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2020

Online at https://mpra.ub.uni-muenchen.de/111035/
MPRA Paper No. 111035, posted 13 Dec 2021 08:17 UTC

Published as Chapter 23, in Oxford Handbook of Industrial Policy, Eds, A. Oqubay, C. Cramer, H. Chang, and R. Kozul-Wright, 2020. October:

Diverse Tools of Industrial Policy in Korea:

A Schumpeterian and Capability-based View on the Korean Experience

November 2019

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*An earlier version of this paper was presented at the Conference held in Addis in September 2019. The author thanks the editors of this volume and the participants, in particular Arkebe Oqubay and John Weiss, for their useful comments and discussion.

Abstract

The current chapter presents a Schumpeterian and capability-based view of industrial policy, reflecting upon its practices in Korea over the last several decades. Given that it is typical for many developing countries to suffer from capability failure, industrial policy should go beyond correcting market failure but aim at overcoming capability failure. In this sense, it is not picking winners but picking good students and allow them a time for learning and building capabilities until they became able to compete with incumbent firms from developed countries. Specifically, this chapter discusses the following tools of industrial policy which has been practiced in Korea at different stages of development: first, tariff to protect infant industry; second, technology import by licensing to promote building of absorptive capacity; third, entry control which guaranteed rents to be paid for fixed and R&D investment; and fourth, public-private joint R&D to break into higher-end products and sectors. While these tools look different in their concrete contents, they share the important commonality of allowing some rents for the targeted sectors or firms so that such rents (extra profits) may be used to pay for building variants of capabilities, such as production capabilities in the case of tariffs or technology licensing in the 1970s, investment capabilities in entry control in the 1980s, and technological (R&D) capabilities in the case of public-private joint R&D in the 1990s.

Key words: industrial policy; tariffs; licensing; public-private joint R&D; entry control; infant industry; leapfrogging,

1. Introduction

The 2008 global financial crisis have resulted in the revival of industrial policy, which was initiated by a notable volume of Stiglitz and Lin (2013). While the classical work, like Johnson (1982), defined industrial policy as policies that improve the structure of a domestic industry in order to enhance a country's international competitiveness, nowadays its meaning has also changed and evolved to meet the context of the 21st century (Radosevic, et al. 2017). The current chapter presents a Schumpeterian and capability-based view of industrial policies (Lee and Malerba 2018; Lee 2013b), reflecting upon its practices in Korea over the last several decades.

For a developing country, it is critical to enhance its capability to produce and sell products in the international market so that the country may earn foreign currency that it can then use to pay for imports of investment goods. However, the challenging part of this process is how to increase that capability. Thus, it is typical for many developing countries to suffer from capability failure (Lee 2013c; Lee and Malerba 2018). Then, industrial policy should go beyond correcting market failure but aim at overcoming capability failure (Lee 2013c; Lee 2019). The view of market failure focuses on providing optimal incentives to correct externalities associated with public goods like R&D, with a hidden assumption that firms are already equipped with capabilities. However, in the absence of capabilities, providing incentives alone does not make agents to make a move or start doing innovation, for example. In this sense, it is not picking winners but picking good students and allow them a time for learning and building capabilities until they became able to compete with incumbent firms from developed countries (Lee and Malerba 2018).

Actually, capability building was the focus of a World Bank study compiled by Chandra (2006). A World Bank (2005) assessment of the reform decade of the 1990s also states that growth entails more than the efficient use of resources, and that growth-oriented action may be needed, for example, on technological catch-up or the encouragement of risk-taking for faster accumulation. Lee and Mathews (2010) synthesize capability-based view as the Beijing-Seoul-Tokyo (BeST) consensus, which is commensurate with their firm-level study (Lee and Mathews, 2012).

In other words, this chapter considers capability building, (not the state-market dichotomy), as the essence of the Korean model of catchup, and is of view that because Korea has built and enhanced capabilities of private firms Korea had been able to sustain growth for several decades until it joined the club of high income economies (Lee 2013b). If we consider industrial development as a long-

term process that takes over 10 or 20 years, it is natural for the tools of policy to change over the course of economic growth. Such a dynamic view of industrial policy is warranted, because the capability level of the beneficiaries of such intervention would change over time as well.

