The effect of GRI and ODA in Korean Electronics Industry Development

By

KIM, Sooyeon

THESIS

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KDI School of Public Policy and Management

In Partial Fulfillment of the Requirements

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Abstract

The effect of GRIs and ODA in Korean Electronics Industry Development:

The case study of Korea Institute of Electronics Technology

By

Kim, Sooyeon

The rapid development of the Korean electronics industry is one of the factors leading to Korea's miraculous economic growth. Despite the unfavorable conditions (i.e., scarce natural resources and small domestic market) and limited technological base in its early years, in 2019, the Korean electronics industry has become the third-largest electronics producer in the world. To support the development of the sector, the public sector played an active role. The government enacted a series of laws and basic plans to enhance and promote the electronics industry. The government also established several government-funded research institutes (GRIs). They developed the basic/appliance technology, facilitated technology transfer, and trained the experts.

At the same time, it would be essential to highlight that Korea was a recipient country of Official Development Assistance (ODA) until 1995. Despite its remarkable growth between the 1970s and 1980s, the country graduated IBRD in 1995. Therefore, this thesis aims to answer two questions. The first question is how these GRIs affected the industrial development of Korea. The second question is what roles the ODA played in this development. To answer these questions, this research conducts a case study of the 'Electronics Technology Project' funded by the International Bank for Reconstruction and Development (IBRD)/World Bank. This project was implemented to establish a government-funded research institute for the Korean Institute of Electronics Technology (KIET).

Therefore, this thesis will describe how the government affected/supplemented industry through the public research institute and how the ODA assisted this move for the recipient country's economic and social development. The KIET functioned as a bridge between the technology adoption phase and the technology embodiment phase by leading the technology assimilation phase. This institute trained personnel for the industry, recruited Korean experts from abroad, provided research infrastructure, developed technologies, and facilitated technology transfer. At the same time, this institute encouraged the private sector to enter the industry with its successes in developing semiconductor technologies.

By studying the case of KIET from its recommendation to the completion, it would be possible to grasp the ideal role of government intervention to the industry and the role of ODA for the recipient country's economic and societal development through the development of specific/desirable sector.

Keywords: Korea Institute of Electronics Technology (KIET), World Bank, electronics industry, semiconductor industry, technology transfer, government-funded research institute (GRIs), science, technology and innovation (SCI), Korea

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I Introduction

Korea has become a vast economy exporting more than seven hundred billion USD per year. Despite unfavorable initial conditions such as scarce natural resources and devastated land due to the Korean war, the real GNP of the Republic of Korea (from now on Korea) has tripled in every decade between 1962 and 1991 (World Bank, 1993). For this marvelous success, much literature has pointed to the government policy as a success factor. In this context, a report published by the World Bank (1993) called the development case of Korea as a case of government-led development. According to the report, the economic policy with a strong outward orientation (export) has a tremendous role in Korea's development. However, what is important here is not the export volume and value but what Korea has exported.

Kwon and Jung's research (2019), using the Input-Output table analysis, figured out that Korea's electronics industry has accounted for a very high proportion of all industries in both production and exports. Also, this high proportion has been continued without being alleviated. As they figured out, Korea is one of the leading exporters of information and communication technology (ICT) products, including semiconductors, computers, and telecommunication equipment. Since 2000, the proportion of output and exports has been maintained at about 10% and 30% respectively. In short, Korea's economy has depended on the electronics industry highly, and the tendency has been continued. Once the share of Korea was less than 2% out of total global information and technology (IT) trade in the late 1970s, but it is about 6%. Considering its GDP size (about 2% of world GDP) and today's global market size for IT, this number is quite significant.

Then how could Korea become the leading country in the field of the electronics industry? There can be much explanation, but it seems that many researchers emphasized the role of government. Lim (2016) mentioned the government's policy that provides space for firms to grow by restricting the inflow of imports. In a similar context, Seo (2001) emphasizes the role of the government-funded research institute (GRIs). Due to the private sector's unwillingness and lack of capacity, these research institutes supported the industry by developing new technologies related to import-substitution/export strategic items and transferred them to the private sector. In the same context, the World Bank (1993) insisted that it is the Korean characteristic to establish an institution to help significant policy changes. The establishment of the Korea Institute for Science and Technology (KIST) in 1966, the first comprehensive research institute in Korea, can be explained in this context. This research starts from this point—the role of GRIs in the development of the electronics industry.

At the same time, Korea graduated[1] from the International Bank for Reconstruction and Development (IBRD) only in 1995. Then was there a role of ODA in Korean industrial development, especially in the electronics industry? Even though the contribution of ODA to Korean economic growth has been known as the construction of social overhead capitals (SOCs), including ports, highways, and airports, today, many international development cooperation projects have been dedicated to policy-shaping in industrial policy. Then what about in Korean case?

Of course, the firms and companies-private sector- are the driving force of industrial development. However, it would be the role of the government to find the most effective path to innovation while minimizing trial and error in the innovation process (Hong et al., 2020). The government's role is to create an environment for companies to pursue innovations through

[1] According to the OECD, IBRD graduation starts when countries exceed the 'Graduation Discussion Income (GDI),' currently at USD 6,795 (current USD, Atlas Method)), initiating a thorough country assessment. Important factors determining graduation include the extent of access to external capital markets on reasonable terms and progress in establishing critical economic and social development institutions.

entrepreneurial and innovative activities (Foray, 2016; Hausmann and Rodrik, 2003). Especially in the developing world, where the development of the private sector is lagged, the government needs to foster the private sector and support them. And if the government doesn't have enough resources and initiatives, official development assistance (ODA) from advanced countries and international organizations could assist this move.

Therefore, this thesis aims to look into the role of GRIs and ODA in the development of the Korean electronics industry. To do so, a case of the Korea Institute of Electronics Technology (KIET) is selected. The KIET was a research institute dedicated to the development of electronics technology. At the same time, the establishment of this institute was supported by the World Bank. Therefore, since this case shows 1) the typical role of a GRI for industrial development in Korea and 2) a very active role of the World Bank in the development of the electronics industry, the lessons learned from this case study could be implied in today's international development cooperation projects.

In conducting the research, the second part of this thesis would address the research question. As mentioned above, this thesis aims to investigate the role of the GRIs and ODA in the development of the Korean electronics industry. However, since it is impossible to evaluate the quantitative impact of the development of the research institute, a qualitative study will be conducted.

In the third part, the literature review will cover the role of government in technology development. This part will start with the introduction of industrial policy. And then, the works of literature on the role of government in improving technology capacity (TC) and facilitating technology transfer (TT) will be covered. Moreover, to figure out the trend of international development cooperation in fostering science, technology, and innovation (STI), the recent documents from the major international organization will be analyzed. The main focus will be given to the Organisation for Economic Co-operation and Development (OECD), the World Bank, and the Asian Development Bank (ADB).

The fourth part will analyze the case of KIET Development. The Korean heavy and chemical industry (HCI) drive from the 1970s and the economic status between the 1960s and 1970s will be described. Also, to look into the science and technology base of the electronics industry, the law and plans designed by the Korean government will be introduced. After that, the development of the electronics industry will be covered. Lastly, based on the World Bank documents for the KIET project, including appraisal report and completion report, the entire project progress will be studied.

The implications for the developing countries and future discussion will be covered in the last section. Due to the danger of distorting the market and free-market order, the public sector's intervention could be a somewhat sensitive issue in international development cooperation. However, since the private sector has limited resources and willingness for large-scale research and development (R&D) for industrial development in the developing world, the government should play a catalytic role in industrial/STI development without disturbing the market order. Financial support from international organizations and advanced countries will be helpful for these governments to pursue the promotion of specific industries. The lessons learned from this case study may have some implications for both donors and recipients of the international development cooperation.

