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The Shifting Role of the State in South Korea's Industrial and Technological Development: A Review of the Semiconductor Industry

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The Shifting Role of the State in South Korea's Industrial and Technological Development: A Review of the Semiconductor Industry

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Abstract

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Due to a weak industrial base coupled with devastation from the Korean War, South Korea was a latecomer in industrialization, and formal economic development began during the 1960s under heavy state intervention. Within this broader context of industrial development, this research examines the role of state in the development of South Korea's semiconductor industry. The results show that government support for semiconductors has gradually shifted from full-fledged intervention through both initial technology procurement and commercialization during the 1960s, to a minimal role of developing human capital and promoting private sector investment in R&D at present. But despite the importance of adhering to principles of free trade, the Hynix crisis of 2003 and the recent economic crisis of 2008 demonstrate the continued importance of the government's role in protecting and promoting strategic industries such as semiconductors.

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Chapter 1. Introduction

Since the end of the Korean War in 1953, South Korea has undergone tremendous economic growth. Whereas the GDP per capita (current $US) in 1960 was $92, that figure rose to $21,653 by 2007.[1] In 2009 the country was ranked the 9th largest exporter in world merchandise trade and the United States' 6th largest trading partner in terms of exports and imports.[2] South Korea is one of the top ten producers of leading manufactured products of iron and steel, chemicals, electronic data processing and office equipment, integrated circuits and electronic components, and automobiles. Despite being decimated by the War and heavily reliant on foreign aid for foodstuffs and basic supplies throughout the 1950s, the country managed to achieve rapid economic development in less than a span of 50 years.

South Korean industries had modest origins, starting from low-technology, labor intensive light industries such as textiles and footwear in the 1960s, gradually shifting towards capital and technology intensive sectors such as shipbuilding, chemicals and electronics during the 1970s. From the beginning, the state was heavily involved in the economic development process. For example, the First Five-Year Development Plan from 1962 to 1967 established growth targets with respect to macroeconomic performance and other indicators, and utilized policy instruments such as industrial policy, trade and monetary policies to promote sectoral development (D. M. Shin, 2003: 55). The introduction of high technology industries such as electrical components and semiconductors also had their roots in the 1960s, but due to the country's extreme

1 The World Bank. 'World Development Indicators (WDI) and Global Development Finance (GDF).' <http://databank.worldbank.org/ddp/home.do?Step=3&id=4>

2 World Trade Organization. 'International Trade Statistics 2010'. <http://www.wto.org/english/res_e/statis_e/its2010_e/its2010_e.pdf>

underdeveloped status and difficulty in acquiring or utilizing advanced technologies, the industries were limited to simple assembly and export in order to obtain foreign currency. As the Korean government imposed on the electronics industry a strategic importance during the 1970s, indigenous semiconductor manufacturers began to emerge for supplying components for domestic consumer electronics firms (Yoon, 1990: 93). During the 1980s, the government continued to promote the electronics industry as a strategic sector, but this time with a focus on semiconductors and computer development as one of the top five national projects (Yoon, 1990: 106). Just as Japan outpaced the United States in Dynamic Random Access Memory (DRAM) production in the 1980s, by the 1990s South Korea managed to outrun the Japanese and become the world's top producer of all memory chips (J. S. Shin, 1996: 129).

Analysis of domestic GDP according to economic activity reveals that since 1995 the electronics industry (electronic components, computers and other equipment) has been the largest manufacturing sector in terms of value added, consisting of nearly a quarter of all manufacturing in 2009.[3] In particular, electronic components made up 57 percent of all electronics, and within this category semiconductors consisted of about 50 percent. The semiconductor industry which comprises 7 percent of total manufacturing was the largest industry within Korea in terms of value added. Looking beyond the domestic realm, Samsung Electronics, which produces a wide variety of products ranging from home appliances to semiconductors and mobile phones, was the world's second largest technology company by sales

[3] Korea Statistical Information Service. Bank of Korea. Economic Statistics Division. Accessed March 11th, 2011. <www.kosis.kr.>

in 2009.[4] The firm was also the second largest semiconductor manufacturer after the United State firm Intel in terms of global market share in 2009.[5]

The semiconductor industry is important due to its forward linkage as a basic supply industry of the economy and provides a wide range of other industries with crucial components (J. S. Shin, 1996: 110). These electronic components embody system functions of virtually all consumer and industrial electronics such as computers, automobiles, communication, household appliances and other apparatus.[6] What is unique about this industry in contrast to other basic industries such as iron and steel is that the former entails very rapid product and process innovation. This is reflected in the quick replacement of capital equipment, differentiation of final products and changes in process technologies. Not only does this entail high-risk involved in large-scale capital investment, but also requires continued investment in research and development to maintain technological leadership in this sector.

For a country that was completely decimated by war and lacking an industrial base, in addition to limited physical boundaries and lack of natural resources, how was the country able to outpace many other developed states to become one of the most technologically advanced nations in the world? With the large capital requirements of the semiconductor industry to sustain R&D and develop human capital, to what extent was the government involved in promoting industries and technological development?

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4 Fortune Global 500. Accessed March 11th, 2011. <http://money.cnn.com/magazines/fortune/global500/2009/industries/9/index.html>

5 iSuppli. 'iSuppli Corporation supplied rankings for 2010'. Accessed March 11th, 2011. <http://www.fabtech.org/images/uploads/Companies/isuppli_2010/isuppli_2010_top20_rankings_table_550.JPG>

6 "Semiconductors and Related Devices." *Encyclopedia of American Industries*. Online Edition. Gale, 2011. Reproduced in Business and Company Resource Center. Farmington Hills, Mich.:Gale Group. 2011. Accessed March 11th, 2011. <http://galenet.galegroup.com/servlet/BCRC>

This research will address these questions by looking at the history of South Korea's semiconductor industry within the framework of industrial development after the Korean War and by observing the role of government in promoting strategic industries, in particular the semiconductor industry. The shifting role of the state during each developmental period will be examined in historical detail.

Chapter two contains a theoretical discussion on how a nation determines a particular economic growth path by reviewing concepts such as national development strategy, industrialization, strategic industries and high technology. In regards to the benefits that accrue from high technology, the concept of positive externality which provides a basis for government intervention is also examined. Chapter three contains an overview of South Korea's industrial history, which will provide a general background for the following section. Chapter four examines in detail Korea's development of the semiconductor industry and the shift in the extent of government support. The final chapter provides concluding remarks on policy implications.

Chapter 2. Theoretical Considerations

This chapter examines the theoretical basis of how high technology industries such as semiconductors have come to be categorized as strategic industries and merited government support in the initial stages of its development.

2.1. National Development Strategy and Industrialization

National development strategies refer to government plans or programs which are set up for achieving economic growth (Hogg, 1970: 184). The type of strategy and the operational means for achieving growth differ for each country and period and according to political and economic circumstances. Industrialization is generally considered the main process of achieving rapid economic growth, but if viewed from the overall economic sphere of activities undertaken in a country, the promotion of agriculture can also be considered a development strategy by arguing that developing countries can have a comparative advantage in specializing in export-oriented crops. But when observing macroeconomic factors such as rates of growth, levels of changes in productivity, introduction of new technology and forms of management, the industrial sector appears to be the leading generator of economic growth in most cases. But whether it is industrialization or agriculture, the particular generators of growth are chosen for their potential properties of having higher growth rates than other sectors of the economy and their ability to create external effects conducive to accelerated growth in other parts of the economy (Hogg, 1970: 186).

The indicators such as GDP growth, real wages and domestic productivity are important measures of economic growth, and as mentioned above, industrialization is generally considered the primary development strategy for contributing to rapid growth. But though these indicators reflect the relative strengths and weaknesses of an economy, they do not reveal the systemic and structural aspects of industrial activity that have an impact on the capacity of a nation to maintain economic growth (Green, 1996: 29). In other words, they do not explain how certain industries are considered more valuable than others in terms of strategic importance. According to neoclassical economic theory, goods and services are produced according to laws of comparative advantage where what is produced is less important than how it is produced. In this framework, it does not matter whether a nation promotes a low technology or high technology industry. What matters is how efficiently a good is produced and how much it adds to productivity.

But in reality, markets do not function perfectly and industries are not contained within a framework of perfect competition. Market distortions such as economies of scale, steep learning curves, positive externalities, large R&D requirements, and substantial fixed costs of entry depict the reality of imperfect competition (Krugman, 1986: 25). An externality is a surplus or loss that results when one party's action affects another party outside of the perfectly functioning market. In the case of positive externality, the surplus exceeds the loss which results in net benefit for the economy. This benefit can take the form of knowledge spillovers or competitiveness in the form of linkages between related sectors of the economy (Krugman, 1986: 17). Since externalities are incompatible with the efficient free-market economic framework, this provides a basis for government intervention in the form of subsidies or other favorable policies that seek to contribute to the net welfare of the economy.