Specifically, this chapter discusses the following tools of industrial policy which has been practiced in Korea at different stages of development. First, tariff to protect infant industry (Shin and Lee 2012). Second, technology import by licensing to promote building of absorptive capacity (Chung and Lee 2015), Third, entry control which guaranteed rents to be paid for fixed and R&D investment (Jung and Lee 2010). Fourth, public-private joint R&D to break into higher-end products and sectors (Lee et al 2005; Lee 2013a: Ch. 6). While these tools look different in their concrete contents, they share the important commonality of allowing some rents for the targeted sectors or firms so that such rents (extra profits) may be used to pay for building variants of capabilities, such as production capabilities in the case of tariffs or technology licensing in the 1970s, investment capabilities in entry control in the 1980s, and technological (R&D) capabilities in the case of public-private joint R&D in the 1990s.

From the next section to section 4, the chapter discusses in sequence technology licensing, tariffs and entry control, and public-private joint R&D. Section 5 concludes the paper.

2. Technology Licensing for Absorptive capacity

Absorptive capacity (AC) was first introduced in by Cohen and Levinthal (1989, 1990) as the ability of a firm to identify, value, assimilate, and exploit knowledge from the environment. AC is also recognized as an important binding constraint in the development of latecomer economies. Borensztein, Gregorio, and Lee (1998) perform a country panel regression and find that foreign direct investment will produce a growth effect only if a country has a certain level of AC. Although several empirical studies emphasize the importance of absorptive capacity by considering in-house R&D or human capital as proxy (Keller, 1996; Mowery and Oxley, 1995), a recent finding indicates that AC cannot be appropriately proxied by R&D or staff quality alone (Flatten et al., 2011; Lane et al., 2006). Moreover, the earlier studies fail to discover the origin of AC aside from formal R&D or education.

Relying heavily on Chung and Lee (2015), this section addresses the question of what the origin of AC is in Korea? How can we tell whether this capacity is established in a firm? These questions are particularly relevant in the context of latecomer countries in which firms are usually uncertain about conducting their own R&D and continue to rely on imported technology by specializing in assembly-type production. Scholars studying Korea as an example of a successful latecomer economy have emphasized the importance of AC in enabling Korean firms to learn and assimilate external knowledge (Evenson and Westphal, 1995; Keller, 1996; Pack, 1992).

As a latecomer economy, Korea has successfully transformed itself from a technology-importing to a technology-generating country. Korean firms only began to conduct in-house R&D in the mid-1980s after undergoing a period of learning, assimilating, and adapting foreign technologies (OECD, 1996; Lee, 2013b). Chung and Lee (2015) observed that the number of foreign technologies acquired by Korean firms increased from as early as the late 1960s, followed by an increasing trend towards private R&D two decades later. In other words, a significant increase in foreign technology inflow preceded local R&D efforts and innovation outcomes in Korea. Many researchers assert that access to external knowledge is especially important in the development of latecomer firms (Bell and Pavitt, 1993; Kim, 1997; Laursen and Meliciani, 2002; Lee, 1996; Park and Lee, 2006).

Leading firms in Korea generally acquired various forms of know-how, such as operational skills and elementary process technology, before starting their own capital investment (Enos and Park, 1988; Kim, 1997, 1998). These firms built their basic technology proficiency during building and testing of their production facilities, enabling Korean engineers to assume responsibility for daily operations as soon as possible.

In 1960, the government addressed two objectives relating to foreign technology acquisition with the Foreign Exchange Control Act. The first was to ensure that foreign exchange, which became scarce after the Korean War, would only be used for critical technologies. Second, the government wanted to use acquired technology as a stepping stone on which Korean firms could build their own technological capabilities (Korea Development Bank, 1991). The scarcity of foreign exchange during the 1960s compelled Korean firms to seek government approval prior to signing a contract with a foreign counterpart if they wanted to receive technical assistance for a year or longer and if they paid their counterparts in foreign currencies. All applications were scrutinized by the Ministry of Commerce and Industry (Korea Development Bank, 1991).

Korean industries attempted to build production and export capabilities in labour-intensive or light industries, such as textiles, wigs, rubber footwear, and stuffed toys, from the 1960s and into the 1970s. However, during the 1970s firms realized that these industries had low profit margins and insufficient cash inflow to produce the necessary foreign debt services. Therefore, both the government and the private sector wanted to integrate backwards into intermediate goods. If intermediate goods could be secured within the country, the need for foreign exchange should decrease in the long run. Under the Economic Development Plan, a series of legislation was enacted to promote the general machinery, electronics, oil refinery and petrochemicals, transport equipment, steel, and shipbuilding industries (Byun and Park, 1989). The approval procedure for the acquisition of foreign technologies in these target sectors was also simplified.

