# Political Economy and Technological Innovation:Implications for Development of High-tech Industries in Korea

SOH, CHANG ROK
*Research Associate*
*Berkeley Roundtable on the International Economy (BRIE)*
*University of California at Berkeley*
*Ph. D., The Fletcher School of Law and Diplomacy, Tufts University*

**Abstract**

Political economy is a key determinant to industrial competitiveness. Korean political economy produced concentrated structure of industries, large firm organizations and price-oriented firm strategies. Even though these conditions were important Korean competitive advantages in the 1960s and 1970s, these are not appropriate for development of high-tech industries. Unless structure of industries becomes more flexible, it will be difficult to expect competitive high-tech industries in Korea. The case of semiconductor industry illustrates this point. The flexible industry structure in the U.S. and Japan has been the key for their successes in this industry. On the other hand, most European countries lack this flexibility and have not been successful as much. Korean semiconductor industry, despite huge investment and the enormous growth, lacks the capacity for technological innovation. This technological problem is a result of the structural vulnerability which has been induced by Korean Political economy.

## I. Introduction

High-tech industries received the largest share of attention among the strategic sectors selected in the Korean government throughout the 1980s. Korea sought to re-organize its industrial structure by concentrating on technology-intensive sectors and turning away from the Heavy and Chemical Industries (HCI) approach of the 1970s. After suffering from a low growth rate and after being criticized by the public for over-investment in HCI in the late 1970s, the Korean government has tried to

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move toward technology-intensive industries, which are considered by both the government and general public to be advantageous to the future of Korea.

However, despite the efforts of both the government and business over the last 10 years, the technological level of Korean industries has been limited. Although a few large vertically integrated conglomerates (*chaebols*) have made huge investment in some of these industries, their strategies of massproduction and low-cost leadership of standardized products have proved to be far from what is required for the development of competitive high-tech industries. The various government intervention policies have not been enough to generate the environment for proper "national systems of innovation," which is a key for the growth of competitive high-tech industries (Freeman, 1988, p. 81).

This paper intends to illustrate the structural problems in Korea which constrain the generation of innovation systems. The structure of industries which led Korean industrial development for last 30 years do not meet the technological imperatives of high-tech industries. The structure of industry can be defined as the flexibility of market structure, the extent of competition, and the degree of market concentration. In the 1960s and 1970s, inflexible industry structure, and large firm organization evolved out of political and security reasons. However, structural requirements for technological innovation are different from what Korea developed in the past.

The immediately following section will discuss importance of political economy in the analysis of industrial competitiveness. While structure of industry and firm's behavior are a function of technological characteristics, they are profoundly influenced by the political economy of each nation. Therefore, the political economy of each nation becomes a key determinant for the industrial competitiveness. Using the analyses of theories of industrial organization, I will demonstrate the importance of political structure to market structure, firm organization and strategies. Section 3 discusses why the conditions of competitive advantages developed in Korea, such as large firm size, concentrated market structure, and centralized firm organization may not be helpful to innovation, the key for high-tech industries. I argue that those conditions of competitive advantages do not suit the technological imperatives of innovation-based industries, and rapid and significant changes are needed for the development of competitive hightech industries. Finally, section 4 contains a case study of semiconductor industry. Despite the need for huge investments, this industry requires flexible structure due to characteristics of high-tech industries. After reviewing cases of developed countries, I will present the implications for Korean semiconductor industries.

## II. Political Economy and Industrial Competitiveness

### 1. The Structure of Political Economy

According to Robert Gilpin, "political economy" is created by the parallel existence and mutual interaction of "state" and "market" in the modern world (Gilpin, 1987, p. 8). He defined political economy as "the reciprocal and dynamic interaction of the pursuit of wealth and the pursuit of power" (Gilpin, 1975, p. 45), While the state is inextricably intertwined with the market, the way in which these two interact with each other will be unique to each nation. The way the state and market interact in a nation structures economic institutions and constrains the behavior of economic actors. Therefore, for the purpose of this paper, the structure of political economy is a set of institutions and behaviors arising from the interactions between the state and market in a nation. Once the structure has been established, barring significant changes in either state or market, this structure continues to determine the shape of the existing institutions and operates to constrain the behavior of economic actors in the nation.

Firms, not nations, compete in the international market place. A nation's standard of living in the long term depends on its ability to attain a high level of productivity in the industries in which its firms compete. Therefore, how firms are organized and behave is the critical variable in explaining the industrial competitiveness of nations. Although the firms' behavior is the most important variable for the competitiveness of industries, the firms operate within larger political economic systems that have a central bearing on their competitiveness. Thus each firm's behavior is in a way a function of the structure of political economy in each nation.