2.2. Concept of Strategic Industry

When considering what economic activity or industry merits government promotion, it is useful to examine the different characteristics of what it means to be strategic (Flamm, 1996: 372). First, it is used in the context of national security where certain industries such as semiconductors were considered important in the United States during the initial stages of the Cold War for maintaining military dominance over the Soviet Union through technological superiority. Second, certain industries are considered important linkages as input to a large array of industries and thus the primary driver of economic growth. In this respect, semiconductors are strategic products because they comprise the fundamental components of computers, mobile phones, automobile and other electronic devices. Third, the term strategic could refer to behavior and policies where a firm acts strategically when it takes actions to influence the behavior of rival firms for realizing additional profit. Government subsidies that enable domestic firms to have an advantage over foreign firms are also considered strategic policies.

For the purpose of this research, strategic industries are defined as those sectors of the economy that are the primary cause of economic growth. According to the Congressional Budget Office, a ‘strategic industry’ is viewed as having a connection between long-term economic growth and surges in technological innovation (U.S. CBO, 1985: 3). In other words, a host of innovations in leading industries are critical to driving and shaping overall economic progress. Such industries are crucial because their technological advances provide opportunities for innovation in related industries. By doing so, strategic industries provide positive externalities to themselves, to customers and other firms that use their products, to the suppliers that provide their inputs, and eventually to the economy at large.

2.3. High Technology Industries and Economic Benefits

High technology industries have the highest levels of productivity. Productivity is a measurement of economic progress as it is revealed through enhanced efficiency and higher output given a limited set of inputs. Although technological innovation is but one of several elements which contribute to productivity, it is one of the most important because much of the productivity gains are found in technological advances reflected in improved manufacturing methods, materials, and machinery (Gee, 1981: 5). Since high tech industries also constitute a high portion of national R&D, the technological innovation and progress which ensues from R&D contributes a great deal to growth in national income and productivity.

These industries are considered leading innovators and rely heavily on the application of new science-based technologies. Industries such as aerospace, semiconductors, drugs and medicine, telecommunications, and computers can be viewed as high technology sectors. They share common features such as large investment requirements in R&D, economies of scale, learning by doing, and product cycles driven by continual innovation (Green, 1996: 31). In addition, they employ an above-average number of scientists and engineers. Of course, high technology does not mean it is necessarily strategic, but economic activity that meets the above definition of strategic industries and has important implications for intersectoral linkages are mostly found in the high technology sectors.

High tech industries provide several benefits to the economy. In terms of compensation, high tech industries provide higher wages than all other manufacturing industries. Higher wages does not necessarily entail that an industry is strategic since high wages can be sustained through high productivity, but in order to maintain high wages a country must be capable of creating goods that low-wage countries cannot produce due to lack of technology. Since the product life cycle suggests that low-wage countries will gain comparative advantage as a technology becomes standardized, the high-wage and technologically advanced country must continue to pursue a constant innovation process in order to sustain a technological edge (Green, 1996: 35).

Another economic benefit is the contribution to traditional manufacturing as well as service sectors. For the past several decades, the manufacturing sector has increasingly relocated to offshore locations, and currently more than 70% of the national workforce is employed in the service sectors. Simply from a comparative advantage perspective, the most efficient course of action for domestic manufacturers would be to relocate to countries where goods can be produced at lower wages. But high tech industries provide fundamental input such as equipment, components, machinery, and advanced materials for traditional industries that produce the final consumer products. Within this framework, failing to maintain traditional manufacturing capability undermines advanced technology sectors. The service sector is also affected through the buyer-supplier relationship, through services tied to the sale of manufactured goods, and through manufactured goods tied to the sale of services (Green, 1996: 36). This interconnection between manufacturing, high technology, and service industries have an important part in contributing to the economic health of the nation. In order to be competitive a country must be efficient, and this efficiency can only emerge from high technology product and system R&D.

A third advantage ensues from the relationship between technology and the defense sector (Holbrook, 1995). Military success requires a technological edge over adversaries. Throughout the Cold War, the containment of the Soviet Union required a strong military capability and this was the basis for government support of advanced technology, and semiconductors in particular, during the 1950s and 60s. In addition to this national security imperative, there were significant technological spin-offs from the military and space-related R&D to the commercial sector (Heinrich, 2002: 269). Products such as computers, automobile electronics, calculators, digital watches, and television can attribute their success to the early defense efforts. The term “spin-on” is the opposite trajectory in which technology diffuses from civilian to the defense sector (Green, 1996: 40). Today it is the high-volume electronics industry which drives the development, costs, quality and manufacture of technological inputs that are crucial to computing, communication, weaponry, and industrial electronics. Products such as televisions, liquid crystal displays (LCD) and mobile phones contain vast amounts of advanced semiconductor chip technology such as optoelectronic components, LCD shutters, scanners and filters, and lasers. In contrast to the past, such technologies are making their way into military technologies and systems.

2.4. Semiconductors: High Technology Industry

This subsection provides a brief overview of the semiconductor device and where some of the main products are used. Semiconductors are miniature electronic circuits etched onto silicon chips and form the critical components that are indispensable to the functioning of virtually all electronic products ranging from computers to automobiles and home appliances.[7] Semiconductor chips are manufactured from thin, round silicon wafers where each wafer is about half a millimeter thick. Microelectronics circuits are built up on the wafers layer by layer. Circuit patterns, which consist of transistors, capacitors, and associated components and their

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[7] Encyclopedia of American Industries. "Semiconductors and Related Devices." Online Edition. Gale, 2011. Reproduced in Business and Company Resource Center. Farmington Hills, Mich.:Gale Group. 2011. <http://galenet.galegroup.com/servlet/BCRC>

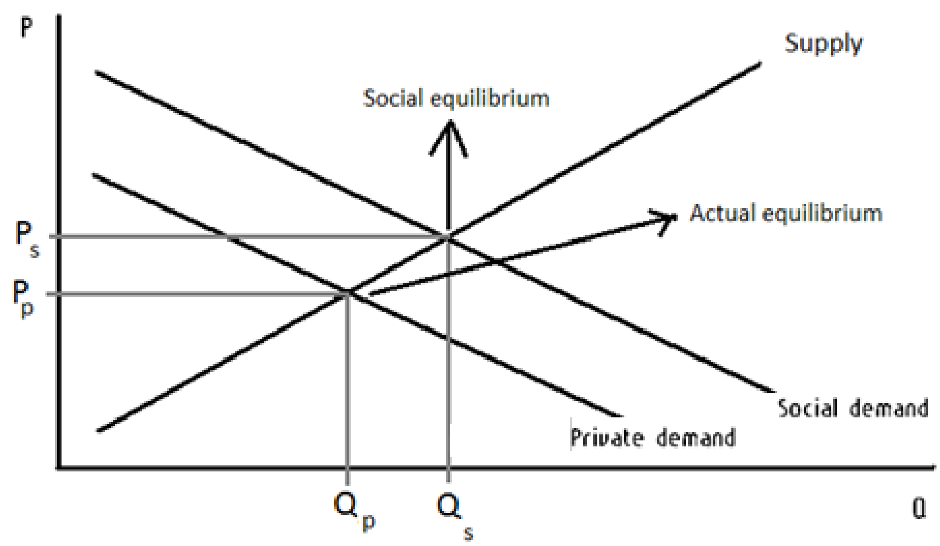
interconnections, are inscribed on large glass plates called photomasks. The photomasks are reduced and projected by photolithography onto the silicon wafers. Each mask comprises a complete integrated circuit design.

There are two main types of products which semiconductor companies design and manufacture, namely, integrated circuits (ICs) and discrete devices. A discrete semiconductor is an individual circuit that performs a single function affecting the flow of electrical current. Integrated circuits are a collection of microminiaturized electronic components, in which a single integrated circuit can perform the functions of thousands of discrete transistors, diodes, capacitors, and resistors. The three basic types of integrated circuits produced by U.S. semiconductor manufacturers in the late years of the first decade of the 2000s were memory components such as dynamic random access memory (DRAM) used to store data or computer programs, logic devices such as application-specific integrated circuits (ASICS) which perform operations such as mathematical calculations and are customized devices for different users, and integrated circuits such as microprocessors which are made of components that combine the two. The latter is the most sophisticated in that they can perform a variety of tasks by manipulating data within a system and controlling input, output, peripherals, and memory devices. Microprocessors are used in computers, mobile phones, automobiles, home appliances, and other high technology electronics.

2.5. Positive Externalities and Government Support

A final point to iterate regarding high technology concerns the issue of positive externalities. As aforementioned, externality is the result of one party's actions influencing another's welfare either positively or negatively. High technologies provide economic benefits for the society as a whole, which means that the private sector that undertakes the R&D to bring about the innovation does not capture all of the benefits. Since the goal of private firms is to maximize profit, they will be reluctant to invest in R&D if it cannot reap the full value of the returns. Figure 1 illustrates a positive externality.