II Research Question and Scope

1. Research Question

Then how could Korea achieve the development of the electronics industry with insufficient resources and limited science and technology base? As it can be observed in today's developing world, where the development of the private sector is lagged, the government's intervention and investment are sometimes the only resources for industry development. It was the same in the Korean case. Even though Korea exported a considerable amount of electronics products between the 1960s and 1970s, they were usually simple assembly products using foreign parts with cheap labor. The characteristic of the electronics industry in the 1960s and 1970s was not capital/technology-intensive but labor-oriented. As Table 2.1 shows, the dominant technology in the 1960s was simple assembly. Then how could it develop to the production technology, semiconductor production technology, and convergence technology today?

Table 2.1 Technology-led items by era (domestic electronic components)

	The 1960s	The 1970s	The 1980s	The 1990s	After the 2000s
Technology	Simple assembly	Product production technology	Semiconductor production technology Product design process technology	Digital circuit design Semiconductor process technology Lightweight shortening technology	Convergence technology Smartening technology Modularization Technology
Main Product	Vacuum tube Passive Parts	Semiconductor assembly, Condenser, voice breaking, Black-and-white CRT, etc.	Audiotape, Color CRT, TV tuner, videotape, DRAM, etc.	CD, DRAM, Magnetic head, CD, Small motor, secondary battery, High-Frequency Components, Multilayer PCB	LCD, OLED, QLED, Flexible OLED, 3D NAND-Flash, ultra-low power DRAM, Lithium battery, High luminance LED, MLCC, Chip Parts
Industry Strategy	Mass production	Item diversification Mass production	Quality Enhancement	World-class advanced technology development	Leading technology development and the next generation of growth engines

Source: KIET[2] (2004) & NAEK[3](2019b)

The answer could be government intervention. Indeed, in the Korean case, the government intervened in the industry by enacting laws and plans in the 1960s. For example, the government announced the Five Year Plan for Electronics Industry Promotion in 1966. It aimed to foster the industry by suggesting import substitution, cultivating technical talents, etc. President Park Chung-hee mentioned the development of electronics engineering and localization in the address of 1967. The Electronics Promotion Law was enacted in 1969.

In a similar context, as the World Bank report (1993) insisted, it is the Korean characteristic to establish an institution to help significant policy changes. Especially, in the field of Science, Technology, and Innovation (STI), from the 1960s, the new technologies were

2 Korea Institute for Industrial Economics & Trade

3 The National Academy of Engineering of Korea

usually developed by the government-funded research institutes (GRIs) and transferred to the industry. Until the 1970s, before the rise of the private sector, their role was decisive. Under the Specific Research Institute Support Act 1976, these research institutes were established and functioned as inventors of new technology and a subject of domestic technology transfer. Sometimes they served as 'interpreters' of foreign technology to the domestic industry. Until 1979, starting from the Korea Institute of Science and Technology (KIST) in 1966, There were 16 GRIs in Korea[4]. Therefore, this thesis will focus on the role of GRIs and how they could facilitate technology/industry development.

On the other hand, foreign loans also played a role in industry development. With the enactment of the Foreign Capital Induction Promotion Act in 1961, the large capital inflow was towards Korea. Despite the expectation, the amount of foreign direct investment (FDI) was much less than foreign loans. Many loans from the International Bank of Reconstruction and Development (IBRD) and the Asian Development Bank (ADB) were allocated by the government to private firms if they belonged to several specific industries. With these loans, the private sector could purchase technology from abroad, invest in research and development (R&D) activity and train their personnel abroad. At the same time, this loan was also used to fund a GRI, the Korea Institute of Electronics Technology (KIET).

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[4] Among them, today, 11 GRIs remain: Korea Atomic Energy Research Institute (1959), Korea Science and Technology Information Center (1962), Korea Institute of Science and Technology(1966), Korea Astronomical Research Institute (1974), Korea Institute of Standards and Sciences (1975), Korea Institute of Geological Resources (1976), Korea Chemical Research Institute (1976), Electronics and Telecommunication Research Institute (1976), Korea Institute of Electronics Technology (1976), Korea Institute of Machinery and Materials (1976), Korea Institute of Energy Technology (1977)

Table 2.2 Foreign Loans and Investments to Korea

(Unit: $ Millions and percentage of total arrivals)

Year	Total Arrivals	Loans	FDI	Number of FDI
1962-66	307.8	291.2 (94.6%)	16.7 (5.4%)	15
1967-71	2,261.9	2,165.5 (95.7%)	94.4 (4.3%)	164
1972	799.2	737.9 (92.3%)	61.2 (7.7%)	107
1973	1,024.3	865.9 (84.5%)	158.4 (15.5%)	194
1974	1,150.9	988.3 (85.9%)	162.6 (14.1%)	85
1975	1,355.7	1,286.5 (94.9%)	9.2 (5.1%)	29
1976	1,658.7	1,553.2 (93.6%)	105.6 (6.4%)	35
1977	1,970.6	1,868.3 (94.8%)	102.3 (5.2%)	37
1978	2,847.9	2,747.5 (86.5%)	100.5 (3.5%)	41
1979	2,833.4	2,707.4 (95.6%)	126.1 (4.5%)	42
1980	2,800.1	2,703.9 (96.6%)	96.2 (3.4%)	36

Source: Stoever (1986)

The research question starts from the Korean characteristic described in the World Bank report in 1993. This thesis assumed that the GRIs had affected the industrialization of Korea, especially in the electronics industry. At the same time, considering the amount of loans described in Table 2.2, this thesis will pay attention to the role of loans from international organizations and multilateral development banks (MDBs) in the development of the Korean electronics industry. As a result, the KIET case is selected.

The KIET was established to facilitate the development of the electronics industry. Of course, the most famous example of GRIs will be the Korea Institute of Science and Technology, funded by the US government in 1966. However, since this institute is for comprehensive research development, not for a specific industrial development, the case of KIET will serve better for the purpose of this research. By looking into this case, the role of GRI and the contribution of international organizations could be investigated.

2. Research Scope and Methodology

With the assumption that the GRIs, especially the KIET, played important role in the Korean development of the electronics industry, the research scope of this thesis is the case of KIET and the policies for the electronics industry from 1959, the assembly of the first radio in Korea, to 1985, the merge of KIET and KTRI (Korea Telecommunication Research Institute). The critical event in the private sector (i.e., Samsung's declaration for entry to the electronics industry) will also be covered.

Due to the difficulties in evaluating the quantitative impact of each law, regulation, and GRI, the research will be conducted based on the second data as qualitative research. Memoirs of leading figures of the Korean electronics industry and private/public documents will be analyzed to describe the formation of the KIET and its role in technology development in the electronics industry.

III Theoretical Background

1. Literature Review on the government intervention for the development of industry

A. Industrial Policy and Science and Technology Development

According to Lim (2016), industrial policy entails all efforts to influence sectoral development and overall industry portfolio. Rodrik (2008) uses the term to denote policies that stimulate specific economic activities and promote structural change. Robinson (2009) argues that industrial policy can play an essential role in promoting development. However, in this thesis, the term industrial policy will be used as a government intervention to encourage the specific industry. The instruments of industrial policies could be various from protection (tariff and trade policy) to promotion (tax relief, subsidies, export zones). Also, support for human resource development and infrastructure, R&D, public-private consultation, especially in sharing information and risk, could be adequate industrial policy tools.

Then why industrial policies matter? According to Rodrik(2007), industrial policies imply positive external effects such as economic development. Promoting specific industries could contribute to the development of the national economy. At the same time, he argues that industrial policies could promote structural changes. Considering many developing countries trying to change their economic structure from agro-centered to manufacturing base, there is no wonder they actively pursue the industrial policies aggressively, and the donor countries and institutions of ODA support these movements.