The relation between the government and business and among businesses are organized differently in each nation, and consequently the dynamics of markets are different. Economists, in their analysis of market, often ignore role of institutions and proceed with their analysis as if institutions do not exist and as if history did not matter. Political scientists, on the other hand, characterize these relationships, using notions such as the strong or developmental state, state-led growth, and corporatism. However, they rarely establish that these institutional relationships shape market behavior. We need to integrate an analysis of policy and institutional relations with an analysis of market behavior.

### 2. Political Factor in the Analysis of Industrial Organization

Theorists of industrial organization have dealt with the relationship between market structure and the performance and behavior of firms. These theories, although been developed and refined over time, fail to consider importance of political structure in the analyses. Consequently, these theories do not address the variances of industrial organizations among different countries.

In the debate on industrial organization, two view points can be distinguished. Firstly, the mainstream scholars of industrial organization, often called the structuralist school, consider that productive structures, existing market forms, and organizational methods adopted by enterprises are a good approximation of the efficient adaptation that should result from some external order dictated by the existing technology (Jacquemin, 1987). They assume that each market's structure tends to influence how firms behave and how well they perform. According to them, the performance variables such as profits, innovation, and the like are a function of industry or market structure.

In contrast, the second, the anti-structuralist view of the Chicago-UCLA School, which came to prominence during the 1970s, reversed the direction of causation found in the mainstream argument. They stresses the role of economic agents modifying their environment instead of being subjected to predetermined conditions. Each firm's relative efficiency is said to be the real determinant of its position in the market's structure and behavior. Thus a firm's superior innovations may generate large profits and enable it to determine the market structure. Some analyses of this view attribute all structural monopoly to superior performance (Shepherd, 1990).

While each argument has its own strengths and weaknesses and cannot be easily repudiated by the other, Michael Porter's structural analysis is very helpful to further understand the function of industry structure. According to Porter's analysis, the nature of competition is embodied in five competitive forces: 1) the threat of new entrance; 2) the threat of substitute products or services; 3) the bargaining power of suppliers; 4) the bargaining power of buyers; and 5) the rivalry among the existing competitors (Porter, 1980, p. 32). The strength of the five forces varies from industry to industry and together they determine industry profitability. these forces determine industry profitability because they shape the prices firms can charge, the cost they have to bear, and the investment required to compete in the industry. To Porter, the strength of each of the five competitive forces is a function of the underlying economic and technical characteristics of an industry (Porter, 1980).

However, I argue that the above analyses fail to consider the political structure as a very important variable in understanding industrial organization. The political structure, by influencing the five competitive forces, has a great impact on market structure and firm organization. In the case of Korea, the state, by intervening in economic activities, has had the power (and intent) to shape and change market structure and firm behavior, and therefore the performance. The state has been a crucial factor in shaping the structure of political economy. Although the economic and technological imperatives still remain as factors, the political structure has been a much more influential factor in determining the shape of industry structure.

Some scholars have argued that the effective government intervention under the authoritarian regime in Korea was the key to the successful industrialization (Jones and SaKong, 1980; Amsden, 1989; Kwon, 1991). However, the simple argument that the strong state in Korea has contributed to its successful industrialization should be revised. The statists, in the 1980s, emphasized the role of the state (Evans, et al., 1985). They emphasized the autonomy and capacity of the state in economic activities. Their main comtribution is that the state's political intervention can have a positive effect on the industries. The Korean state has contributed to economic growth in general, however it cannot be considered an omnipotent power fulfilling the requirements of every industry. Its role changes over time and across industries.

The Korean government under military leadership in the 1960s and 1970s needed rapid economic growth to support both its political legitimacy and address national security concerns. The authoritarian regime intervened the economy effectively and implemented policies efficiently. Rapid economic growth was realized through huge investments by large, centralized, and well connected conglomerates, called *chaebol*. These big businesses have continued to contribute to rapid economic growth through large investments and export of mass-producible low-tech products.

In the 1980s, the role of the Korean state, compared to previous decades, reduced significantly. At the start of the decade, the Korean state confronted dual imperatives: industrial restructuring and the economic stabilization. The government implemented aggregate stabilization policies intended to reduce the state's discretionary intervention. Private firms, in the meantime, increased their economic power. Although political changes in the 1980s changed the role of the state in the economy, the fundamental structure of political economy remained unchanged. The pressures such as need for rapid economic growth provided the rationale for the existing structure to remain.