Figure 1: Positive Externality



Source: Mankiw, N. Gregory. *Principles of Microeconomics* (Fort Worth: Harcourt College, c2001).

For example, a high tech industry is assumed to be selling in a competitive market. The above supply curve portrays an external benefit. If the market does not account for the additional social benefits of high technology, both the price for it and the quantity produced are lower than the market capacity. Here the marginal private benefit of investing in R&D is less than the marginal social benefit by the amount of the external benefit. This marginal external benefit of investing in R&D is represented by the distance between the two demand curves.

If firms only consider their own private benefits from investing in R&D, the market will result in price Pp and quantity Qp, instead of the more efficient price Ps and quantity Qs. In a perfectly competitive market, since the marginal social benefit should equal the marginal social cost, ideally R&D investment should be increased as long as the marginal social benefit exceeds the marginal social cost. Society as a whole would be better off if more funds are invested in R&D. But in reality, since firms only invest quantity Qp, this results in market inefficiency because the social benefit is greater than the societal cost. External benefits concern public goods, where it is difficult to exclude society as well as other firms from enjoying the benefits (Mosteanu, 2009: 37). Much of the reward from technological innovation is also accumulated as improvements to the industrial framework which other firms are linked to and depend upon. Ultimately, this problem of market inefficiency results in underinvestment by firms.

Capital markets such as loans provide a venue for assisting in the development of new R&D activities, but there is the element of high risk involved in R&D where the initial costs of achieving technological innovation are enormous due to the eventual standardization of technology inherent in the product life cycle (Green, 1996: 34). High risk involved in R&D increases the level of uncertainty in new activities, which raises the costs of capital formation.

Hence, positive externality means that investment in R&D cannot be solved by competitive markets. This is why government must intervene in the market to offer various incentives such as subsidies to private firms, or utilize fiscal and monetary policies that are favorable to the promotion of high technology sectors.

Chapter 3. South Korea's Industrial History

3.1. Overview

This section examines the process of South Korea's industrialization according to the stages of development and the role of government support in the development of industries. The development process occurred in roughly five stages: economic stagnation from 1953 to 1961, recovery and growth from 1962 to 1971, economic self-sufficiency from 1972 to 1980, economic stabilization and adjustment from 1981 to 1992, and liberalization and globalization from 1993 and beyond (Chung, 2007: 13). These stages coincide with the shifts in the political regimes and the different sets of economic policies that the government in power enacted.

Until the early 20th century South Korea had been a nation entirely based upon agriculture. The first contact with Western nations occurred during the mid-19th century, but unlike Japan which opened its doors to industrialization and modernization early on, Korea adhered to a strict policy of isolation from foreign influence. It was not until the Japanese annexation of Korea in 1910 that the country began to transition from an agrarian economy to a semi-industrial economy (Chung, 2007: 7). The Japanese built extensive transport and communication networks and set up various types of modern industries such as chemical and steel mills. But virtually all of the industries were owned by Japanese corporations, and their purpose was to integrate the Korean economy with that of Japan in order to supplement the latter's economic development and military preparations.[8]

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[8] Savada, Andrea Matles, and William Shaw. "Korea Under Japanese Rule." ed. *South Korea: A Country Study*. Washington: GPO for the Library of Congress, 1990. Accessed March 11th, 2011. <http://countrystudies.us/south-korea/7.htm>

Most of the gains from production accrued to the Japanese, and whatever remnants that remained of modernization and industrial development from the colonial period were nearly wiped out by the Korean War of 1950. Destruction in all social and economic sectors including housing, power plants, factories, and transportation networks and utilities was so extensive that by the end of the war in 1953 per capita GDP was only $67 (equal to $778 in 2000 prices) (Chung, 2007: 12). Since any effort for economic development had to occur after the War was settled, it was after the period 1953 that Korea began to undertake a formal and rapid industrialization.

3.2. Initial stage: Economic Stagnation

The first period which is during 1953 to 1961 is characterized as a recovery period where few advances were made beyond prewar levels. Due to devastation from the war there was hardly any infrastructure to build upon, most of the government expenditures and the labor force were focused on national defense, and the nation continued to rely heavily on external aid from the United States and abroad (Lee, 1996: 17). The political situation continued to be turbulent to merit any economic progress or establishment of economic programs. What development that occurred was geared towards rebuilding basic infrastructures, and it was not until 1960 that industrial production was able to reach prewar levels. Although the focusing of resources on reconstruction was a critical factor in underdevelopment, another equally important factor was attributed to an inexperienced administration as well as President Syngman Rhee’s lack of initiative for any economic development plan (Kuznets, 2001: 39).

3.3. From Recovery to Growth

The second stage of economic development occurred from 1962 to 1971, when General Chunghee Park assumed the presidency through the Military Coup of 1961. This was the first opportunity for any type of coordinated government economic policy to occur when President Park enacted two Five-Year Economic Development Plans that transitioned Korea's path from economic recovery to growth. Unlike the previous government, the Park regime was a stable and continuous force with the willingness and ability to implement a strong growth plan (Kuznets, 2001: 41). 'Economic self-sufficiency and prosperity' was the justification for the coup, and soon after gaining power the military junta restructured the government by establishing the Economic Planning Board (EPB), the Ministry of Finance, and the Ministry of Trade and Industry (D. M. Shin, 2003: 52). Various ministries such as the Ministry of Reconstruction and departments such as the Bureau of Budget and the Bureau of Statistics were brought under the EPB. The Board was given authority to set economic development plans, and manage and regulate the execution of the plans through the allocation of budget, coordination of foreign aid activities, promotion of foreign investments, and evaluation of all major public and private projects. In addition to restructuring of government agencies, the regime instituted a shift in state-business relations from patron-client relations, where firms would engage in excessive rent seeking, to a more formalized working relationship (Chang, 1994). The state's control over allocations of domestic and foreign capital, in addition to the policy of export promotion, which will be addressed below, contributed to a strengthening of a state-dominated alliance between the government and businesses.

Under this new configuration, the government set up the two Five-Year Economic Development Plans. Two major factors were considered into the formation of the Development Plans. First, due to a small domestic market and limited natural resources, the government pursued an export oriented growth strategy. Second, due to the extreme weakness of domestic production facilities, labor intensive light-industries such as textiles, footwear and plywood were promoted. The Plans established aggregate growth rate targets and sectoral output goals with respect to macro-economic performance, investment, industrial structure and trade balance. In addition, the government heavily utilized policy instruments such as industrial and trade policy, and macro-economic policies.

During the First Five-Year Plan period from 1962 to 1966, as the government emphasized export promotion in the labor-intensive light industries, growth results were quite successful in that the annual GDP growth was 8.5 percent per year (Chung, 2007: 13). During the Second Five-Year Plan period from 1967 to1971, Korea experienced a growth rate of 11.4 percent. Through the Second Plan, the government prioritized the modernization of industrial structure and the promotion of a self-sufficient economy. While export promotion through light industries continued, the government introduced a series of laws to begin investing in the development of heavy and chemical industries such as steel, machinery and petrochemicals (J. H. Kim, 1990: 4).

3.4. Economic Self-Sufficiency

The third stage from 1972 to 1980 was a period of achieving economic self-sufficiency (Lee, 1996: 19). Light-industries continued to be pursued to supplement the lack of domestic capital and acquire foreign reserves. But compared to the 1960s, this period oversaw heavy state intervention in economic policies, in part due to the Yushin reformation[9] of 1972 which strengthened the powers of the Park dictatorship (D. M. Shin, 2003: 85). Owing to a number of events such as massive domestic protests on grounds of electoral fraud, Park had proclaimed the 'Garrison Decree' in Seoul in October 1971 which empowered the government to take charge of public order (Sohn, 1989: 40). In December the Decree was extended to the whole nation as the 'Emergency Decree for National Security', and finally in October 1972 the regime proclaimed a Martial Law on grounds of irresponsibility of political parties which dissolved the National Assembly, increasing military threats from North Korea, and changes in the regional security setting after President Nixon's visit to China (Sohn, 1989). The Emergency State Council instituted the Yushin Constitution, which greatly expanded Park's authoritarian rule. Any form of criticism of government was banned and anti-government activities were prohibited. Park had the power to appoint nominees for the court, members of the National Assembly, and government ministries. In effect, such course of events made Park the most powerful policy-maker within the state.