However, could government deploy effective industrial policy? There are various opinions on the identification and development of promising industries. According to the rent-seeking theory, for the government, it is difficult to have the information and policy enforcement capabilities necessary to identify and nurture the selected industry. Therefore, a winner cannot and should not be chosen because it is likely to be corruption in the process. However, according to the theory of developing countries, the government can identify and nurture promising industries through consultation with the private sector, as can be seen in the cases of Korea and Taiwan. As a compromise, Rodrik (2007) insists on the self-discovery theory. According to this argument, promising industries cannot be selected by the government but instead discovered through the exploration and experimentation of entrepreneurs. The government's task is not to directly identify promising industries but to support them to be found. His theory could be applied to this thesis.

At the same time, industrialization means the rise of the manufacturing sector. Therefore, the need for advanced technology is aroused. Technological progress and its diffusion are significant. In 1963, OECD suggested that all countries should introduce a science policy directed towards industrial development. According to Wicken (2007), the OECD became a driving force for establishing industrial science policies by introducing a concept of research and development (R&D). From that time, the R&D policies have been highlighted in western economies for industrial development (OECD 1963), and this trend has continued in today's world. However, except for public R&D investment, there is little room for the government to act as a direct source of technology. Therefore, the next section will highlight the role of the government in the acquisition of technology, especially in technology transfer and technology capacity building.

B. Government's role in facilitating Technology Transfer

Again, there is a consensus that investment in science and technology is a viable option to achieve industrialization. Wicken (2007) has emphasized the role of R&D in Norwegian public industrial policy. Even though the part of the public sector in technology development is very controversial, but there is no doubt that in the developing countries where the private sector's development level is low, the government and public institutes (i.e., public universities, government-funded research institutes) are the primary sources of R&D activities. Because of the scarce resource and lack of willingness of the private sector to invest in a specific industry that may somewhat be developed than other industries, the government should play a decisive role. In this context, the literature on the part of the government in facilitating technology transfer could be introduced.

First of all, Bozeman (2000) argues that the term technology transfer can be defined in many different ways. Nevertheless, most intuitively, it means the flow of technology from one agent (government, company, research lab, university, etc.) to another agent (mainly the industry). On the other hand, it could be categorized into two parts: domestic technology transfer and international technology transfer in its most simple form. Belderbos et al. (2010) define domestic transfers as technology acquisition in the local market and international transfers as technology acquisitions and transfer from abroad. Therefore, the government could facilitate technology transfer in two ways. First, it can facilitate domestic technology transfer by providing a secure innovation ecosystem, protecting intellectual property, investing in R&D, and supporting advanced technology development through the GRIs. Second, to facilitate international technology transfer, it could create an attractive environment (i.e., stable macroeconomy) for foreign companies to invest.

According to Bozeman (2000), before the 1980s, the academy trend focused on cross-national technology transfer, especially the transfer of technology to less developed world from advanced countries. In this context, Westphal et al. (1981) in the World Bank report defined the source of technology into four categories: 1) Foreign Direct Investment (FDI), 2) Technical Assistance, and Licensing, 3) Acquisition of Technology by Exporting Firms and 4)

Accumulation of Local Know-how. However, since the 1980s, domestic transfer has drawn attention. Therefore, the universities and government laboratories started to be regarded as a cradle for technology transfer.

Naude et al. (2013) insist that emerging economies can access international knowledge and technology through FDI and domestic investment. Therefore, creating a secure environment to attract FDI is the role of the government. In the same context, according to Lloyd(1996), multi-national enterprises (MNEs) could diffuse technologies to developing countries in three ways: 1) by directly transferring technology to an affiliate or joint ventures, 2) through spill-over effects, and 3) through doing R&D within developing countries. Morrison et al. (2008) emphasize the importance of participating in the global value chain (GVCs) to acquire technological capabilities. Technology capacity is the managerial and organizational skills that an organization needs to efficiently utilize hardware and software technologies and complement technical change processes. By actively participating in GVCs, international technology transfer from MNCs to the developing world could occur.

However, before the technology transfer occurring, some experts have insisted on the importance of absorptive capacity as one of the main factors for successful technology transfer. Penner-Hahn and Shaver (2005) and Song and Shin (2008) emphasized that effective technology transfer requires a sufficient degree of 'absorptive capacity.' According to Naude et al.(2013), the MNEs could bring technology and know-how to a local economy once good absorptive capacities have developed. In other words, to gain an advantage from technology transfer, the ability needs to be equipped first. This capacity could be achieved through general education and training.

In the case of Korea, while much literature focusing on international technology transfer, including FDI, GVCs, original equipment manufacturer (OEM), Chung (2009) emphasizes the role of GRIs based on the Korean experience. According to him, FDI had minimal impact on the Korean economy since it only accounted for 3.9% of the cumulative total of long-term capital in Korea throughout 1962-1982. These GRIs helped industries to adopt new technologies from abroad. They worked with the private sector closely and built a technological cornerstone for industrial development. Therefore, the government could act as a facilitator of technology transfer.

2. The role of ODA (Official Development Assistance) in STI development

ODA could be defined as supporting developing countries' economic development through concessional resources (OECD, 2019). Today, many projects to facilitate science, technology, and innovation (STI) are implementing by the International Organization and MDBs for the socio-economic development of recipient countries. These activities are based on the belief that STI could promote economic growth. In this section, based on recent reports published by major international organizations, their views on STI in ODA will be introduced.

The role of STI in achieving the Sustainable Development Goals (SDGs) has been emphasized for decades. New technologies and innovation could facilitate learning and the exchange of information. In this context, in 2020, United Nations Inter-Agency Task Team on Science, Technology, and Innovation for the SDGs proposed a guidebook for STI preparation for SDGs roadmaps. This report emphasized the importance of institutional arrangement, fostering a learning environment, mobilizing resources, etc., to develop the science and technology to achieve the SDGs.

In OECD's 2019 report, "Connecting ODA and STI for inclusive development," advancement in science and technology are described as virtual drives of economic growth and potential that could transform economies and societies. Therefore, according to this report, significant investments are needed to strengthen countries' research capacity because adopting new technologies help developing countries leapfrog. The public spending and development cooperation could fill gaps where the private sector lacks incentives to intervene. At the same time, this report emphasized the importance of investing in soft infrastructures such as training and education, enhancing the technology absorptive capacity.

On the other hand, it seems that World Bank is more focusing on structural change to the Knowledge Economy (KE) and takes an industry-related approach. According to the working paper published in 2004, technology projects are diverse since they depend on each country's situation. For the reform of the science and technology sector, on the supply side, the reform should aim at 1) assist the restructuring of R&D institutions to reorient them toward industry, 2) build-up measurements, standards, testing, and quality system to enhance the competitiveness of products domestically and internationally, and 3) provide the necessary protection of private sector in the form of a healthy intellectual property rights regime. At the same time, on the demand side, the reform needs to support the use and adaptation of technology by the industry of innovations and newly developed technologies by the research community.

In a similar context, the report published by Asian Development Bank (ADB) insisted that innovation can promote more inclusive and sustainable growth (ADB, 2020). It can improve the quality of life. Therefore, the role of R&D, human capital, and infrastructure needed to be highlighted. Moreover, since the quality of connectivity (energy, transportation, and ICT) correlates positively with innovation, the investment in these connectivity infrastructures needs to be strengthened. Also, investment in human resource development (education), strong institutions, and intellectual property systems are required for innovation.

Furthermore, this report also insisted that the government should become catalysts for innovation.

The private sector would be a key driver for developing STI in a development context (OECD, 2019). It is not merely because they can drive much technological development, but because they are the factor that leads the economy of developing countries to industrialization. It can also be observable in the case of the KIET. However, as Mazzucato(2012) mentioned, sometimes, the private sector cannot invest in a promising industry. This can be due to the weakness and risk inherent in investment or specific industries. Or, they are just short-sighted. Therefore it is the role of the public sector to foster particular industries and provide high technology to the market. Moreover, even if the private sector has the willingness to invest in STI, it is the role of the government to foster an adequate environment for investment. Also, for the developing countries where even the government has a tight budget, advanced countries and international organizations could have a supportive role in their economic and societal development.