The conditions that Korea has developed for its competitive advantage over the last 30 years include: (1) a small number of large private conglomerates (*chaebol*) rather than many competing small and medium size firms: (2) the establishment of a monopolistic or oligopolistic market structure rather than a full competitive market structure; and (3) the adoption of mall-production technologies based on borrowed technologies rather than craft-production technologies with indigenous technologies. These conditions of the competitive advantages that Korea has exploited cannot be advantages in all industries. I argue that, although these conditions have been appropriate for many industries (traditional and mature), they may not be advantageous for more innovative, technology-intensive industries.

## III. Structural Requirements for High-tech Industries

In this section, I present the structural requirements for the development of high-tech industries. Due to technological characteristics of industries, flexible industry structure and decentralized firm organization are needed for the competitive high-tech industrial development. The structure of Korean political economy developed during the last three decades may not suit the technological imperatives of innovation-based industries.

### 1. Characteristics of High-tech Industries

What makes high-tech industries unique is the rate at which innovation occurs. Although virtually all industries require certain type of innovations, the characteristic of rapid and seamless innovation marks the difference between high-tech industries and others. In traditional mature industries, levels of innovations, once reached, tend to remain relatively unchanged for long periods of time. Developing countries, given the willingness of either the state or firms to invest aggressively, can acquire high-level, state of art technology without indigenous innovation capacity.Therefore, competitive advantages in smokestack industries rest more on efficiency rather than on innovation.

In contrast, in high-tech industries, innovation is continuous. The life span of the innovation-to-obsolescence cycle is shortened. Competitive advantage is to the firms that innovate most rapidly. Some industries, new only a few years ago, can suddenly become out-dated industries. Without continuing innovation activities, it is not only impossible for a firm to sustain its position but it also makes it likely to be caught by those that follow it(Kay, 1990).

### 2. Innovation, Technology and Organization

Some scholars like Alfred Chandler argue that companies must grow big in order to be successful. From a 10 year study of 200 large firms in the US, Germany, and the UK, Chandler concluded that, to succeed in the long run, companies must grow. He claims that the large industrial company has been the engines of the growth for the past 100 years and will continue to be same for the next 100 years (Chandler, 1990). The critics of Chandler claim that he ignores the effects of new technologies on markets (The Economist, Mar 24, 1990, p. 79). His argument may apply more readily to industries where fast changes in technology do not seem likely, and it may not apply to industries where rapid changes in technology occur. Moreover, his argument is based on the economies of developed countries. These are, of course, very different from the economies of developing countries. Therefore, to address Chandler's critics, we need to consider the effect of new technology and innovation on the industry structure and firm organization, as well as the differences between the economies of developed and developing countries.

According to technology management theorists, industry structure and firm organization are closely related to technological innovation. Conditions required for rapid innovation are extremely defferent from those required for high levels of output and productivity. Under the demand for rapid innovation, organizational structure needs to be fluid and flexible, whereas under the demands for high levels of output and productivity, organizational structure needs to be standardized and less flexible (Utterback, 1987, pp. 16-48; Abernathy, 1978; Woodward, 1965).

In the dynamic model of Utterback, there are three states in the industrial evolution: the fluid state, the transition state, and the specific state (Utterback, 1990). Firms that are new to a product area will exhibit a fluid pattern of innovation and structure. As the market develops, a transitional pattern will emerge. Finally, the market stabilizes, fostering a more specific pattern of behavior. In the fluid state, while product requirements are still ambiguous, there will be a rapid entry of firms with few failures. A new entrant might succeed, for example, by stressing a high degree of product innovation. In the transition state, product requirements become more defined. Fewer firms will enter and a large number will either merge or fail.A new entrant at this stage might succeed by stressing process innovation and process integration. In the specific state, there will only be a few, large firms each controlling a fairly constant share of the market-with possibly a few small firms serving highly specialized segments. A new entrant might succeed by having financial strength and investing in a plant at the most economic scale and location (Utterback, 1990).

Although Utterback's model is based on the evolution of a industry over time, it implies that industries in which the innovation rate is rapid and product cycle is short, will have a more flexible industry structure than the less innovative industries. Without continuous entry of innovative firms into industry and/or flexible response of existing firms to the rapid technological changes, it is hard to expect the innovation-based industry to be successful.

Firm organizational structure along with industry structure also varies, say technology management theorists. According to these scholars, during periods of high target and technical uncertainty, the organizational structure is required to be organic. Such an organization emphasizes, among other things, frequent adjustment and redefinition of tasks, less hierarchy, and more lateral communication. An organic organization is more appropriate to uncertain environments because of its increased potential for gathering and processing information for decision making (Burns and Stalker, 1961).