As the state had played an active role in economic development during the 1960s, the state sought to play an even greater role in the developmental process during the 1970s. In January 1973 President Park made public his Heavy and Chemical Industries (HCI) Plan. Despite criticism by many technocrats and businesses that the current light industries were not prepared for a radical shift to heavy industries, in addition to a weakened financial structure due to the oil-shock of 1973, Park's leadership was crucial for pushing through with the HCI initiative. His

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[9] The National Assembly, dominated by President Park's Democratic Republican Party, amended the 1963 constitution to allow Park to run for three terms and removed the limits on reelection. In short, the Yushin constitution legalized the Park dictatorship.

concern for national security was also instrumental in directing more resources into defense-related production, augmenting his ambition for developing the HCIs (C. R. Kim, 1994: 83-84). The Heavy and Chemical Industry Planning Council which was formed in September of 1973 was a powerful body that bypassed the Economic Planning Board and gave orders directly to the Ministry of Finance (MOF), banks, and the Ministry of Commerce and Industry (D. M. Shin, 2003: 86). The Council had authority to decide the allocation of capital, and the president had the final approval over major industrial projects. In addition, economic ministries underwent organizational reform to implement the HCI plans more effectively. Throughout the 1970s the government expanded social infrastructures and geared financial assistance heavily towards the HCIs, in particular steel, machinery and petrochemicals. Despite the worldwide oil crisis and recessions, the South Korean economy as a whole grew at a rate of 7.5 percent per year during 1972 to 1980, and per capita GDP grew from $289 to $1,597 during the same period (Chung, 2007: 15). It is during this decade of preferential support for HCIs that many large firms were able to grow into chaebols (large business conglomerates), hence the shift in state-business alliance from the state and general exporting business to an alliance between the state and a few HCI chaebols chosen by the president (E.M. Kim, 1997: 147).

3.5. ECONOMIC STABILIZATION AND ADJUSTMENT

The fourth stage from 1981 to 1992 was a period of economic stabilization and adjustment of the HCI policies. Although during the 1970s the HCIs had boosted South Korea's growth, the economy became more susceptible to the world economy since the HCIs had been heavily financed by foreign loans and had been increasingly dependent on world market demands (J. H. Kim, 1990: 30). In addition, there was the problem of overcapacity of HCIs as the majority of manufacturing investment and consolidation were centered on the industries. For instance, between 1977 and 1979 nearly 80 percent of financing went to HCIs (Table 1).

Table 1: The Growth Rate of Investment: 1970-71 to 1978

(unit: %)

	1970-71	1972-73	1974-75	1976	1977	1978
Investment Growth Rate	3.6	12.9	8.3	14.7	26.6	40.5
GNP Growth Rate	8.1	10.2	7.3	14.2	10.5	12.5
HCI	56.5[1)]			74.2	75.4	82.5
Light Industry	43.5[1)]			25.8	24.6	17.5
Share in Total Investment	100.0[1)]			100.0	100.0	100.0

Note: 1) During the 1971-74 period.

Sources: Economic Planning Board, 1981
The Bank of Korea, 1987

After President Park was assassinated in December 1979 and Kyu-hah Choi had assumed the presidency for 6 months, General Chun Doo-Hwan grabbed power through a military coup in May 1980 which ushered in another period of authoritarian rule. But this time the new regime initiated a different style of economic management from the previous two decades. Worsening economic conditions that began in 1979 prompted the government to reevaluate the economic management style of the previous decades. During the early 1980s, Chun pursued economic stabilization and structural adjustment by implementing three measures, namely, tight control of the government budget, limiting monetary growth, and wage restraint policy (Haggard and Collins, 1994). Also, the government undertook several initiatives for economic liberalization, but on the whole the state continued to exert influence on the economy through the Ministry of Finance and was reluctant to liberalize the financial sectors or relinquish its right to appoint bank directors. In terms of industrial policy, adjustment was geared mainly towards the heavy and chemical industries. Special tax treatments for specific industries were ceased with the exception of machinery and electronics industries. The Industrial Development Law (IDL), enacted in 1986, emphasized that the primary role of the state in industrial development should be limited to technology development and industrial adjustments (G. Kim, 1991).

An important point must be made regarding the independence of the chaebols. During the HCI Plan of the 1970s, industrial concentration around the chaebols empowered them not only economically but also politically (J. H. Kim, 1990: 13). This was evident in several respects. First, the Chun government’s adjustment policy of the HCIs failed to be implemented due to objection from the chaebols. Second, the chaebols increasingly demanded reduction of state intervention in the economy. Their increased power can be observed from the fact that by 1987 the share of sales from the five largest chaebol groups comprised 75.2 percent of manufacturing GDP in the Korean economy (E. M. Kim, 1997: 183). In addition, for the four largest chaebol groups more than one-third of their total assets were in financial service sectors (Table 2).

Table 2: Basic indicators in the four largest chaebol groups: 1981-1988

Chaebol	No. of firms		Annual Growth rate (%)	Distribution of total assets %		
	1981	1988		Light	Heavy	Services (financial)
Daewoo	21	33	18.8	0.3	37.5	62.3 (38.7)
Samsung	22	41	25.0	9.7	33.6	56.7 (24.8)
Hyundai	24	33	15.3	0.9	43.0	56.0 (24.8)
Goldstar	20	54	21.3	0.2	52.1	47.7 (36.1)

Source: Bankers Trust Securities Research 1989 (E. M. Kim, 1997: 186)

Since the state prohibited them from owning banks, chaebols turned to the non-bank financial sector which was a significant avenue of financial growth. Not only was this a lucrative business, but this allowed chaebols to become less dependent on domestic banks and state support. By the late 1980s, the relationship between state and businesses shifted to a direction of the state having to gain the consent and cooperation of chaebols in order to implement the former’s policies (D. M. Shin, 2003: 112).

By the mid 1980s the economy began to grow once again, experiencing a growth rate of nearly 12 percent between 1986 and 1988. But this was mostly due to favorable external conditions such as low oil prices, a weak dollar, and low global interest rates (Lee, 1996: 24). During this period, although HCIs still consisted of a large part of manufacturing, industrial development began to diversify into more complicated sectors such as high technology electronics and automobiles, increasing their share of manufacturing (Seong, 2001: 127).

3.6. LIBERALIZATION AND GLOBALIZATION

The fifth stage from 1993 and beyond was a period of liberalization of the financial system and globalization of the economy. During the 1980s despite the official promotion of free market policies, the government had retained tight controls on the financial system and was slow to lift the protectionist measures on financial markets, import restrictions and high tariffs. But in 1993 the newly elected President Kim Young-sam implemented significant reforms of deregulation measures to encourage business activities, expand money supply to lower interest rates, and drastically liberalize the financial system (D. M. Shin, 2003: 145). The government ceased to pursue sector specific industrial policies and emphasized the importance of a full-fledged market-led economic system. The government increased its assistance to manufacturing industries in the form of investments in R&D in science and technology and human resource development (D. M. Shin, 2003: 144). For example, the G7 project was a large scale R&D project initiated by the national Science and Technology Policy Institute (STEPI) from 1992 to 2001 in order to elevate the science and technology of Korea to the level of the group of seven advanced nations.[10]

After the period 1993, during a span of less than twenty years, there was a drastic reduction in manufacturing employment as well as a significant increase in the share of employment in the service sector such as information and communications and business services, technical and scientific activities.[11] For example, examining industrial employment data from 1993 to 2008, the share of manufacturing dropped from 31.72 to 20.12 percent, while the share of information

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10 Koreabrand.net. 'Korea's Science and Technology Policy and STEPI's roles.' Accessed April 10th, 2011. <http://www.koreabrand.net/en/know/know_view.do?CATE_CD=0006&SEQ=1628>

11 Korea Statistical Information Service. 'Employment by sector 1993-2008'. Accessed Oct 13th, 2010. <http://www.kosis.kr/eng/index/index.jsp>

and communications rose from 0.61 to 2.58 percent, and business services, professional, scientific and technical activities rose from 2.90 to 8.30 percent (Table 3).