IV Case Study of Korean Institute of Electronics Technology

1. Foundation for Science and Technology Development

According to Kim (1991), until the 1960s, Korea truly represented a backward, desolate economy. With insufficient natural resources, only about 30% of the land area is cultivable, and the arable land per farm household ranks among the lowest in the world. The small infrastructural base built during Japanese rule was mostly destroyed during the Korean War. Therefore, it is not surprising that the country's per capita income in the 1960s was even lower than Haiti, Ethiopia, and Yemen (World Bank, 1993).

However, the government-led, outward-oriented economic strategy has transformed Korea into an industrialized country. In 1965, Korea's export was only about $175 million, but in 1978, it increased to $12,700 million. Considering Korea's limited natural resources, this massive increase in trade had been driven by the manufacturing sector, especially the light industry. Thanks to the rapid growth in export, the GDP increase rate in the 1960s was around 9%. However, this expansion of the economy caused inflation. Also, due to the increase in export, foreign exchange flowed into Korea largely. The low wage, one of Korea's comparative advantages, started to rise. The competition started with less developed countries with more favorable natural conditions and abundant and cheap labor. In short, in the late 1960s and early 1970s, Korea started to lose its charm in the global market. The government needed to find a solution, such as diversifying its export items.

In this context, in 1973, President Park declared the heavy and chemical industry (HCIs) drive. Six sectors (steel, nonferrous metal, shipbuilding, machinery, electronics, and chemicals) were designated to be promoted, and they were considered in the preparation of the Fourth Five Year Economic Development Plan (1977~1981). At that time, Korea's long-term goals were specified as two sentences: 1) growth with enhanced self-sufficiency and 2) more significant equity and social development. Again, to achieve these goals, continuing economic development and steady export growth were required. Fortunately, Korea's comparative advantage was starting to shift from unskilled labor-intensive items to more capital- and skill-intensive products such as electronic devices, thanks to its trained but comparatively cheap human resources. The change was needed, but it was in progress. As Table 3.1 describes, starting with the ratio of 8:2 (light industry: heavy industry), the share of heavy industry has increased in the 1960s and 1970s.

Table 4.1 Structure of Manufacturing (1953 – 1985)

	1953	1960	1965	1970	1975	1980	1985	1990
% of Light industry	78.9	76.6	68.6	60.8	52.1	46.4	41.5	34.1
% of Heavy Industry	21.1	23.4	31.4	39.2	47.9	53.6	58.5	65.9

Source: Kim (1997)

Then how could the shift toward heavy industry occur? Unlike the light industry, the heavy industry requires a certain level of technology. In this context, the National Academy of Engineering of Korea (NAEK) (2016) argues that investment in technology development was the primary factor of Korean development and industrialization. In a similar context, it seems that many researchers agree on the role of technological innovation as one of the Korean government's outward-looking development strategies. Then how could Korea develop a high level of technology?

The Science and Technology Promotion Act and the Science Education Act were enacted in 1967, and they provided a legal base for the government's drive for science and technology development. Also, the Korea Institute of Science and Technology (KIST), the first comprehensive science and technology research institute, was established in the same year with assistance from the US to conduct basic science research. In 1968, the Ministry of Science and Technology was established as the central government agency responsible for science and technology policies. Also, from the 1970s', the various GRIs started to be established to assist the private sector through absorbing and assimilating basic and advanced technologies. Since the private sector lacked resources and human capital to invest in R&D, the public research institutions played a role as a pioneer with the budget from the government for technology development. These GRIs acted as a bridge between advanced technology from abroad and domestic industry.

In more detail, the role of GRIs could be categorized into 1) R&D focusing on science-technology principles, 2) supporting the private sector, and 3) technology development for a public purpose (i.e., import substitution) and future-oriented exploration. In Korea, in its early stage, these research institutes supplemented the private sector's R&D activities. For example, in the case of KIST, the institute facilitated the penetration of knowledge required for creating an industry foundation by translating and explaining manuals from foreign companies and transferring them to the private sector in its early years.

2. The Formulation of the Electronics industry and supportive government mechanism

In the late 1970s and early 1980s, the critical turning point had occurred for the transition from "imitation to innovation" (Kim, 1997; Choi, 2007). According to the Bank's loan proposal for the Korean Institute of Electronics Technology (KIET), production and exports in the industry increased by about 50% between 1970 and 1977. Production increased from $106 million in 1970 to $1,760 million in 1977, and exports increased from $55 to $1,108 million over the same period. The number of firms also increased dramatically from about 175 in 1970 to over 700 in 1978. The industry became increasingly important to Korea's economy and accounted for 11% of the nation's total exports and employed over 140,000 persons in 1977. Then what made these changes?

The Korean electronics industry started with domestically produced radios by Goldstar (Geumseong) as an import substitution industry. This company imported mechanical equipment from West Germany and assembled and released the first domestic radio in 1959[5]. In 1966, Goldstar developed the first domestic black and white TV. At that time, the Korean electronics industry was consumer electronics oriented, and the role of companies was limited to the simple assembly of imported parts using cheap labor. Therefore, it is not surprising that until 1966, there were no systematic strategies for the electronics industry promotion in Korea. Also, there was no policy for promoting technology and human resource development. Even though there were some fragmented laws and ordinances aimed to stipulate technical standards and quality standards, they were mainly for the quality control for export items.

In the institutional aspects, the Electric Industry Division was established in 1964 under the Ministry of Commerce and Industry. In 1966, the Five Year Plan for Electronics Industry Promotion had been announced. The primary goals were 1) import substitution of electronic parts, 2) division and specialization of assembly and parts factories, 3) reduction of export costs, 4) cultivation of technical talents, and 5) diversification of export markets, etc. Based on this plan, the goal of developing the electronics industry as an export-oriented strategic industry and achieving $ 100 million export by 1971 has been set. Considering Korea’s total exports amounted to $250 million in 1966, the goal was quite ambitious at that time.

In 1968, the Korea Institute of Science and Technology (KIST) published a report

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[5] Therefore, there is a consensus that 1959 is the first year of the Korean electronics industry.

named 'Investigation of the domestic electronics industry and related fields to establish a policy to promote the electronics industry.' The report consisted of three parts: 1) Economic status, 2) Technical status, and 3) Condition analysis for development. The report emphasized the importance of fostering the electronics industry. Based on this report, the Electronics Industry Promotion Basic Plan (1969-1976) was established.

And it was the late 1960s when Dr. Wan Hee Kim made an entrance to the Korean electronics industry. The history of Korean electronics development could not be written without Dr. Kim's effort, who was a professor at Columbia University at that time. He provided advice on promoting the electronics industry to the Korean government in a briefing to President Park in 1967 on the importance of promoting the industry. He emphasized the characteristics of the industry, high value-added and labor intensiveness. At that time, since the government and private sector tried to find the next industry to promote economic expansion after the garment industry, Dr. Kim's suggestion was drawn the attention of President Park and Korean decision-makers. Based on his briefing, in 1969, the Electronics Industry Promotion Law was enacted. This law aimed to 1) modernize industrial facilities and technology and 2) contribute to the development of the national economy. It was the legal basis for industrial policy for the electronics industry, the Electronics Industry Promotion Basic Plan (1969-1976), and the construction of the Gumi Electronics Industrial Complex (Lim, 2016). According to the law, the government was responsible for designing products to be promoted and support the industry financially through the general budget.

In the case of the Electronics Industry Promotion Basic Plan (1969-1976), it had four goals: 1) development of designated products, 2) export targets to be achieved, 3) increasing the localization rate, and 4) establishment of promotion funds. According to the plan, the government planned to invest 14 billion won in promotional funds during its proposed period and achieve the export targets of $ 400 million in 1976.

