfer to KOREA 1962-1993

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|   | Technology imports (TI)a | Foreign direct investment (FDI) b | Ratios (TI:FDI) | Machinery imports (KI)c |
|   | Payment (m$) [A] | Cases [B] | Amount (m$) [C] | Cases [D] | [A]/[C](%) | [B]/[D] (%) | Amount (m$)[E] | [E]/total imports |
| 1962-66 | 0.8 | 33 | 47.4 | 39 | 1.7 | 0.85 | 255 | 9.94 |
| 1967-71 | 20.4 | 285 | 218.6 | 350 | 9.3 | 0.81 | 1,387 | 16.02 |
| 1972-76 | 96.5 | 434 | 879.4 | 851 | 11 | 0.51 | 3,543 | 11.94 |
| 1977-81 | 451.4 | 1,225 | 720.5 | 244 | 62.7 | 5.02 | 12,335 | 13.05 |
| 1982-86 | 1,184.9 | 2,078 | 1,767.5 | 565 | 67 | 3.68 | 16,988 | 11.81 |
| 1987-91 | 4,359.4 | 3,471 | 5,634.7 | 1,622 | 77.4 | 2.14 | 52,503 | 17.18 |
| 1992-93 | 1,797 | 1,240 | 1,938.8 | 506 | 92.7 | 2.46 | 94,718 | 17.12 |
| Total | 7,906.1 | 8,766 | 11,207.6 | 4,177 | 70.5 | 2.1 | 181,729 | 15.97 |

*Note* c: figures are based on SITC Rev.1

*Source:* a and b:Korea Industrial Technology Association (KITA) and Bank of Korea, respectively, as cited in OECD (1996, 83), c: United Nations Commodity Trade Statistics Database, "http://comtrade.un.org"

[Figure 1] Trend of the Rice Production Yield per 10 acre (1965-2000) (unit : Kg)

Source: Korean Statistical Information Service

[Figure 2]: Korea’s Entry into Shorter Cycle Technology Sectors and Diversification



Notes: The numbers in the vertical axis are the cycle time of technologies measured by the mean backward citation lags of the Korean-held US patents. For instance, a cycle time of “9” means that patents in the field are no longer cited or useful after an average of 9 years. The names of sectors are positioned along the average cycle time of Korea near the year when Korea entered those sectors, ranging from low-end, long-cycle sectors (apparel), medium-cycle sectors (steel and autos), short-cycle sectors (most IT goods), and finally high-end, long-cycle sectors (bio and medicine). The first turning point indicates the point (in the mid-1980s) during which Korea started to turn decisively into shorter-cycle technologies, and the second turning point indicates that, since the 2000s, Korean industries are maturing or becoming more similar to those of advanced countries and that they are trying to enter into more hard-science-based (long-cycle) sectors. For a detailed explanation, see Lee (2013: Ch 1, Ch 6, Ch 9).

1. IR667 means 667th rice variety made by International Rice Research Institute [↑](#footnote-ref-1)
2. are is 0.01 hectare (ha) [↑](#footnote-ref-2)
3. The term ‘technology imports’ means technology imported with the technological licensing or technical assistance needed to train local engineers to run turnkey plants. [↑](#footnote-ref-3)
4. . Slavo Radosevic observes that the European discussion on smart specialization is about targeting domains but less about smart designing. The whole ED is confined to bringing all stakeholders about targeting, not about designing the next stage. [↑](#footnote-ref-4)