By the late 1970s, many of the initial entrants into the 'heavy' industries were acquiring both physical capital and relevant technology from foreign sources. Westphal, Kim, and Dahlman (1985: 190–1) reported that more than a quarter of gross domestic investment in Korea from 1977 to 1979 was spent on foreign capital goods. In 1978, an automatic approval system for the acquisition of foreign technology was introduced in general and electric machinery, shipbuilding, chemicals, textiles, and finance under the following conditions: (1) the duration of the contract must be three years or shorter; (2) the down payment must be US$30,000 or less; (3) the running royalty rate must be 3 per cent or lower; and (4) the fixed fee must be US$100,000 or less. From 1979 onwards, most sectors, except weapons, explosives, and nuclear power, were granted automatic approval for their projects subject to satisfying the conditions.

The deregulation process continued in the 1980s and the 1990s until the filing requirement was eventually abolished in 1994. The approval process was simplified to a filing-and-confirmation process from 1984. From 1988, foreign exchange banks were assigned to handle foreign technology acquisition applications under certain scales (Korea Development Bank, 1991; Korea Industrial Technology Association, 1995: 6).

The Korea Industrial Technology Association, a semi-government agency, published a data book, KOITA (1995), covering foreign acquisition in the period 1970–93. The value of this unique data set lies in the fact that all contracts are reported and classified into three categories: know-how-only acquisition, know-how-and-patent-rights acquisition, and patent-rights-only acquisition. Know-how-only acquisition typically consists of technical services and training that are bundled with relevant documents. Know-how-and-patent-rights transfer consists of technical services, training,

and documentation protected by the patent system. Patent-rights only consists of patent-right licensing.[1] The finding by Chung and Lee (2015) from the analysis of this database is as follows.

First, they found that contracts for know-how licensing dominated in the early years, whereas contracts that involve patents followed later. The shares of know-how-only, know-how-and-patent-rights, and patent-only contracts during the period 1970–5 were 69 per cent, 27 per cent, and 4 per cent, respectively. However, these shares amounted to 50 per cent, 45 per cent, and 5 per cent between 1976 and 1981, reflecting the subsequent increase in know-how-and-patent-rights licensing. This pattern may imply that those firms that successfully assimilated basic operation skills and elementary process technology through know-how acquisition advanced to the acquisition of technologies that involve patent rights at later stages. These contracts include not only printed information and blueprints, but also technical services and training information. Expatriate engineers usually come to Korea to ensure that the initial operation of new facilities goes according to plan. Selected Korean engineers are sometimes sent abroad for training, which emphasizes the importance of human capital investment in building AC, as demonstrated by leading firms in Korea, such as Hyundai Motors (Kim, 1998) and POSCO (Pohang Steel Co.) (Song, 2002).

Various types of training, particularly overseas and on-site training, were arranged or provided by the firms' foreign suppliers of facilities and equipment. For instance, after Hyundai entered into an agreement with Ford to assemble compact cars on a semi-knocked-down basis, Ford transferred 'packaged' technologies to Hyundai with an accompanying set of explicit knowledge, such as blueprints, technical specifications, and production manuals. Ford also provided tacit knowledge to Hyundai, sending ten Ford engineers to Hyundai and training Hyundai engineers at Ford sites in procurement planning, procurement coordination, production engineering, process engineering, production management, welding, painting, after-service, and marketing (Kim, 1998). In the case of POSCO, the company sent thirty-nine engineers to Japan in1968–9 and 1,861 staff members abroad from 1968 to 1983 during the construction of its first mill (Song, 2002: 128).[2]

Second, they found that the acquisition of foreign technologies is dominated by four capital-intensive sectors—electrical and electronic equipment, chemicals, transport equipment, and general

[1] We follow Kiyota and Okazaki (2005) in using the term, 'foreign technology acquisition'.
[2] These foreign-trained engineers played very substantial roles in the early days of POSCO as their share in the workforce in charge of facility operation and maintenance reached as high as 62 per cent and 24 per cent, respectively (Song 2002: 128).

machinery—rather than by labour-intensive sectors. These findings reflect the industrial policy of the Korean government and the effort of firms to enter these sectors from the early 1970s. The contracts in these four industries comprised more than 70 per cent of the total contracts filed in the sampling period and throughout each sub-period.[3] This finding indicates that the state's control over foreign technology acquisition was critical for structural transformation of Korean industries from labour intensive to capital intensive, which has ultimately helped them achieve industrial upgrading. The pillar companies of Korea, such as Samsung Electronics, Hyundai Motors, and POSCO, were all established around 1970.