Table 4.2 Major event of Korean electronics industry development

Year	Event
1959	Assembly of the first radio (Goldstar)
1964	the establishment of the Electric Industry Division under the Ministry of Commerce and Industry(MCI)
1966	Assembly of the first black and white TV (Goldstar) the Five Year Plan for Electronics Industry Promotion
1967	Dr. Wan Hee Kim's briefing to President Park
1969	Electronics Industry Promotion Law the Electronics Industry Promotion Basic Plan (1969-1976)
1971	the establishment of Gumi Electronics Industrial Complex
1973	President's declaration on the promotion of heavy and chemical industry (HCI)
1976	the establishment of the Korea Institute of Electronics Technology (KIET) the establishment of the Electronic Industries Association of Korea (EIAK)
1978	the establishment of the Electronic and Electric Industry Bureau under the MCI
1982	Development of TDX-1(Time Division Exchange, KIET)[6]
1983	the Development of 64k DRAM (Samsung)
1985	the establishment of the Electrotechnology and Telecommunications Research Institute (ETRI) and merge of KIET

6 TDX is a technology that opens the era of one phone per household in South Korea and has an economic ripple effect of 37.66 trillion won

Table 4.3 Summary of the Technology Development Process of Korean Semiconductor

Phase	Technology introduction (1965~1973)	Technology embodiment (1974~1981)	Technology leading transition (1982~1991)	Technology leapfrog (1992~1997)	Technological maturity (1998~present)
Growth Stage	Assembly processing stage by foreign companies	Individual element and wafer processing stage by the domestic company	Full-scale business initiation stage in the memory sector	World-leading stage in memory	Memory restructuring and system semiconductor development stage
Key Policies	Enactment of Foreign Capital Induction Act/ Electronics Industry Promotion Act	Establishment of KIET/ Establishment of a long-term development plan for the electronics industry	Establishment of semiconductor industry promotion plan/Implementation of industry-university joint R&D project	Enactment of Semiconductor Chip Protection Law/ Establishment of Semiconductor-related Human Resources Training Center	Implementation of System IC-2010 Project / Establishment of Semiconductor Industry Vision and Development Strategy
Technical Stage	Acquisition of assembly skills	Acquisition of wafer processing skills	Self-development of product technology and process technology	World-leading memory technology	Acquisition of system semiconductor technology
Product Development	Assembly processing	Clock chip/Transistor	64K, 256K, 1M, 4M, 16M DRAM	64M, 128M, 256M, 1G DRAM	16Gb DRAM, 1Tb NAND-Flash, MCU, SoC
Enterprise Form	Multi-national	Medium-sized	Large	Large	Large, Venture companies

Source: Korea Institute for Industrial Economics and Trade (KIET) (2004)

Table 4.3 shows the summary of the technology development process of Korean semiconductors. As it can be observed, during the technology introduction stage (1965~1973), the multi-national companies dominated the Korean semiconductor industry. Through foreign direct investment (FDI), these companies assembled their products using Korea's cheap labor. Table 4.4 shows the list of foreign investments in Korean semiconductor firms.

Table 4.4 Foreign Investment in Korean Semiconductor Firms (1965-1973)

Year	Firm	Investor	Country	Investment ($1,000)	Foreign Ownership (%)	Form
1965	Komy	Komy	USA	76	25	Joint
1966	Sumiko	Fairchild	USA	2,145	100	
1966	SIGNETICS	SIGNETICS	USA	1,679	100	
1966	Korea-Micro	KMI	USA	224	49	Joint
1967	Motorola	Motorola	USA	7,544	100	
1968	IMEC	Komy Car Co.	USA	432	100	
1969	Mining	Hahn-American	USA	145	35	Joint
1969	Korea Toshiba	Toshiba	Japan	1,400	70	Joint
1969	Samsung-Sanyo	Sanyo/Sumitomo	Japan	1,500	40/10	Joint
1970	Daehan Micro	AMI	USA	2,264	100	
1970	Electrovoice	EV	USA	50	50	Joint
1970	Varady	Varady	USA	294	49	Joint
1970	Korea IC	Tesco	USA	700	50	Joint
1970	Toko	Toko	Japan	390	100	Direct
1971	KTK	Toko	Japan	N/A	100	
1972	Rohm	Rohm	Japan	N/A	95	Joint
1972	Tokyo Silicon	Sanyo	Japan	1,624	100	
1973	Sanken	Sanken	Japan	700	100	

Source: Soh (1997)

However, from 1974 to 1981, the second stage, the domestic companies started to enter the industry. These medium-sized companies became large companies in the phase of technology-leading transition. And based on the acquisition of foreign technology during the first and second phases, the Korean firms started to develop their own products. Also, as can be observed in Table 4.5, after the second phase (1974 – 1981), the share of the electronics industry increased rapidly, around doubled. Therefore, it would be essential to investigate what happened in the second phase and what was the most critical event in the development of the Korean electronics industry.

Table 4.5 Structural Change (value-added) in Korean Manufacturing (Unit: %)

	1953	1965	1975	1980	1987	Real Growth ’83-’87 p.a.
Light Industries	87.4	75.5	55.5	48.6	38.4	8.1
Heavy Industries	11.3	22.8	44.4	51.4	61.6	16.8
- Chemicals	3.7	10.7	22.6	23.8	18.4	8.9
- Basic Metals	2.0	4.3	5.7	8.9	7.8	7.5
- Electronics			10.4	13.4	23.5	
Transportation	2.3	4.0	5.0	4.3	11.7	26.4
Others			0.9	1.0	0.2	
Unspecified	1.3	1.7	0.1			

Source: World Bank (1991)

In 1973, even though President Park declared the heavy and chemical industry (HCIs) drive and designated six industries for promotion, however, the first oil shock affect negatively the Korean economy. Since the electronics industry was less energy-intensive than other industries, the industry was highlighted out of six and drew President Park's attention. Financial and tax benefits were given to the industry. Also, it was the Third Basic Plan for Electronics Industry Promotion that emphasized upgrading the industry before the implementation of the Fourth Five-year Economic Development Plan (1977-1981). It designated a unique role to the electronics industry as a leading industry in Korea's export-oriented growth, targeting $4,700 million and export $3,000 million by 1981.

In this context, in 1975, the Korean government requested Arthur D. Little (ADL), an American industry consulting company, to conduct the 'Long-term outlook of the Korean electronics industry' project. The analysis suggested home appliances such as color TVs and VTRs and private premises (PBX), semiconductors, computers, and peripherals, all 24 items are promising in Korea. As such, the electronics industry was regarded as a promising industry that could lead to the growth of the Korean economy. According to Lee and Yoo's report published in 1979, "status and issues of Korea's electronics industry," there was a broad consensus that existing economic conditions in Korea match the electronics industry's requirements.

Most importantly, in 1976, the Korean government decided to establish a research institute to promote electronics technology. The institute, the Korea Institute of Electronics Technology (KIET), started to research semiconductor design technology and laid the foundation for large-scale integrated circuit design technology in 1977. By recruiting foreign-educated personnel, the institute laid the foundation for semiconductor research and development. Developing some technologies successfully, including 32k ROM (read-only memory), gave confidence to Korean companies who were reluctant to invest in the semiconductor sector. As a result, the 64K DRAM (dynamic random access memory) was developed by Samsung Semiconductor Communications (now Samsung Electronics) in 1983.

3. The Development of Korea Institute of Electronics Technology (KIET)

According to Chung (2009), in the 1960s', due to the lack of technological capability, Korea's policy strategy aimed to promote the inward transfer of foreign technology and develop the absorptive capacity to digest, assimilate and improve the transferred technologies. The objective of the KIET establishment could be explained in this context. In 1973, the Korean government enacted the Law for Promoting Specific Research Institute. This was to nurture GRIs to develop science and technology to promote industry and economy. In this context, the Korean government established the KIET in 1976, recognizing the need to develop a research institute dedicated to technology development in the electronics industry.