Table 3: The Sectoral Rate of Employment, South Korea: 1993 vs. 2008

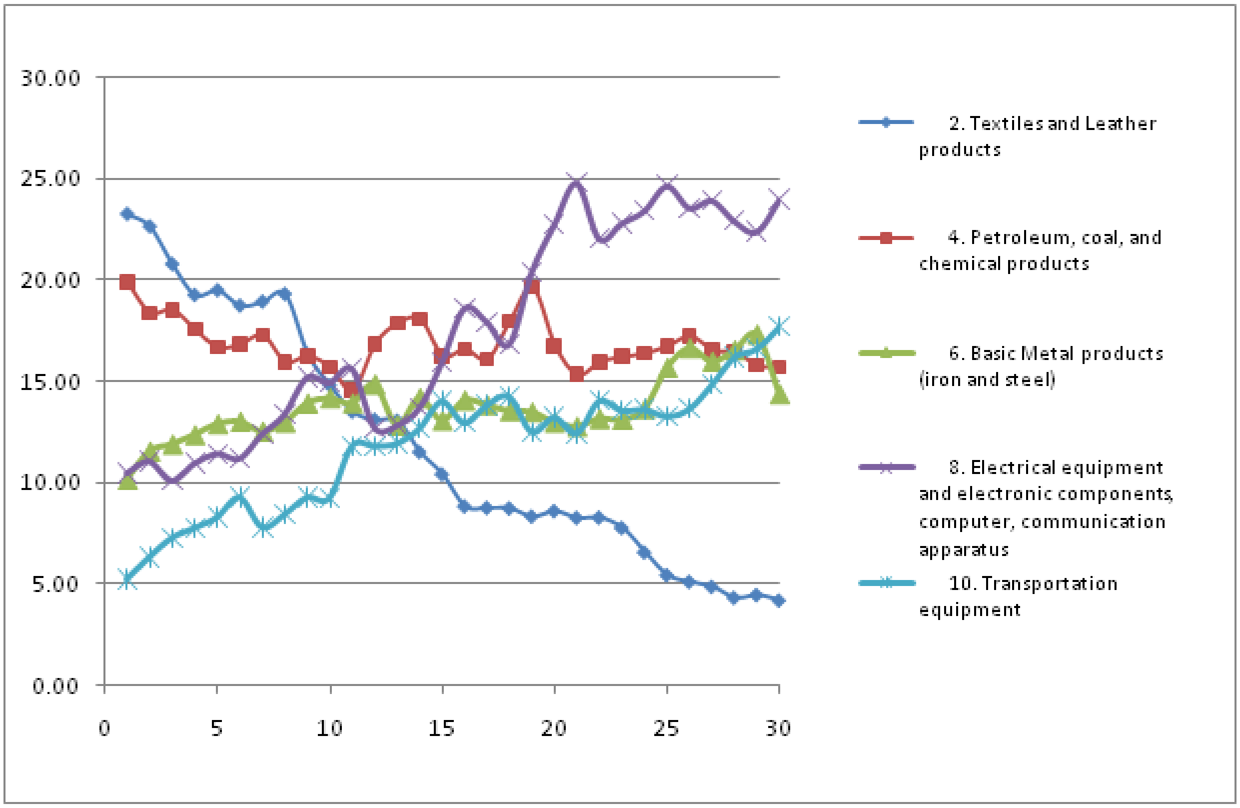
Industry	**1993**	**2008**
Agriculture, forestry, fishing, mining and quarrying	0.64%	0.29%
Manufacturing	31.72%	20.12%
Electricity, gas, steam and water supply; sewage & waste mgmt.	0.32%	0.80%
Construction	5.34%	5.36%
Wholesale and retail trade	18.58%	15.62%
Transportation	4.68%	5.69%
Accommodation and food service activities	8.98%	10.61%
Information and communications	0.61%	2.58%
Financial and insurance, Real estate and leasing activities	7.37%	6.76%
Business services, professional, scientific and technical activities	2.90%	8.30%
Public administration and defence; social security	4.14%	3.53%
Education services	5.30%	8.05%
Human health and social work activities	2.31%	5.46%
Arts, sports and recreation related services	1.56%	1.93%
Membership organizations, repair and other personal services	5.54%	4.89%
Total	100%	100%

Source: Korea Statistical Information Service. ‘Employment by sector 1993-2008’

At the same time, the economy during the late 1980s and early 90s no longer produced the high levels of manufacturing rate of growth as seen in the previous decades. By 1992, economic growth experienced an all time low growth rate of 4.7 percent (Lee, 1996: 27). Several observations in structural change can be made during this period. The year 1989 was the point in which the share of employment in manufacturing began to experience a downhill slope, and the share of GDP in HCIs and light industries began to decline as well. Industries that had driven economic growth in the past such as labor-intensive industries lost their competitiveness to markets in other countries. Meanwhile, employment in the service sector had been rising steadily throughout the decades. Whereas in 1970 the percentage of employment in SOC (Social Overhead Capital) and services was 30.9%, this figure rose to 50.7% in 1993 (Chung, 2007: 23). The contribution of traditional manufacturing exports to economic growth was declining, while the share of GDP of the electronics industry in particular was growing (Figure 2).

During the 1990s and onward Korea has undergone a major shift in industrial organization from traditional manufacturing industries to increasingly high technology and service related sectors. The government's role has transitioned from previously full-fledged state involvement through sectoral-specific policies to a more limited role through investment in national R&D projects. These shifts can be attributed to both international and domestic elements, for example, increasing pressure from abroad and especially the United States for market liberalization and free trade, as well as pressure from chaebols to decrease state involvement in the private sector.

Figure 2: Change in Share of GDP, Top Five Industries: 1980-2009



Source: Korea Statistical Information Service. 'GDP & GNI according to industry (category, period), 1980-2009'

Chapter 4. Development of Korea's Semiconductor Industry

4.1. Overview

The previous section provided an overview of the changing role of the state in the process of South Korea's industrialization. Within this background, this section examines the development of the semiconductor industry and the shifting framework of state involvement from full-fledged government support during the 1960s to private sector lead after the 1980s.

While the periods of the semiconductor industry development process nearly coincide with the four stages of national industrial development examined in the previous chapter, this section categorizes the semiconductor industry according to the following four periods:

1. 1965 to 1972: The insipient stage as a pure export industry through foreign direct investment (FDI) and state initiatives.

2. 1973 to 1980: The stabilization period from 1973-1980 under the heavy and chemical industry (HCI) initiatives

3. 1981 and beyond: Private sector initiatives and take-off of the semiconductor industry

4. Recent developments in government support

4.2. Semiconductors as a Pure Export Industry and Enclave Development

During 1960s, unlike other export oriented sectors, the Korean government attempted to pursue strict import-substitution policies in the electronics industry in order to nurture indigenous technological capabilities of domestic firms (L. Kim, 1980: 4). Consumer electronics firms started off with simple assembly operations of foreign components and parts with equipment purchased from overseas. The state banned the import of finished consumer electronics products such as radios, television sets, and etc. Gradually the government imposed import-substitution on components as well, and allowed the imports of parts and equipments only if users demonstrated the inferiority or insufficiency of local supply (L. Kim, 1980: 12). But Korea's 'extreme backwardness' compared to that of nations such as Japan, which already had moderate levels of industrialization that existed during the early 20th century, and primitive technological capabilities later resulted in a 'dual structure' of the Korean electronics industry (J. S. Shin, 1996: 123).

Due to a limited domestic market coupled with the lack of natural resources, the government had to emphasize the importance of competing in the international market, and thus import-substitution was pursued with export-promotion simultaneously. Some products were supported by a protected domestic market, but others such as calculators, tape recorders and digital watches were produced almost exclusively for the export market. The semiconductor industry was formed in the midst of this dual structure context (Yoon, 1990: 10).

After the mid-1960s semiconductor firms in the United States had begun to cater to industrial and commercial demands for large quantities and low prices (Braun and Macdonald, 1982: 154). This led to intense competition in price-cutting, which in turn prompted firms to search abroad for cheap labor. In the midst of the Korean government trying to acquire sources of foreign capital and technologies, the first semiconductor industry ever to be established on Korean soil was a joint enterprise with a U.S. firm Komy Semiconductors in 1965, a small scale project which did not have much success (Moran, 1998: 131). The officials of the then Ministry of Commerce and Industry (MCI) subsequently contacted another U.S. firm Fairchild Semiconductors in October 1965 and persuaded them to invest in Korea (Yoon, 1990: 11). But Fairchild demanded complete ownership and selling rights, which was inconsistent with domestic laws that forbade 100 percent foreign ownership. Faced with constraints by such external conditions and internal capability, the Economic Planning Board (EPB) which had control over foreign investment hoped that a successful business deal with Fairchild would attract other foreign firms and decided to accept Fairchild's request. Within a year Signetics and Motorola also set up semiconductor firms in Korea.

In addition to American firms, the government actively sought to attract investment from Japan as well. During this period Japanese firms increasingly had begun seeking investment abroad due to shifting industrial conditions such as shortage of labor and industrial sites as well as rising labor and capital costs in Japan (Yoon, 1990: 16). The Korean government hoped that by establishing a successful relationship with Toshiba, this would also lead to sequential investment by other Japanese firms (KEIA, 1981: 308). In 1969, Toshiba set up the joint enterprise Toshiba Korea which produced silicon transistors in Gumi, South Korea (Yoon, 1990: 16). Through this venture, the government established the Gumi industrial complex, providing tax incentives and other benefits to foreign investors. In 1970 when the Masan free trade zone was established, three other Japanese semiconductor firms - Toko, Sanyo, and Sanken - set up assembly lines in Masan.

During this period from 1965 to 1972, Korea's semiconductor production was limited to the simply assembly of standardized commodity products, and the Korean semiconductor industry developed as an 'enclave' sector with no forward or backward linkages (J. S. Shin, 1996: 125). The semiconductor industry was first initiated through 100 percent foreign direct investment, and semiconductors were aimed purely for the export market. Korea's premature electronics industry made it difficult to acquire and utilize advanced capabilities through licensing or indigenous technological effort. In addition, foreign firms' strategy of exploiting low wages without transferring advanced technologies, and the government's lack of intention for acquiring advanced semiconductor technologies, contributed to mainly export policies (Braun and Macdonald, 1982: 157). Table 4 illustrates how the share of export to production in the Korean semiconductor industry was close to 90 percent for more than 30 years.