The entry of Korean firms into these industries typically involved the manufacture of products that were new to Korea yet common in the developed world. According to a survey by the Korea Development Bank (1991) on foreign technology acquisition in the 1980s, 55 per cent of such acquisitions by Korean firms related to mature technologies in developed countries, whereas 70 per cent related to the expansion of product mix. Given that Korean firms found the knowledge embedded in manufacturing facilities insufficient for their operations, they sought additional services and training (or know-how-and-patent licensing) from firms in developed countries at an appropriate price.

From the suppliers' point of view, concealing mature technologies was pointless because providing know-how was a way of exporting large manufacturing facilities. The Japanese government's decision to move away from 'pollution-prone', 'natural-resource-consuming' heavy and chemical industries in 1971 provided a favourable environment for Korean firms (Enos and Park, 1988). Selling unnecessary technologies proved profitable for Japan (Enos and Park, 1988: 34), consistent with the 'flying geese' pattern of economic growth in East Asia, where Japanese companies serve as leaders to their follower firms from Korea or Taiwan by transferring their technologies or relocating their factories abroad (Akamatsu, 1962; Kojima, 1973). In this regard, as noted by several scholars including Kiyota and Okazaki (2005), Korean industries followed a similar path to those of Japan, with foreign technology acquisition in the form of licensing rather than FDI nurturing their domestic absorptive capacity and improving their performance (Lee and Kim, 2010).

[3] However, this case was not evident during the period from 1976 to 1981, when the heavy investment in social overhead capital increased the demand for technology in cement and utility firms, such as electricity.

According to the Korea Development Bank (1991), technologies that were bundled with patent rights were more expensive or had a higher value than those that were only bundled with know-how. This arrangement suggests that Korean firms may have demanded something more than the mere operation of manufacturing facilities after stabilizing their daily production. Patented technologies may have been adopted as a means of completing the assimilation and improvement processes that are initiated by investment and know-how acquisition.

Imported capital goods have been considered among the most important forms of technology transfer in Korea (Lee and Kim, 2010; OECD, 1996). However, these goods become ineffective without the transfer of technology, and especially of tacit knowledge, through know-how-only contracts. Thanks to frequent on-site training by foreign expatriate engineers, Korean engineers quickly learnt to manage their daily operations efficiently. If the knowledge were deemed insufficient, the turnkey contractor and/or other sources, including R&D specialty companies or equipment providers, were contacted for additional information. Enos and Park (1988) argue that even in the most successful cases, such as POSCO and Hanyang Chemicals, time and effort were necessary for Korean firms to become able to use foreign technologies effectively.

Finally, the econometric analysis in Chung and Lee (2015) shows that know-how licensing associated with imported capital led Korean firms to build AC and then to start in-house R&D, whereas patent-only licensing was not significantly related to being able to conduct R&D. Therefore, a substitution effect may be observed between the introduction of foreign patents and the initiation of own R&D activities at the early stages of development. A similar econometric exercise for the second step shows that conducting in-house R&D leads firms to generate innovations, in terms of either patent applications or increased productivity, during the later stages of their development. Moreover, know-how licensing experience tends to be significantly related to firms' first-time patent applications, whereas patent-only licensing helps stimulate the subsequent generation of patents. This study also finds that firms generally spend at least three to four years building their AC, from the first year of know-how licensing to the first year of patent applications.

Chung and Lee's study (2015) was the first to verify the dynamic link between the learning of tacit knowledge and the formation of AC, as well as the first to measure the actual length of time firms take to build this capacity. This finding verifies the two-step-based differentiation of 'potential'

and ‘realized’ AC that is proposed by Zahra and George (2002), as well as the decomposition of AC into learning capacity and problem-solving capacity by Kim (1998). In contrast to Lee (1996), our view is that the substituting or inducing effect of foreign technology acquisition on indigenous R&D depends on the specific licensing method. Patent-only licensing exhibits a substituting relationship, whereas know-how licensing tends to produce an inducing effect on in-house R&D. Moreover, a learning process that involves foreign technology, especially tacit knowledge in the form of know-how, occurs before firms can conduct in-house R&D and innovation. However, this specific learning process may not be the only way to build AC, given the importance of worker education, on-the-job training, and overseas training.