A. Project Planning and Final Approval from the World Bank (1976~1979)

Within manufacturing, the Korean electronics industry has served as a leading growth sector since the 1970s. According to the appraisal report prepared for the KIET project (World Bank, 1979), between 1970-78, electronics production and export rose at an average annual rate of about 50% from a low base. In 1977, electronics products represented 11% of Korea's total merchandise exports.

In the meeting of the Minister of Economy held on September 25, 1976, where the Electronics Industry Promotion Plan was embodied, the government planned to convert the industrial structure into a technology-intensive system by 1981 by investing $600 million. Also, establishing an electronics research institute with 31 million dollars and 5.1 billion Korean won was decided in this meeting. In December 1976, the KIET was officially launched in Seoul[7]. Because KIET was developed from the Semiconductor Development, and Systems Unit established under the KIST in 1974.

To construct the building and equip it with production lines and R&D facilities, the loan from IBRD was a precondition for the establishment of KIET. Since the institute needed to be equipped with high-tech facilities and machinery, the KIET needed to import almost every facility from advanced countries. Therefore, the KIET prepared the proposal for the Korea Electronics Technology Project to borrow the loan of $29 million from the IBRD/World Bank.

However, the decision to provide loans within the World Bank was not easily made. Until that time, IBRD loans were to provide infrastructures, including roads, dams, and bridges, to developing countries, not to create the specific, especially high tech industry. Also, as of December 31, 1978, Korea received 41 bank loans and 8 International Development Association credits, totaling $2,247.5 million in loans and $106.8 million. Therefore, some

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[7] Even though the KIET was located in Seoul in its early years, the move to Gumi, the birthplace of President Park, was scheduled. A large part of the IBRD loan was for the construction of the institute in Gumi.

members of the World Bank had opposite opinions.

Nevertheless, in 1977, Dr. Magdi Iskander, director of the World Bank's Asia Economic Development Bureau, visited Korea and concluded that Korea is the only country that could develop semiconductors and computers among developing countries. Also, even though the World Bank staff participating in the project were well-recognizing the risks inherent in this establishment of the KIET project due to the rapidly changing technological environment of the electronics industry, they saw that the potential benefits and the costs of inaction considerably outweigh the risk. Especially, they recognized the trend towards industrial electronics from consumer electronics. Thanks to their effort, the loan was approved in 1979.

In the project designing phase, five objectives of the project were decided: 1) provide a technological infrastructure of actual production and support services, 2) assist in the training of technical staff of the industry, 3) lead the industry in acquiring and developing technologies, 4) carry out research, development & engineering (RD&E) program for the industry, and 5) explore market opportunities for the industry abroad. KIET was expected to be a focal point for the initial technology transfer of intermediate technology. At the time of its establishment, the purpose of the KIET was to comprehensively conduct research and development, investigation, and testing on electronic components and produce electronic devices connected with the electronics industry.

B. Project Implementation (1979~1985)

It was March 1979 that the report and recommendation for an electronics technology project had been submitted and approved by the executive directors of the IBRD. The proposed

Bank loan of US$29 million would finance about 87% of the foreign exchange component of the project. The planned date of effectiveness of the loan was June 1979.

The project could be divided into two parts—the development of KIET and the RD&E program. The development of KIET included building construction reflecting the latest technology at that time. Also, this component included a comprehensive program for technology development. KIET was expected to emphasize relatively mature applications of a limited number of dominant technologies expected to be available from various sources at reasonable costs.

For the RD&E program, a total of $ 5 million of the budget was allocated. This program was to ensure that the research outcomes are aligned with the industry goals. Therefore, 70% of research projects needed to have an industry sponsor. However, it was unable to create the project and withdraw RD&E funds because no companies were willing to invest in the semiconductor sector at that time.

Instead of borrowing loans, the World Bank continuously committed to the project to help the institute maintain focus on its activities, especially by selecting the appropriate products and technologies for Korea and preventing a situation from spreading valuable resources too thinly to provide an essential impact on the industry. Also, the execution of funds was thoroughly supervised through monthly reports and quarterly reports submitted to the Bank. In various fields, such as education, invitation of foreign experts, and installation of facilities and equipment, procedures were made to be approved by the Bank to ensure no waste of funds. Also, the Technical Advisors were designated to evaluate the validity of every purchase.

KIET stimulated and supported the development of the semiconductor and digital systems capabilities necessary for the growth of the Korean electronics industry. Following the development of 4k DRAM in February 1982, the KIET succeeded in developing the 32kROM prototype for the first time in October. This success surprised academia, research, and entrepreneurs. Even though the Korean conglomerates were hesitant to develop semiconductors, the success of development became a catalyst for large companies to jump into the semiconductor industry confidently. Moreover, in 1983, using N-channel metal-oxide-semiconductor process (NMOS) technology, the institute succeeded in developing 64k ROM. Although it combined foreign technologies, 32K ROM and 64K ROM were the first memory devices in Korea. Their experiences and technologies were used as assets in the domestic semiconductors industry. Also, they provided a footstep in creating a boom in the semiconductor industry in Korea.

In the computer sector, the development of computer-related technologies centered on the Division of Systems since 1981. The investment in computer technology was relatively small compared to the semiconductor sector. However, it was enough to build a foundation for the development of the domestic computer industry through continuous R&D. In 1982, KIET launched an 8-bit computer development project jointly with Goldstar, Samsung Electronics, Oriental Nylon, Sambo Computer, and Korea Commerce. They successfully opened the domestic computer era in March 1983 by succeeding the project. They developed and produced 5,000 educational computers and distributed them for free for the education of students. This project became a catalyst for Korea's computer industry and led Korea to a computer exporter.

Thanks to the development of the 8-bit computer, the institute began developing the 16-bit UNIX computer in collaboration with Korea Electronics (now Samsung Electronics) in April 1982. The project was successful in developing prototypes in 1984. As a project to develop computers with the performance of the mini-computer, a total of 800 million won was invested. This technology was immediately transferred to Samsung Semiconductor Communications, and SSM-16, the first domestic computer, was commercialized. In the phase of technology embodiment, the KIET played a role as a facilitator of technology transfer and the source of advanced technology.

C. Project Completion and Evaluation (1985)

At the time of planning, the KIET was expected to provide necessary infrastructure and specialized services that individualized private firms could not offer. Indeed, it facilitated the initial technology transfer (intermediate technologies) to the domestic industry and provided job training to the industry. However, in the early 1980s', encouraged by the success of the KIET and rapid increase in world semiconductor demand, the Korean private sector started to invest heavily in the electronics industry. In February 1983, Samsung declared entry to the development of semiconductors. With the technology from the US, they succeeded in developing the 64k DRAM (dynamic random-access memory) in the same year. DRAM is a more advanced technology than ROM. It took only six months for Samsung to develop the 64k DRAM, while the same took more than six years in Japan. This success was linked to the development of 256k DRAM and 1M DRAM.

In 1983 alone, investment in the electronics industry by the private sector was more than $300 million, and it climbed to over $400 million for 1984, 1985, and 1986 (World Bank, 1992). As Table 4.6 shows, between 1980 and 1985, the R&D expenditure of the private sector exceeded that of the government. As Choi (2014) mentioned, in the 1980s, private-sector R&D took over the role of GRIs that had been at the forefront of advanced technology between the 1960s and 1970s.

The shift occurred due to worldwide shortages in semiconductors, which increased the prices of semiconductors and severely impaired the production of consumer goods. It was against the expectations that Korean firms are unwilling to invest in the electronics industry, especially semiconductors and computers. Instead, Korean firms decided to achieve their technological foundation in the major services that KIET aimed to provide. At that time, KIET did not have a leading technological edge, and its wafer fabrication capabilities were not considered reliable enough by the industry (World Bank, 1992). Due to the unfortunate delay in the construction of KIET in the Gumi estate for over one and a half years, the facility was only ready to be equipped only in 1981, and at that time, this equipment was already out of the technological edge.