As a dominant design emerges and production operations expand rapidly in response to increased demand, a product becomes more standardized and is produced in a more systematized process, interdependence among organizational subunits, thus gradually increases, making it more difficult and costly to incorporate radical innovations. In contrast to the organic organizational structure, this type of organizational structure is termed mechanistic (Burns and Stalker, 1961).

While the flexibility of industry structure and firm organization varies along with the development stages of each industry, they also vary along with the characteristics of each industry. For industries which require huge initial investments and less technological sophistication, highly concentrated industry structure and mechanistic firm organization may be favorable conditions. On the other hand, for industries which do not need huge capital, but instead require sophisticated technologies and continuous innovations, more flexible industry structure and organic organizational structure would be more favorable.

According to Woodward's analysis, it is the type of production technology which forces firms to adopt strategies or evolve into particular organizations in order to be competitive in the market. In other words, certain organizational structures and management styles associated with the type of production technology are required for market success. In a brief summary of her analysis, successful firms in unit and small-batch production are likely to have short and relatively broadly based pyramids, and an organic management system. On the other hand, successful firms in large batch and mass production are likely to have taller and more narrowly based pyramids, and a mechanistic management system (woodward, 1965)

By combining the above arguments, we can outline some relationship between technological innovation, firm organization, and strategies for adopting production technologies. (see Table 1) For industries requiring rapid innovation and frequent product changes to be competitive, flexible firm organization and adoption of craft production technologies are necessary. Especially, in the early stage of industry, the flexibility is needed to be innovative.

<**Table 1**> Innovation, Technology and Organization

| Innovation | Rapid Innovation/Short Product Cycle | Slow Innovation/Long Product Cycle |
|---|---|---|
| Production Technology | Craft-Production<br>Differentiation<br>Strategies | Mass-Production<br>Low-Cost Leadership<br>Strategies |
| Firm Organization | Flexible<br>Organic<br>Decentralized | Inflexible<br>Mechanistic<br>Centralized |

Source: Adapted from Burns and Stalker, 1961; Woodward, 1965; Utterback, 1990; L.Kim, 1990.

### 3.Divergence in Developing Countries

In most developing countries, industries became established througn transfers of standardized technology from developed countries to firms having both the strategy and the organization capable of absorbing such technology. Thus, the firms' organizational structure is mechanistic rather than organic from the beginning. Firms in developing countries enter an industry when that industry has reached the specific level in the developed countries. At this level, in developed countries, the set of competitors becomes an oligopoly and competition begins to shift to product price. Margins are reduced, and production efficiency and economies of scale become emphasized. Consequently, the requirements for the market become simpler and more precise. As price competition increases, production processes become more capital-intensive and may be relocated to achieve lower costs. Firms in developing countries, then with low labor cost, are entering the market at this stage.

The pattern which arises in developing countries encourages firms to have a mechanistic structure. This type of structure is more compatible than an organic one in dealing with the implementation of the production of matured products. At the stage of a new industry formation, the firms lack the innovation capacity. With the lack of competitive stimulus and local technical capability, organizations at this stage cannot be expected to innovate. Developing countries' state intervention policies such as import-substitution and capital allocation may reinforce this pattern even further. New industries in many cases are initially created and protected by government intervention policies. Production at this phase is merely an assembly operation of foreign components and parts with equipment purchased from overseas. In this situation, due to a lack of technological capability and market incentives, few indigenous efforts are undertaken toward technological innovation in products and processes.

It is incorrect to assume, however, that developing countries will never be able to acquire the capabilities of technological innovation because of their inflexible industry structure and mechanistic organizational structure. Linsu Kim, a leading scholar on the management studies of Korean technology, developed a model which allows for the possibility that developing countries might acquire the innovation capability in later stages of industrialization. He has proposed a three-stage model of technological change within an industry that can be generalized to include developing nations.The three stages of his model are 'implementation,' 'assimilation,' and 'improvement' (L. Kim, 1980, pp. 254-77). Firms in developing countries import advanced technologies and the most immediate task for them in the implementation of these transferred foreign technologies so as to produce products whose technology and market has been tested and proven elsewhere. Once the implementation task is secured, production and product design technologies are then quickly diffused within the country. Competition that stemmed from new entrants calls for indigenous technical efforts for the assimilation of foreign technologies in order to produce differentiated products at lower costs. The relatively successful assimilation of general production technology and increased emphasis upon export promotion, together with increased capability of local scientific and engineering personnel, will lead to a gradual improvement of technology through local efforts (Ibid.).