Lee (2013b), arguing that it may be difficult to derive generalizable lessons from the state-versus-market view of Korean economic development, proposed instead a ‘capability-based’ view and elaborated various modes of capability building that may be useful in other latecomer countries. Chung and Lee’s (2015) econometric study provides a microeconomic foundation for a macro-level view of economic development from which several generalizable implications may be derived.

First, the building of AC is a dynamic process that may become more effective when combined with access to foreign knowledge, particularly tacit knowledge (know-how). This suggests that know-how transfer should be an essential element in technology licensing contracts for a latecomer firm. Moreover, the potential substituting effect of foreign patent licensing may interfere with formation of in-house AC, especially if it is not linked to the start of in-house R&D activities or contracting for know-how transfer.

3. Infant Industry Protection by Tariffs and Entry Control

One of the most traditional industrial policy tools come in the form of infant industry protection by tariffs. However, empirical studies report conflicting results on the effectiveness of tariffs.

According to Beason and Weinstein (1996), tariff protection, preferential tax rates, and subsidies did not affect the rate of capital accumulation or TFP in Japan from 1955 to 1980. Moreover, Lee (1996) found no impacts of tariffs on TFP (total factor productivity), such that nominal tariff was negative and significant to the growth rate of labor productivity and total factor productivity (TFP) at the sectoral level in Korean industries from 1963 to 1983. Nevertheless, several studies verify the positive contribution of industrial policy, in particular tariffs.

Shin and Lee (2012), using the same period and sectoral data as Lee (2006), find that tariff protection, especially when combined with export market discipline, leads to the growth of export share and RCA (revealed comparative advantages). They also argue that the goal of such industrial policy was not productivity at the early stage – as in the 1970s – but output or market share growth. Aghion, Dewatripont, Du, Harrison, and Legros (2011) also find that subsidies widely distributed among Chinese firms have had a positive impact on both TFP and the innovation of new products in the sectors with a high level of competition. Both of these recent studies identify competition or discipline as a common precondition for effective industrial policy.

An example of success with tariffs would be the case of Hyundai Motors established in 1970. Hyundai's first own brand car was Pony with 44% market share in Korea in 1976. However, it was protected by as high as 82% tariff rate on imported cars, such as Japanese cars. While its domestic market price was about 4,500 dollars, it was exported to US market at the prices of 1,850$. In other words, without such dumping Hyudai cars were not able to compete other cars and it was possible owing to extra profits associated with oligopoly market situation based on tariffs; at that time, Japanese or German cars at the similar segment were sold at 2,300$ in US markets. In other words, domestic profit compensated the loss in foreign market, and such guaranteed profits helped Hyundai to survive and pay for fixed and R&D investment for expansion.

Thus it can be argued that if Korea had been opened up from the beginning without tariffs, the Korean economy would not have been as successful in promoting indigenous firms and sustaining their catch-up in market shares. A hidden assumption of trade liberalization is that local firms are sufficiently competitive to potentially compete against foreign companies or imported goods. This assumption is not true in many cases. In such circumstances, naive trade liberalization may lead to monopoly by foreign goods or the destruction of local industrial bases.

A smart or better opening strategy, as discussed in Shin and Lee (2012), is 'asymmetric opening' in which latecomer economies liberalize the import of capital goods for the production of final or consumer goods while protecting their consumer goods industries by charging high tariffs on imported goods. Actually, Korea implemented an asymmetric tariff policy for its consumer and capital goods; for instance, extremely high tariffs for consumer goods (e.g., around 70% for household electrical appliances in the 1970s) which were promoted as export industries; but considerably lower tariffs for capital goods, such as machineries, which Korea had to import for its assembly industries, mostly in consumer goods sector.

Besides tariff-based protection, another form of industrial policy in Korea was entry control. Simply, the idea is, for instance, that 5 firms with profits in a sector better than 10 firms with no profits. Such practice of entry control has been one of the typically used tools of industrial policy in the past Japan, and copied in Korea too. In Korea, this tradition of implementing entry control in many sectors has been regarded as a sort of industrial policy copied from the Japanese practices (Johnson 1982). The practice has two meanings. The first is to sort out the 'good and bad' producers and the second is to allow stable profits for the selected producers so that they are assured long term profits so that they may feed more inclined to conduct more investment in fixed capitals for business expansion.