Table 4.6 Research and Development (R&D) Expenditures, 1965-1985 (in billions of won)

	1965	1970	1975	1980	1985
R&D Expenditure	2.1	10.5	42.7	282.5	1,237.1
- Government (G)	1.9	9.8	30.3	180.0	306.8
- Private Sector (P)	0.2	1.3	12.3	102.5	930.3
- Ratio (G:P)	61:39	87:12	71:29	64:36	25:75
R&D/GNP(Gross National Product)	0.26	0.38	0.42	0.77	1.58
Number of Corporate R&D Centers	0	1	12	54	183

Source: Kim (1997)

Also, at the same time, the government designated the electronics industry as a priority industry and started to direct and finance national projects in electronics. Therefore, KIET's activities were shifted to participation in government-sponsored projects from their own R&D. Therefore, it remained dependent on government funding instead of becoming a self-financing, profit-making institution. Only about 15% of the revenues came from private business and export (World Bank, 1992).

Also, the semiconductor research facility in Gumi designed to combine research and production facilities at its plan in 1978 started to result in high maintenance costs due to the aging in the 1980s. In 1983, the government and IBRD recognized the need for new research facilities at the institute. Therefore, the Korean government decided to merge the institute with another research institute for telecommunication and form a new institute, the Electronics and Telecommunication Research Institute (ETRI). The World Bank initially opposed the merger of the research institute but did not dispute later because the IBRD loan project was regarded as a success with the development of the semiconductor industry in Korea, and the repayment of the loan was succeeded by a company that acquired semiconductor facilities in Gumi. Therefore, the loan was closed on June 30, 1986, 4 years after the original plan. Since the RD&E part of the project was never operated, the actual loan amount was $ 23.9 million.

The project supported an industrial policy in high technology and made a considerable contribution to the electronics industry in Korea. Considering creating a domestic technological capability in semiconductors and systems was an essential precondition to Korea's electronics industry's further growth and development, by proving that Korea could acquire advanced technology, the KIET had a pivotal role in the electronics industry. Also, from 1978 to 1984, the KIET trained around 1,000 mid-level technicians. Considering that these experts played their roles in the electronics industry, it would be possible to evaluate that the KIET project profoundly affects the industry.

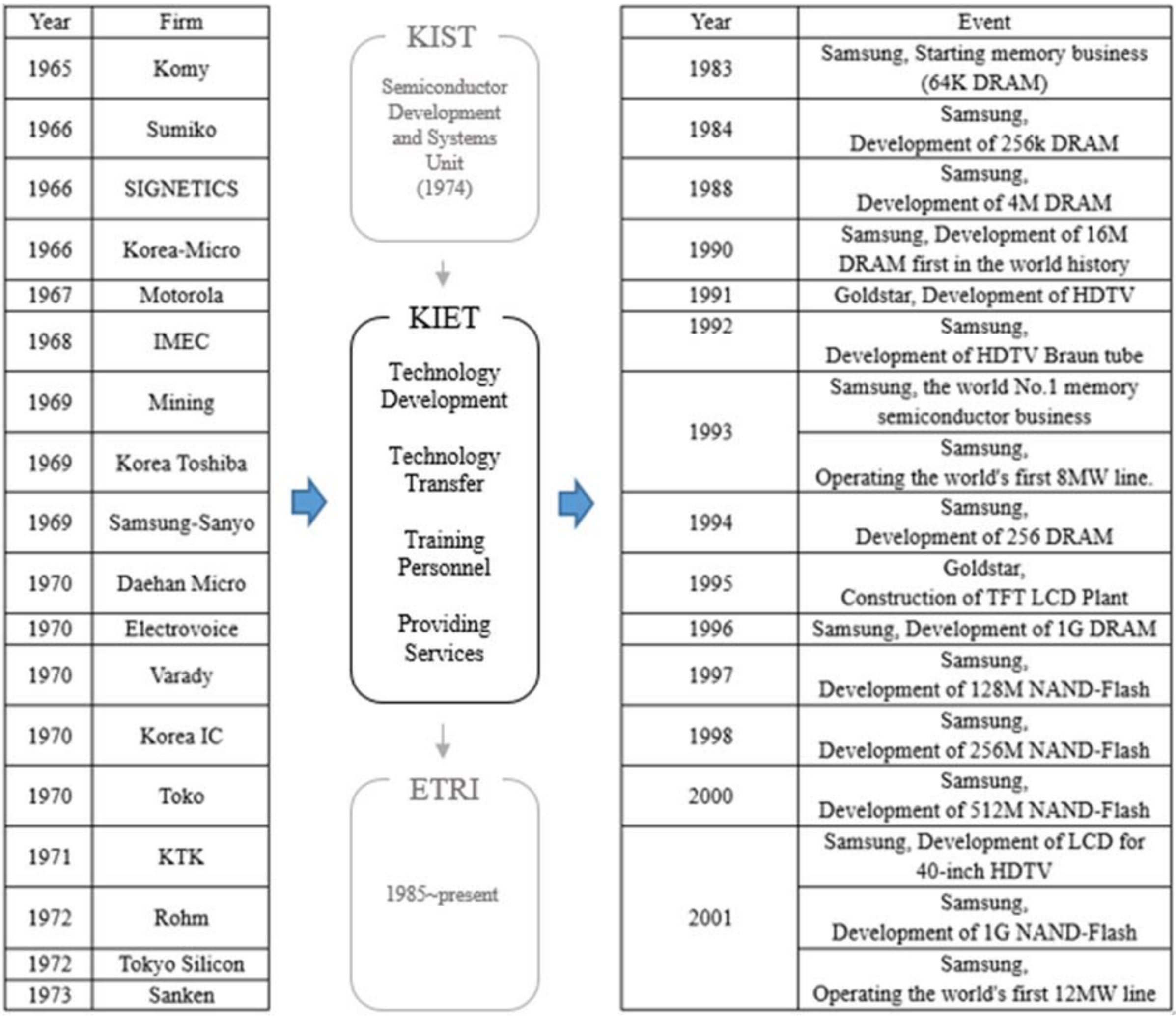
Figure 4.1 The role of KIET

In short, the KIET contributed to the shift from the era of foreign technology adoption to the period of domestic/self technology development by assisting industries in assimilating advanced technology. Even though it could not achieve its original goal –a financially independent research institute-, by providing advanced technological infrastructure, recruiting foreign-educated experts and training industrial personnel, and acquiring and developing technologies, the KIET contributed to the electronics industry. At the same time, the KIET encouraged the private sector 1) by signaling the government's willingness to promote the electronics industry and 2) with its successes in technology development projects. The KIET facilitated the participation of the private sector in the industry.

V Conclusion: Implications and Discussions

Even though the KIET could not play a leadership role as expected, it played a catalytic role in developing the electronics industry in Korea. Between 1979 and 1981, it pioneered an effort in the acquisition of semiconductor technology. Also, personnel trained in KIET and foreign-educated experts recruited by the institute entered the Korean electronics industry and led the development in their positions. Considering that the foreign firms dominated the Korean electronics industry until 1973, the KIET (former Semiconductor Development and System Unit established in 1974 under the KIST) contributed to the shift from the simple assembly of foreign parts under the foreign companies to self-technology development by local companies. Figure 5.1 describes the role and contribution of KIET (former KIST, later ETRI) in the development of the Korean electronics industry. Based on this evaluation, this chapter will address the 1) implications and 2) contributions and limitations of this study.

Figure 5.1 The role of KIET in the development of technology phase



Implications for both the donors and recipients of ODA

This research aims 1) to analyze the role of a GRI in the context of industrial policy and 2) to figure out the desirable role of ODA in the development of the specific industry. Through the case study of KIET, this thesis concluded that 1) the electronics industry has played a vital role in Korean economic development, 2) the KIET contributed to the development of the Korean electronics industry by assisting technology acquisition of the private sector, and 3) the active/supplement role of donors of ODA is needed for the development of recipient countries. From these conclusions, this thesis would suggest three implications.