Table 4: Share of production to exports: 1962-1987

Year	Total Exports (a)	Electronics		Semiconductors		b/a (%)	c/a (%)	c/b (%)
		Production	Export (b)	Production	Export (c)			
1962	55	5	0.05			0		
1963	87	8	0.4			0.5		
1964	119	10	1.0			0.8		
1965	175	11	1.8			1.0		
1966	250	22	4	0.002	0.002	1.6	0	0
1967	320	37	7	1	1	2.2	0.3	1.3
1968	455	56	19	14	14	4.2	3.1	73.7
1969	623	79	42	36	35	6.7	5.6	83.3
1970	835	106	55	32	32	6.6	3.8	58.2
1971	1068	138	88	49	47	9.2	4.4	53.4
1972	1624	208	142	77	76	8.7	4.7	53.5
1973	3225	462	369	176	173	11.4	5.4	46.9
1974	4460	814	518	270	241	11.0	5.4	46.5
1975	5081	860	582	231	178	11.5	3.5	30.6
1976	7715	1442	1037	315	298	13.4	3.9	29.7
1977	10047	1758	1107	327	305	11.0	3.0	27.6
1978	12711	2272	1359	350	329	10.7	2.6	24.2
1979	15036	3280	1845	459	420	12.3	2.8	22.8
1980	17505	2852	2004	424	415	11.4	2.4	20.7
1981	21254	3791	2218	502	482	10.4	2.3	21.7
1982	21853	4006	2200	648	624	10.1	2.9	28.4
1983	24445	5558	3047	850	812	12.5	3.3	26.6
1984	29245	7170	4204	1268	1297	14.4	4.4	30.9
1985	30283	7285	4352	1155	1062	14.4	3.5	24.4
1986	34714	10611	6687			19.3		
1987	47281							

Source: Korea Electronics Industry Association. Electronics, Electrical Industry Statistics. yearly; Electronics Industry Handbook. yearly; Economic Planning Board. Major Economic Indicators. yearly; Precision Equipment Center, 1970; 25, 33, 49.

Nonetheless, stimulated by such foreign semiconductor firms' investment activity, the government actively sought to induce further foreign investment in order to develop the domestic electronics industry. Although the government had to concede a great deal in terms of providing incentives such as exceptions from domestic regulations and creation of advantageous business environments, at the same time these were 'calculated' compromises when considering the primitive domestic market and the lack of financial capital and technical capability of domestic firms. Overall, the government's strategy was able to achieve the objectives of expanding exports and creating employment within the country (Yoon, 1990: 22).

As the state began to evaluate the promotion of the heavy and chemical industries (HCI) during the late 1960s, the government continued its support of the electronics industry. It is within this context that an indigenous semiconductor industry began to emerge. Anam which was an independent firm was established in 1970 as a subcontractor for foreign semiconductor producers, and Goldstar (later LG) and Samsung began to invest in semiconductor assemblies in 1970, mainly for the purpose of supplying internal demand.

4.3. Stabilization of the Semiconductor Industry

The stabilization of semiconductor industries occurred only after Korea's indigenous electronics industries were established during the 1970s. The structure of the electronics industry was shifting as companies such as Goldstar, Daehan and Samsung began to increase local contents of parts and components, and gradually began to develop more advanced products using domestic capital. But in order to expand exports, it was necessary for firms to diversify and enhance the quality of products. Reliance on imported parts and equipment to produce advanced products were still high, and it was imperative for firms to produce these components domestically in order to improve their competitiveness and profitability (Yoon, 1990: 28). In addition, the composition of semiconductors in electronics was increasing, which meant that the increase in demand for electronics resulted in an increase in semiconductor demand as well. For this purpose, various technology licensing or joint venture agreements with foreign firms were set up.

Korea began to enter the international market with successful products, but as the wage levels increased during the HCI program in the 1970s, foreign firms became hesitant to invest in Korea or decreased their joint ventures. In addition, most of the demand for semiconductors and other components were being imported from Japan, and initially this was not an issue in Korea when wages were low and the industry focused on low-technology products. But Japanese semiconductors firms which were structured vertically produced general electronics products at the same time. As wages increased and Korea began producing more sophisticated products, direct competition with Japan became inevitable, and dependence on Japanese semiconductors was seen as nothing more than dependence on a potential competitor (J. S. Shin, 1996: 126). In effect, Korean electronics firms experienced semiconductor supply deficiencies when their exports were booming (Yoon, 1990: 28).

Both the government and private industries sensed the importance of developing indigenous semiconductor capabilities. As the electronics industry was formally designated a strategic industry of the HCI program, the government began seeking strong promotional measures for domesticating the semiconductor industry. For example, in October of 1975 the EPB relaxed the direct abroad investment regulation for electronics firms, and the Ministry of Commerce and Industry (MCI) announced an ambitious 6 year plan for fully domesticating six high-technology components which were centered upon silicon wafer manufacturing and memory integrated circuits. The government also planned to increase funding for overall R&D activities and provide a broad institutional framework for the development of the semiconductor industry. In 1975 semiconductor technology was designated as the most important research item of the Korea Advanced Institute of Science and Technology (KAIST). The Korea Institute of Electronics Technology (KIET) was also established to specialize in semiconductors and computers. The KIET was a collaborative public research institute between the state and the private sector aimed at providing instant manufacturing technologies for private firms. In addition to basic research facilities, KIET also ran 'pilot production facilities' for memory chips and computers (J. S. Shin, 1996: 127). KIET was successful in designing and producing an 8-bit microprocessor and a 2K SRAM in 1981, and also developed a 32K ROM in 1982 and a 64K Rom in 1983 (Chen and Sewell, 1996: 6). Another national R&D institute, Electronics and Telecommunication Research Institute (ETRI), was focused solely on developing semiconductors, computers and telecommunications equipment (Byun and Ahn, 1989: 9).

In addition, private firms also became active in the semiconductor business due to needs of long-term corporate strategy. Companies focused their efforts on fields that were directly related to its consumer electronics business. For example in the early 1970s Samsung had begun to invest in the semiconductor business on a small-scale for its consumer electronics products. In 1974 South Korea Semiconductor was established under a joint venture between Samsung Electronics and a group of US-based South Korean expatriates, but this group became absorbed into the Samsung Group as part of the Samsung Semiconductor and Telecommunications Company (SSTC), later again being transferred over to Samsung Electronics in 1979 (Chen and

Sewell, 1996: 6). Technology transfers which occurred between the original US-based partners and Samsung were crucial in providing semiconductor designs, fabrication and assembly capabilities which were previously unable from off-shore assembly plants or even local ventures (Byun and Yoo, 1987). Goldstar (currently LG) set up a joint enterprise with American Microsystems in 1978. Riding upon this tide, numerous other firms began showing an interest in semiconductor manufacturing. Daewoo Electronics was established in 1976, and Saengsa Korea set up a joint venture with Fairchild called Saengsa Semiconductors in 1977. But a majority of ventures were unsuccessful since firms had to rely on their foreign partners for technologies, and in most cases the latter were reluctant to transfer advanced technologies in the midst of Korea'a underdeveloped domestic market, uncertain export prospects, and intellectual property issues. By the end of 1979, only three firms were left— Samsung, Goldstar and Korea Electronics (Yoon, 1990: 33).

Due to rapid innovation and change in product life cycles, foreign firms were either unwilling to transfer high technologies or imposed demands which were too incompatible with domestic regulations. For instance, Korea Microsystems which was a subsidiary of American Microsystems tried to establish a venture with the German firm Wacker Chemitron for setting up a silicon manufacturing facility, but Wacker requested 100 percent ownership due to technology leakage issues (KEIA, 1981a: 255). Unlike the past, this time the government did not allow an exception to regulations that allowed foreign ownership at less than 50 percent.

Although the 1970s were an ambitious period for the state striving to domesticate the semiconductor industry, in addition to increased efforts by the private sector, Korea had limited achievements because of difficulty in securing and assimilating advanced technologies. Most attempts by new entrants into the semiconductor industry were failures, and even among the remaining three in 1979 only Samsung and Goldstar had enough capital to continue sustaining semiconductor R&D and manufacturing capabilities, as they were affiliations of the massive chaebols that were able to divert revenues obtained from other subsidiaries into the semiconductor business.

4.4. Private Sector Initiatives and Take-off of the Semiconductor Industry

The take-off of the Korean semiconductor industry occurred during the 1980s with the adjustment of the government's HCI policies as well as aggressive investment by major chaebols. International economic conditions began to deteriorate in 1979 and this prompted the government to reevaluate the economic management style of the previous decades. In addition, the new military regime which grabbed power in 1980 was eager to find political justification for the Coup and this added another impetus for economic reform.