This practice also has the effects of having the return rates to be higher than interest rates, which is good for boosting private investment into manufacturing which would correspond to low rates of return with longer time horizons. This way, manufacturing sectors were able to earn "rents" associated with entry control by the government. Industrial policy was to find out the "optimal number of the firms" in each sector in consideration of the market size so that the admitted firms are sort of guaranteed a minimum level of profits (rents) which can be source of investment funds for next period. Making the rate of return in certain industrial sectors higher than interest rates can be another mean for industrial policy, especially in a situation facing high interest rates.

Of course, one can point out that the protection of local firms by tariffs and entry control will lead to an oligopolistic domestic market. However, a study by Jung and Lee (2010) demonstrates that monopoly rents can be used to fund R&D investments because firms are exposed to the discipline of world export markets while their privileged protection from the government is not free but linked to their export performance. In other words, such combination of rent-generating protection in domestic market and discipline from the world markets is one of the most important aspect of industrial policy in Korea during the catching-stage (or the mid 1980s and 1990s). The study then confirm that such financed R&D led to enhanced innovation capabilities of Korean firms which enabled their productivity catch-up with Japanese firms from 1985 to 2005 (Jung & Lee, 2010).

In other words, In-house R&D became eventually more important than foreign technology acquisition because (1) foreign firms became increasingly reluctant to provide core technology to their potential competitors in Korea, (2) labour cost-based competitiveness gradually disappeared, and (3) government support for private R&D increased (OECD, 1996: 91–2).

4. Public-Private Joint R&D

Industrial policy at the final stage would be public-private R&D consortium which can serve as an important vehicle to break into higher end segment or sectors which requires bigger amount of capital and risk.

One of the first example would be the government-led R&D consortia in the telecommunication equipment industry, specifically the accompanying local development of telephone switches. This led to the successful localization of telephone switches in the 1980s and 1990s in several latecomer countries, including China, Korea, India, and Brazil (Lee, Mani, & Mu, 2012). Most of the developing countries used to have serious telephone service bottlenecks in the 1970s and 1980s; they had neither their own telecommunication manufacturing equipment industry nor their own R&D program. As a result, they used to import expensive equipment and related technologies, and local technicians merely installed foreign switching systems into the country's domestic telephone networks. With industrial and commercial bases developing rapidly – along with population growth – a number of countries decided to build their own manufacturing capabilities.

Starting with Brazil in the 1970s, followed by Korea and India in the mid-1980s, and finally by China toward the late 1980s, all of these countries crafted a state-led system of innovation in the telecommunication equipment industry, with a government research institute at the core. The research institute developed more or less "indigenous" digital telephone switches that were then licensed to public and private domestic enterprises. In these four countries, a common pattern in the indigenous development of digital switches was the tripartite R&D consortium among the government research institutes (GRIs) in charge of R&D functions, state-owned enterprises (SOEs) or the ministry in charge of financing and coordination, and private companies in charge of manufacturing at the initial or later stages. However, the subsequent waves of industry privatization and market liberalization in Brazil and India versus the consistent infant industry protection in Korea and China differentiated the trajectory of the industries in these four countries (Lee, Mani, & Mu, 2012). At one extreme, the indigenous manufacturers of China and Korea took over from the importers and MNCs. Their enhanced capabilities in wired telecommunication, which were accumulated over the preceding decades, led to the growth of indigenous capabilities in wireless telecommunication as well. At the other extreme, Brazil and India have increasingly become net importers of telecom equipment, and their industries are now dominated by affiliates of the MNCs.

As noted by Lee and Mathews (2002), examples from Taiwan include the cases of calculator and laptop PC production. The calculator case is an example of the acquisition of more fundamental design capability or the basic design platform, which is made possible with the help of a government entity such as the Industrial Technology Research Institute (ITRI). Another example is the public-private R&D consortium to develop laptop PCs from 1990 to 1991(Mathews, 2002). This consortium developed a common mechanical architecture for a prototype that could easily translate into a series of mass-produced standardized components. The consortium represented an industry watershed, and even after several failed attempts, it succeeded in establishing new "fast follower" industries in Taiwan.

While the above case of telephone switch is to localize somewhat mature technologies, the same public and private joint R&D can be used to try leapfrogging into emerging technologies or products.. A Korean example is digital TV development, which can be regarded as the decisive and final watershed that enabled Korea to begin taking over Japan in the TV business. An example from China would be its recent move toward electric-engine cars and the use of solar power. In these areas, there are no products to imitate from the latecomers' point-of-view; instead, the advanced and latecomer countries enter the market at the same time. If the former latecomers succeed first, there would be a strong momentum for them to surpass the middle-income group and join the rich country club. In this leapfrogging endeavor, the public-private R&D consortium takes a more vital role given that the risk involved is huge and different. Furthermore, coordinated initiatives for exclusive standards and incentives for early adopters would be important in reducing the risk faced by the weak initial market.