First, the role and capacity of government are essential in selecting and fostering the promising industry. The Korean government designated and promoted the electronics industry intentionally, and it has shown remarkable growth aligned with the expansion of the Korean economy. As Table 5.1 describes, there was a massive growth in the electronics industry since 1975. The scale of all electronics manufacturing tripled every five years from 1975 to 1990. By selecting the 'right' industry, the government could achieve economic development and industrial/technological development simultaneously.

Table 5.1 Growth of Korean Economy and Electronics

(Unit: US$ Million)

	1965	1970	1975	1980	1985	1990	1996
GNP	1,586	8,800	20,475	60,500	83,100	242,300	451,230
- All Electronics	11.1	106	860	2,852	8,460	29,711	61,367
- All Elec./GNP (%)	0.7	1.2	4.2	4.7	10.2	12.3	13.6
Total Exports	175	835	5,080	15,505	17,505	30,283	129,715
- All Electronics Exports	2	55	582	2,004	2,004	4,532	41,223
Import	5		445		2,941		27,564
Domestic Demand	14		723		5,636		47,647

Source: Cyhn (2002)

Second, establishing GRIs for the promising industry could be a good industrial policy. Especially in developing countries where the resource for investment is scarce and private R&D activities are insufficient, the GRIs could help to promote the industry by facilitating technology transfer. In Korean electronics industry development, the KIET facilitated international technology transfer by purchasing foreign technology and digesting, and transferring to domestic firms. At the same time, the institute transferred the self-developed technology to the private sector. In 1982, when the Ministry of Science and Technology began to develop essential technologies such as design processes and test of high-end circuits as a specific research and development project, the KIET led this project and transferred the result, the 32k ROM, which was the first Korean memory, to the private sector. By doing so, it laid the foundation for independent semiconductor manufacturing technologies. As a result, Korea could become the world's No. 1 and No. 2 producers since the late 1990s in the memory sector

Also, the existence of GRIs could guarantee the government's willingness to promote specific industries and attract private companies. In 1979's recommendation report for the KIET project, between 1977 and 1982, local production of semiconductors and systems was forecasted to increase from $21 million to $260 million, reaching $700 million by 1987. These numbers were regarded as conservative by the authors of the report because this forecast did not reflect the indirect effect of the institute's existence. The KIET was expected to attract new firms to enter the industry. Indeed, as Table 5.2 shows, the export of integrated circuits (ICs)/semiconductors reached $ 1,967 million in 1987. It is hard to say that this development is solely due to the existence of KIET, but as the report said, the presence of KIET could facilitate the entry of companies.

Table 5.2 Electronic Exports of Korea (Unit: $ Millions)

	1965	1970	1972	1980	1981	1982	1983	1984	1985	1986	1987
Total Exports	1.8	55	142.0	2,015	2,210	2,201	3,093	4,448	4,549	7,170	11,195
ICs/Semiconductors	-	17.3	39.0	425	483	623	812	1,297	1,062	1,359	1,967
Transistors/Audio products	1.4	12.9	35.6	462	489	407	464	672	558	754	1,573
Televisions	-	3.1	8.2	415	489	410	624	751	624	955	1,297
Computers and Peripherals	-		-	6	12	36	112	283	402	707	1,089
VCRs	-		-	-	-	-	-	-	205	593	895

Source: Bloom (1992)

Also, the success of GRIs could encourage the investment of the private sector. As the completion report of the World Bank on the KIET project announced, it is hard to ascertain to what extend KEIT contributed to the Korean thrust into semiconductors because it seems evident that the development of the electronics industry was industry-led, not government-led. However, by succeeding in several projects, KIET proved that as a latecomer, Korea could develop advanced technologies and encouraged the companies to enter the industry.

Furthermore, the role of the World Bank in this project could have some implications for today's international development cooperation projects. First, the active role of international organizations in the selection of specific industries could help developing countries. Even though the Korean government enacted various laws and plans for the development of the electronics industry, World Bank also suggested the Korean government foster the electronics industry. In 1974, the industrial sector mission of the World Bank recommended that Korea should seriously consider the acquisition of semiconductor technology as a basis for the development of the electronics industry. In 1975-1976, the World Bank, as an executing agency for a UNDP-financed Planning Assistance Project, reviewed the prospects of the electronics industry and made suggestions for policy formulation in this sector

(World Bank, 1976b). With the accumulated experience and knowledge in various countries and sectors, international organizations could help developing countries select a promising industry for economic development.

Second, international organizations, especially MDBs, could financially assist the promotion of specific industry including R&D activities. As observed in the case study of KIET, if there was no IBRD loan, the KIET could not develop several semiconductor technologies. Of course, it is hard to affirm that without these successes, the private sector would not enter the industry. However, considering the leading role of the KIET in the development of semiconductor technology between 1976 and 1982, the development of the Korean semiconductor industry could be postponed if there was no KIET. And if there was no IBRD loan, it is evident that the Korean government could hardly think up the establishment of KIET due to the expensive facilities and equipment for the semiconductor technology.

Therefore, for the economic and social development of the developing countries (recipients), international organizations could play a more active role. With the knowledge and know-how in industrial policies, they could assist the government of developing countries in selecting promising industries. Also, they could financially supplement the government's industrial policy. Providing loans on soft infrastructure also could contribute to the development of recipient countries.

Contribution

This thesis could contribute to the academy in three ways. First is the uniqueness of the subject. There is little literature focusing on the role of GRIs in the development of economy and industry except the case study of Korea Development Institute (Kim et al., 2014) in Korean economic development. Even though each GRI related to the SCI in Korea has published their history with the estimated ripple effect of each technology, there was no independent research on their role in the development of each industry. Therefore, this thesis could facilitate the other case studies of Korean GRIs and their role in industry development.

Second, by focusing on the role of GRI and ODA at the same time, this research took a creative approach. While much literature focusing on Korean development did not pay attention to the status of Korea as an ODA recipient country until 1995, this research highlights this characteristic and analyzed the role of GRIs in industrial development and the role of ODA in this process. By considering the status of Korea as a recipient country, it would be possible to derive implications for both donors and recipients of the ODA.

Third, by assuming the role of GRI as a bridge between the technology embodiment phase and the technology leading transition phase[8], this study could fill the gap between technology acquisition and technology development and grasp the shift from FDI-oriented foreign firms to local firms. Also, it could explain the sudden technological leapfrogging of the Korean electronics industry except for the heavy investment of the firms. By acquiring foreign technologies and transferring to the private sector after digesting, the KIET could lay the foundation for developing product technology in the semiconductor industry. Even though there was no technological base between 1965 and 1973, with the help of KIET, Korean companies could develop many semiconductor technologies from 1983.

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[8] Please refer to Table 4.2

Limitations and proposals for the future study

However, there were limitations of the study. First, since there was no prior research on the case of KIET, it was hard to collect data and information. It related to the difficulties in conducting an in-depth analysis of the case. Even though this case was one of the initial loans for SCI development in developing countries and was designed as one of the biggest GRIs in Korea, little academic attention was given to this case. Since there were only a few research materials just mentioning the project briefly, it was hard to analyze the case thoroughly.

Second, due to the Fine Instruments Center (FIC)'s closing, it was impossible to find the statistical data of the electronics industry in the 1970s used in the preparation of the World Bank documents for the KIET project. Therefore, it was hard to provide consistent statistical information. Since the statistics used in this thesis are from various sources, it alleviated the consistency of the paper.

Third and lastly, since this thesis aims to emphasize the role of GRI and ODA, in other words, public sector, less attention was given to the private sector's roles and achievement including chaebol and SMEs. Also, the part of public-private partnership in the development of the electronics industry could not be dealt with enough. The public-private consultation also played an essential role through the Korea Electronics Association (KEA), a private organization established in 1976. They could be studied in the future.

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