The government's economic stabilization plans consisted of the following: indicative planning instead of direct intervention; promotion of industries that retained potential for growth and international competitiveness; and instead of focusing on specific industrial projects, operate general functions such as R&D, automation, energy conservation and pollution control (EPB, 1981a). In addition, financial liberalization policies led to privatization of banks, expansion of non-bank financial sectors, and liberalization of the capital market (EPB, 1981b).

In the midst of these developments, the government's interest in promoting the semiconductor industry did not diminish, but rather the state continued to promote the industry, although on a less active scale and through different measures from the 1970s. The state designated the industry as a leading sector and provided various promotional measures. For example, semiconductors were included in the government's fifth Five-Year Plan (1982-1987) as one of the principal 'target' industries. During this period 700 billion KWN was set to be invested into R&D for semiconductors, computers and communications equipment (EPB, 1981a). In 1983 the Semiconductor Industry Fostering Plan was set up to begin full-scale support for the semiconductor industry. The government also organized public-private research projects to develop new generations of semiconductors from the development of 4M DRAM in 1986 (NIPA, 2003). The VLSI collaborative research project was established in 1986 to secure a domestic foundation for generating independent technological capabilities.[12] The plan was a collaborative effort between ETRI[13], universities, and domestic semiconductor manufacturers, especially Samsung, Goldstar and Hyundai. The specific functions of each party are illustrated in Table 5.

[12] The VLSI project was a three stage plan to develop a 0.8μm 4M DRAM chip by March 1989. The first stage (1986. 08 ~ 1987. 3) was to develop a 1.0μm 1M DRAM chip; the second stage (1987. 04 ~ 1988. 03) was developing a 1.0μm 4M DRAM chip; and finally in stage three (1988. 04 ~ 1989. 03), using design, process, assembly and other production and basic techniques from stage 1 and 2, to develop a 0.8μm 4M DRAM chip.

[13] In 1985 the research institute KIET was merged with the Korea Electrotechnology and Telecommunications Research Institute to become the Electronic and Telecommunications Research Institute (ETRI)

Table 5: VLSI Collaborative Research Project

	Private firms	Research Institutes	Academic Institutions
Participants	-Consortium of Semiconductor Advance Research - Samsung, Goldstar, Hyundai	ETRI	- Seoul National University Semiconductor Research Center - KAIST
Functions	- Design / production - Basic technology development	- Coordinate overall research - Allocate funding for design / production and basic research	- Provision and training of researchers - Basic technology research

Source: National IT Industry Promotion Agency (NIPA) (2003)

In March of 1988 this project succeeded in developing the 4M DRAM chip. Building upon this achievement, the Ministry of Science and Technology set up future collaborative projects for developing 16M and 64M DRAM chips as well. This next plan was also a three stage project that anticipated developments according to the following stages:

Stage 1 (1989. 04 ~ 1991. 03): 16M DRAM

Stage 2 (1989. 04 ~ 1993. 03): 64M DRAM

Stage 3 (1989. 04 ~ 1993. 03): Develop equipment and materials for 64M production

The project achieved success rather earlier than the anticipated deadlines. Korea managed to develop the 0.5-6μm 16M DRAM in 1990 and the 0.4μm 64M DRAM chip in 1992.

In contrast to the 1970s, despite the government's enthusiasm towards semiconductors, the main impetus for semiconductor development after the 1980s arose from the private sector where previously the competitiveness based on low wages was being eroded and firms needed semiconductor technologies to increase the competitiveness of their products (J. S. Shin, 1996: 130). In order to overcome the recession in the international market for electronics, firms proposed to the government the formation of a state supported semiconductor promotion fund, increased funds for R&D, relaxation of foreign investment regulations, and increased tax breaks (Yoon, 1990: 43). As illustrated above, these proposals were quickly implemented by the government. It is evident that government support was based more on inducements by progress from the private sectors than vice versa.

During the HCI programs in the 1970s, the chaebols saw their positions become firmly established in the economy. As they searched for new business areas for further growth, semiconductor technologies were considered pivotal for entering into new businesses such as telecommunications and computers, or to further develop existing businesses such as automobiles and heavy machinery (Choi, 1991: 61). Even though short-term entry costs were enormous, firms saw that the long-term prospects of demand growth in the semiconductor industry were promising. Hence, existing wafer manufacturers such as Samsung and Goldstar heavily increased their investments in semiconductor facilities and the proportion of R&D to sales in the midst of initial significant losses in the semiconductor business. Hyundai entered the semiconductor market in 1984 without any prior experience in electronics, and Daewoo which had entered the electronics business in the late 1970s also invested in integrated circuits, but mostly for internal supply.

When examining sources of funding, internal financing and international funds significantly increased than those compared to financing through domestic banks (Table 6). Firms were utilizing the domestic capital market to raise their investment funds, and also turned to the international capital market for financing (Yoon, 1990: 43). During the 1970s the government had initiated foreign loans, while in the 1980s chaebols now raised foreign loans with their own credit. In terms of R&D, the private sector was outperforming the state as well. While in the 1970s the government was the major source of R&D, the trend was reversed in the 1980s as a result of the R&D expansion by chaebols, especially into the electronics industry (Table 7).

Table 6: Financing of Investments in a Semiconductor Firm: 1983-1988

(Units: 100 million won, %)

Year	Domestic Source		Foreign	Total	Investment Content		Total
	Internal	External			R&D	Infrastructure	
1983	82 (31)	113 (42)	73 (27)	268	15 (6)	253 (94)	268
1984**	270 (27)	204 (20)	526 (53)	1,000	40 (4)	960 (96)	1,000
1985**	203 (19)	145 (14)	295 (67)	1,043	300 (29)	743 (71)	1,043
1986**	212 (22)	132 (14)	620 (64)	964	320 (33)	644 (67)	964
1987**	243 (25)	115 (12)	619 (63)	977	330 (34)	647 (66)	977
1988**	355 (30)	129 (11)	696 (59)	1,180	360 (31)	820 (69)	1,180

Source: Undisclosed firm, Yoon (1990: 111, table 4)

Note: ** Estimated figures. Number in parentheses is ratio between funding source and total investment.

Table 7: Major R&D indicators in Korea

(billion, won, %)

	R&D expenditure	R&D / GDP(%)	Public R&D / Total R&D (%)	Public R&D / Total R&D (%)	R&D / Total sales (%)
1981	526	0.8	53.0	47.0	N.A.
1990	4,676	1.9	22.0	78.0	N.A
1995	9,441	2.5	19.0	81.0	0.3
1996	10,878	2.6	22.0	78.0	0.3
1997	12,186	2.7	23.0	77.0	1.2
1998	11,337	2.6	27.0	83.0	1.9
1999	11,922	2.5	27.0	73.0	2.9
2000	13,849	2.7	25.0	75.0	2.9
2001	16,110	3.0	26.0	74.0	2.3

Source: Nagano (2006: table 2)

Even when the Korean semiconductor industry faced a recession during the mid-1980s, the government did not provide specific supportive measures. The chaebols devised different corporate strategies on their own for survival. For example, beginning in late 1984 to 1985 there was an abrupt shift in the global semiconductor market. Whereas in 1984 the price per 64K DRAM chip was $4, in April of 1985 the price fell to 80 cents per chip which was less than Samsung's production cost of $1.7. Such rapid fall in prices were partially attributed to deliberate dumping at below-cost prices by Japanese companies in order to undermine Korean efforts for market entry (Hart-Landsberg, 1993). Samsung responded by diversifying its products and advancing its production of the 256K DRAM, and Goldstar focused on products that were certain to reach the market. After severing relations with AT&T in 1989, Goldstar also began focusing on DRAM production. Hyundai closed down its pilot operations in the California and opted for the foundry business, in addition to developing its own designs through several technological agreements.

Just as Japan did nearly a decade before, Korean firms were focused on narrow products and technologies, mainly in DRAM production. Initially, Korea lagged behind world leaders by 6 years in development and by 4 years in production of DRAM (Table 8). But in 4M DRAM, Korea was able to narrow the time lag production to one year, and in 16M DRAM production there was no significant time lag. By 1991, Samsung became the world's largest producer of 1M DRAM (Elsevier Advanced Technology, 1993:151). In 1992, it became the world's largest producer of all DRAM products and the world's leader in memories in 1993. Korea's share of world DRAM production reached 20% in 1990 and 23.6% in 1993. Its total share of memories was increased to 13% in 1990 and 17.9% in 1993.