In these public-private R&D consortium, private firms take the lead over the public labs in conducting R&D jointly whereas the opposite would work during the early stage of public-private joint R&D. Thus, in the final stage of the R&D consortium, the role of public research arms would change to be in charge of monitoring the trend of technologies as well as to provide information and knowledge about the choice of proper technology standards and the identification of suitable foreign partners in collaborative development. Examples of the foreign partner include Qualcomm for mobile phone development and Zenith for digital TV development. Furthermore, a foreign company usually has a different role. In the second stage, the foreign company is the direct teacher in the co-development contract; however, in the final stage, it becomes the supplier of source technology to be commercialized by the latecomer firms or their consortium. This has been case with Korea's entry into the mobile phone or digital TV market (Lee et al., 2005). In terms of relationships with foreign

actors, the final stage features horizontal collaboration or alliance based on complementary assets. Some Korean firms (e.g., Samsung) have reached this stage, and are now engaged with Intel, Sony, Toshiba, and Microsoft in diverse modes of alliances.

In light of the above, the success probability of leapfrogging may be higher when a new techno-economic paradigm or a new generation of technologies begins to emerge. Perez and Soete (1988) and Freeman and Soete (1997) observe that some latecomers may be able to leapfrog older versions of technology, bypass heavy investments in previous technology systems, and jump on new technologies to take over the market from the incumbent firms or countries. This leapfrogging strategy makes more sense at the time of a paradigm shift, because every country or firm is a beginner in using the new techno-economic paradigm, and the entry barriers tend to be low. Furthermore, the so-called winner's trap may operate in the sense that the incumbent tends to ignore new technologies and continue to use the existing dominant technologies until it exhausts its sunk investment in the existing facility. The concept of leapfrogging is consistent with the idea of technological discontinuity proposed by Anderson and Tushman (1990) and Tushman and Anderson (1986) that competence-destroying discontinuity may lead to the emergence of new entrants.

Korea's catch-up with Japan in the development of high-definition TVs (HDTVs) would not have been successful if Korean electronics companies, such as Samsung and LG, did not target the emerging digital technology-based products more aggressively than Japanese companies that opted to continue manufacturing the dominant analogue products.[4] The Japanese firms developed, for the first time, the analogue-based HDTV in the late 1980s, and suggested that Korean companies follow new technologies and products by learning from them. Initially, the Korean companies considered going in that direction as they used to do in the 1970s and 1980s. Instead, they decided to try a leapfrogging strategy of developing an alternative and emerging technology, i.e., producing digital technology-based HDTVs. These companies succeeded by forming the public-private R&D consortium, which marked the beginning of the Korean hegemony in the global display market previously dominated by Japan. Without such risk-taking and leapfrogging strategies, Korean catch-up with Japan would have taken much longer or might have never happened.

Leapfrogging is more likely to happen when there are more frequent changes in technologies or generation changes in products, and when there are certain technological sectors with such features.

[4] The case of digital TV production is further explained by Lee et al. (2005). A direct comparison of Samsung and Sony can be found in the work of Joo and Lee (2010).

As argued, such features are closely linked with the length of the cycle time of technologies, as they indicate the speed with which technologies change or become obsolete over time, paving the way for the continued emergence of new technologies. We can reason that it is advantageous for qualified latecomers to target and specialize in such short cycle technology-based sectors. Although this is considered a risky venture, it would prove to be a logical one because the latecomers do not have to rely substantially on the existing technologies dominated by the incumbents; moreover, there are always more growth opportunities associated with ever-emerging technologies.

Finally, we should note the importance of carefully handling the risks involved in opting to implement the leapfrogging strategy. As Lee et al. (2005) explains, one of the biggest risks is choosing the right technologies or standard in the ex-post sense. In the competition for standard setting and market creation, the role of the government is to facilitate the adoption of specific standards, thereby influencing the formation of markets at the right time. In general, when the involved target is in the area of information or another emerging technology, the critical function of standard setting should be emphasized. Aiming to achieve isolated development without consideration for standards might lead to a failure of the entire project. In a standard setting, collaboration and partnership with rivals or suppliers of complementary products are essential. Another key factor is determining who creates and reaches the market first, given the fact that market size determines the success or failure of one standard in relation to another.