Table 8: Time lag of DRAM development versus production

		64K	256K	1M	4M	16M
Development	World	1977	1980	1983	1986	1987
	Korea	1983	1984	1986	1988	1990
	Lag (year)	6	4	3	2	3
Production	World	1980	1982	1985	1989	1992
	Korea	1984	1985	1987	1990	1992
	Lag (year)	4	3	2	1	0

Source: Chu (1992: 43, table 3.11)

During the early stages of the semiconductor industry, the government was a substitution for the underdevelopment of the private sector in terms of procuring advanced technologies from abroad and providing investment. The historical underdevelopment of industrialization meant that Korean electronics industries had very weak backward linkages to merit any indigenous capability. In addition the industry also had weak forward linkages such as computers or telecommunications industries, which explains the high-degree of export orientation. But during the take-off stage of the semiconductor industry in the 1980s, foreign firms were becoming more reluctant to transfer advanced technologies, which meant the government could now assume only a limited role in intervening in the process of technology transfer from abroad. This was what made the chaebols play a greater role in developing semiconductor technologies during the 1980s and onward. This combination of the limited role of state, coupled with the impending technology needs of the electronics industry prompted chaebols to actively engage in securing advanced manufacturing technology from abroad.

4.5. Recent Developments in Government Support

As observed above, during the 1990s the Korean semiconductor industry succeeded in commercializing its products and experienced rapid growth, capturing the world's largest market share of memory chips by 1993. The success of the Korean semiconductor industry in the 1980s and beyond can be attributed to mostly corporate leadership (H.K. Kim, 1993: 246). Unlike countries such as Taiwan that relied on the leadership of state enterprises for semiconductor development, the Korean government's R&D policies were geared towards enhancing private R&D investment activity.

One notable example of the reduction of the scale of government activities in the semiconductor industry pertains the recent trade conflict of 2003 between South Korea and United States that dealt with the imposition of countervailing duties on DRAM chips from Hynix Semiconductors.[14] Previously known as Hyundai Electronics, Hynix Semiconductor was formed when Hyundai Electronics merged with LG Semiconductor in 1999. During 1999 and 2000 there was a boom in the world semiconductor market owing to a recovery in the world economy, increase in computer sales due to the internet boom, and increase in demand for telecommunications equipment. Initially during 1999 and early 2000 Hynix experienced increase in profits and sales as well, achieving a revenue of nearly $6 billion at the end of 1999 (S. W. Kim, 2004:11). But beginning in late 2000 and onwards the firm began recording significant losses, from revenue of $7.7 billion in 2000 down to $2.8 billion in 2002. Hynix was faced with

[14] Office of the United States Trade Representative (USTR). "Countervailing Duty Investigation on Dynamic Random Access Memory Semiconductors (DRAMS) from Korea." Accessed, April 10th, 2011. <http://www.ustr.gov/trade-topics/enforcement/dispute-settlement-proceedings/wto-dispute-settlement/countervailing-duty-i.>

massive financial setbacks due to low liquidity, decrease in profitability, uncertainty surrounding its financial procurement plans and difficulty in investing in new infrastructure. Due to the firm's vast market share, scale of employment, export volume, large number of subcontractors and linkage effects, government officials began expressing their concern for the Hynix crisis, and from late 2000 to 2001, various financial measures were provided through banking sector (Table 9). On November 2002 the United States Department of Commerce (DOC) began the countervailing duty investigation on behalf of the petition filed by Micron, for the period ranging from January 1st 2001 through June 30, 2002.[15]

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[15] Ibid.

Table 9: Financial Support for Hynix

2000. 12	- Syndicated loans of 800 billion won
2001. 01	- Expansion of Bill of Exchange underwriting facility
2001. 05	- Syndicated loans of 800 billion won - Convertible bond (CB) underwriting to 1 trillion won - Extension of Bill of Exchange / Maximum Purchase to $1.4 billion - Overdraft loan limit extension to 289.5 billion won - Foreign currency loan extension to $556,980,000
2001. 10	- Financing for corporate bond amortization funds 370 billion won - Debt-equity swap for existing loans 3 trillion won - D/A (Documents against Acceptance) mid-to-long term general loans swap $805 million - Extension of previous credit limit and lower interest rate to 9% - Extension of investment firm 3-year corporate bonds to 1.2 trillion won - Extension of leasing company principal and interest amortization to 1 year and 6 months with 520 billion won

Source: S. W. Kim (2004: 11, Table 1)

On April 7, 2003 in the Preliminary Determination, the DOC imposed a countervailable subsidy rate of 57.23% for Hynix DRAMs. The Korean government and Hynix objected to the DOC's decision and began negotiating with the United States to suspend tariff imposition by limiting DRAMs export quantities or imposing price constraints. But negotiations broke down in May, and on June 23, 2003, the DOC published its Final Determination. The DOC found that the financial assistance to Hynix in the form of loans, equity infusions, and debt forgiveness were specific contributions that benefitted the firm, and imposed a countervailing duty of 44.29% *ad valorem*.[16]

The basis of the DOC's investigation had three elements, first, whether financial support from Hynix' creditors provided a benefit specifically for the firm compared to general forms of financial support; second, whether the provision of equity or adjustment of interest rates were decisions based on reasonable commercial judgments; and finally, whether the debt-equity swap or convertible bond writing were reasonable commercial judgments based on prudent inquiry of Hynix' equity-worthiness (S. W. Kim, 2004: 13). In other words, the three main issues that the DOC addressed can be summed up in the following agendas. Despite financial assistance from the private sector, was there government involvement? Through such measures, was there benefit to a specific firm? Finally, was the assistance a part of the government's economic policies towards overall industries or was it for a specific firm? The DOC argued that the Korean government was involved both directly and indirectly in the financial support to Hynix, while the Korean government and Hynix rejected all of these claims on the grounds that private firms were behind the financial assistance and that the DOC did not have direct evidence that the government was involved. Korea appealed to the World Trade Organization (WTO), which ruled in March 2005 against the U.S tariff, but later on reversed the decision to uphold the U.S. duties on Hynix DRAMs.[17]

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[16] Ibid.

[17] Nystedt, Dan. 'WTO upholds US tariffs on Hynix : Status quo retained' *IDG News Service,* June 28, 2005. Accessed April 10th, 2011. <http://news.techworld.com/storage/3934/wto-upholds-us-tariffs-on-hynix/>.

This crisis demonstrates the shifting nature of the role of government in protecting and promoting domestic industries, particularly a strategic sector that was crucial to the economic health of the nation. Unlike the past, as clearly witnessed during the Hynix situation the government was eager to deny any claims of support for the ailing firm. The government was no longer able to intervene directly through fiscal or industrial policies that benefit a specific sector or industry without significant backlash from foreign entities such as the United States who was determined to observe and restrict unfair trade practices against itself.

Chapter 5. Conclusion

South Korea's technological development has experienced tremendous growth compared to the 1960s and 70s. In particular the technological capability of the private sector has outpaced many developed countries to achieve world class status in semiconductors and other areas. As seen in this study, the role of government in the development of technology has shifted greatly over the decades. During the early stages of industrialization when technology was virtually nonexistent, there was no distinction in the roles between the entities that engaged in R&D or the commercialization of products. The government took the lead in both procurement and production because without an existing strong industrial base, firms neither had the ability nor the willingness to utilize advanced technologies. Also the state decided it was the most effective means to rapid technological innovation and economic capacity improvement in a short period of time. Gradually as the private sector began to enhance their financial and R&D capabilities, in addition to increased international market competition and rising investment costs, the government began to assume a more supportive role of private sector R&D initiatives.

In the current era of economic liberalization and free trade, since the private sector now leads the trail in economic growth, theoretically the state should assume only a minimal role in technology development and involvement in broader economic policies. For example, the government should implement regulations that promote fair trade within the country and abroad. Although the government can no longer use tariffs, taxes and other trade or fiscal policies on an active basis simply to benefit domestic industries, the government should use these measures for balancing unfair trade activities. In addition, as the IMF crisis of the late 1990s and the recent economic crisis of 2008 demonstrates, such a weakening of the external business environment diminishes private sector incentives to search for new areas of economic growth and so induces firms to focus on maintaining their existing core businesses. This may be viable in the short term, but as the product life cycle demonstrates, firms must pursue a constant innovation process in order to sustain a technological edge over competing firms. As illustrated in the concept of positive externality, the government should continue to increase public investment and R&D activity in technology areas of high risk in order to induce private sector activity. Finally, the government should focus on structural reform of the semiconductor industry such as expanding the production system of the domestic market for decreasing foreign market dependency and obtaining price stability.

Then again, when assessing the economic reality of Korea’s small domestic market and continued reliance on exports, the volatile international market, and the heavy share of manufacturing GDP in electronics and semiconductors, should the government maintain a passive stance towards events that occur in the private sector? In other words, circumstances such as the Hynix crisis are bound to occur in the future, and so the policy question remains as to whether the government should allow the free market to determine the fate of strategic industries such as semiconductors which are currently the biggest drivers of national economic growth, or whether to assume politically controversial but nonetheless active positions in protecting vital industries when necessary.

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