The above case for successful public and private joint R&D for leapfrogging in Korea can be contrasted with a mixed case in South Africa, which was also discussed in Lee (2017). Swart (2015) explained that the South African government provided the initial funding and established Optimal Energy in 2005, which actually succeeded to develop four roadworthy prototypes of a electric car called ‘Joule’ by December 2010. The Joule Electric Vehicle was a ‘born electric’ five-seater passenger car that sported a totally new vehicle design, which incorporated a locally developed battery, motor, and software technologies. However, the company closed in June 2012; The government decided to stop the funding required to start large-scale production of the electric cars because of uncertainties in marketing success. The failure of ‘Joule’ cars was caused by the lack of involvement of private companies to take the role in volume production and sales. Thus, existing foreign multi-national companies and local auto companies did not want this new ‘disruptive innovator’, a state-owned company, to grow as another rival that sells cars.

The government should have formed a public-private consortium with the plan that volume

production would be carried out by private actors after the consortium developed the prototype. Thus, this South African case can be considered one of 'design failure' rather than a 'targeting failure'. 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 favorable if the South African project had involved private firms throughout. Caution against government activism often does not distinguish whether the sources of failure are due to targeting or design. The sources are often mixed together. While one might expect more cases of targeting failure, this is not always the case. Uncertainty diminishes if targeting is seen in terms of identifying the potential or existing markets as long as the private sector with knowledge 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.

5. Concluding Remarks

The empirical literature on industrial policy has reported conflicting or ambiguous results on its effectiveness. One way to interpret this diverse outcome is that it might be difficult to verify the average positive impact of industrial policy because the effects tend to appear only in certain conditions, depending upon specific contexts (countries or sectors). Moreover, the results would change, depending upon the criteria used in assessing the effectiveness of industrial policy. As discussed in this chapter, while expansion of production volume and sales to increase market shares had been the primary goal at earlier stage of catching-up, productivity has become an important criterion only since the late 1980s, that is, after the Korean government shifted its policy tools from tariffs to research and development (R&D) subsidies as well as joint R&D (Jung & Lee, 2010).

Given that structural change in an economy is a long-term process, the idea of adopting different policy tools over time is consistent with the reasoning that industrial policy should deal with the various dimensions of capabilities of firms and industries in the latecomer countries. Different tools are necessary, depending on whether the target involves simple operational or production capabilities, investment capabilities, or technological capabilities at the advanced level.

In Korea, tariffs and other forms of protection led to export and output expansion through fixed investment during the early period (i.e., 1970s and 1980s) according to the study by Shin and Lee (2012), whereas Jung and Lee (2010) find that for a later period (i.e., from the mid-1980s to 2005), R&D investment stimulated by tax exemptions led to productivity growth. These two studies find that for both periods, the disciplinary impact of export orientation is significant, because it pushed the rents associated with tariffs (earlier period) and with an oligopolistic market structure (late period) used for fixed (earlier period) and R&D investments (later period), respectively. In sum, while the specific tools and contents of industrial policies were different, they share the commonality of allowing some rents for the targeted sectors or firms so that such rents (extra profits) may be used to pay for building variants of capabilities, such as production capabilities in the case of tariffs or technology licensing in the 1970s, investment capabilities in entry control in the 1980s, and technological (R&D) capabilities in the case of public-private joint R&D in the 1990s.

Such a dynamic shift in policy tools is not simply imposed by the government but also reflects the available and/or desired level of firm capabilities that have been changing over time. Although Korea has grown fast with exports of labor-intensive and low-end goods, this growth strategy already reached its peaks by the mid-1980s. Around that time, Korea saw an increase in its own wage rate, which coincided with the emergence of lower-wage countries that competed against it in the world market. Given Korean firms' realization of the need to upgrade to higher-end or value-added goods, they began, for the first time, to establish in-house R&D centers, after which the tools for industrial policy switched toward tax exemption on R&D (Lee, 2013b; Lee and Kim, 2010).

The Korean experience indicates a dynamic shift in the form of government activism from the traditional industrial policy (tariffs and undervaluation) in the early stage of development, to technology policy (R&D subsidies and P-P R&D consortium) in the later stages. This dynamic shift is required for a developing country to evolve from a low-income to a middle-income status, and eventually move on up to a higher-income status. It can be argued that without such a shift, any country may be stuck in the so-called middle-income trap, in which it struggles to remain competitive as a site for low-cost, high-volume production (World Bank, 2010; Lee 2013).

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