It is in marked contrast to the pattern indicative of developed countries, the pattern of the developement of organizational structure is reversed in the case of developing countries. The structure in the initial stage is rigid and inflexible in the protected environment, yet it can become more flexible in later stages as comestic competition and innovation capability increase.

While Kim's model does suggest a solid theoretical background with which to explain the development pattern of industrial technology in developing countries, it is only possible when political economy is able to adjust quickly to the new environment. If the political structure constrains structural transformation and blocks the flexibility of industry structure, firm organization and strategies remain the same. Even if it changes, the slow adaptation would not tolerate the characteristics of rapid change of high-tech industries.

The Japanese case illustrates the possibility for a late-industrializer to acquire innovation capacity. The typical pattern of Japanese success has been the rapid penetration of a narrow, selected segment of a expanding world market in which superiority in production efficiency, economies of scale, and exploitation of learning curve effects were particularly important. However, the Japanese have broadened out, moving gradually toward more sophisticated and higher value-added products in the same or in a closely allied market segment. Their success in technologically-dynamic product markets is not based on same strategies and organizational structure as those that had previously brought them success at different stages in their economic development. The structural capability of Japanese political economy enabled new firms to continuously enter the market. That way the innovation required to maintain success could take place (Friedman, 1988).

Korea no longer enjoys the industrial late-comers advantages of low wages and easy transfers of technology. Furthermore, high-tech industries,on which the future of Korea's economic development depends, differ from most traditional and mature industries and require rapid innovation capacity.Flexible industry structure and decentralized firm organization are required for indigenous technological innovation. In the absence of such structure and organization, competitiveness in high-tech industries is unlikely. If the Korean political economy structure resists change from the pressure of technological imperatives, the industry structure and firm organization will not change. Consequently, firms' strategies will remain unchanged. An inability to implement innovation results and thus the high-tech industry cannot be competitive.

## IV. The Case of Semiconductor Industry

This section shows how political economy of each nation can influence the industry structure and consequently the industrial competitiveness of firms in case of the semiconductor industry. After discussing why different structures of different countries influence the competitiveness in the cases of the U.S., Japan, and European countries, I will discuss implications that Korean political economy has in this industry. I suggest that even though the Korean semiconductor industry has made enormous progress in terms of volume over last 30 years, the industry structure and firm organization in Korea may hamper the further development of the industry. Although large Korean firms have contributed to the growth of the semiconductor industry, the inflexible structure of industry has not produced the environment in which firms can innovate.

### 1.Technology and Innovation

Since the inception of the industry in 1947 with the introduction of the transistor, the semiconductor industry has experienced a number of major and minor innovations. Semiconductor technological innovation can be categorized into three eras or technological regimes: the transistor, the integrated circuit, and the microprocessor (LSI and VLSI) regimes. The first era lasted from 1947 to 1961 when the first integrated circuits were commercially produced. The second regime lasted from 1961 until 1971 when Intel Corporation developed the microprocessor. The advance of the microprocessor inaugurated the third and present regime (Jorque, 1990; Malerba, 1985).

Thoughout the history of the semiconductor industry, the technological characteristics of *continuous change, uncertainty, and complexity* have a profound impact on the organization, structure, and behavior of firms (Malerba, 1985, p. 31). Change in the industry has always been the rule, not the exception. It has occurred through continuous product and process innovations and through the competitive dynamics of the firms in the industry. Uncertainty has been closely associated with the industry's continuous change. The rapid change of product and process makes the industry extremely uncertain. Complexity has increased in semiconductor technology since the mid-1960s. This increase has been the result of a technological trajectory toward miniaturization and integration.

American technological leadership of the industry in 1960s resulted in major new innovations which radically transformed the existing semiconductor industry. The integrated circuit first began to be produced on a large scale by American firms. In the 1970s, American firms introduced major innovations such as the microprocessor and the microcomputer. By the early 1970s, LSI devices had very sophisticated production processes and architecture, and had become electronics systems themselves. These innovations altered the boundaries between the semiconductor industry and the other electronic sectors, and increased the characteristics of change, uncertainty and complexity.

The incremental innovations and production engineering improvements are also an important to the semiconductor industry as major innovations. Technological advance in the semiconductor industry has in fact been continuous and incremental. The short life span of most semiconductor devices demonstrate a continuous change of products and processes. New types of products or processes are developed to replace former ones even before the previous type of semiconductor device has entered the phase of maturity and decline. In this way, the industry became enormously dynamic and uncertain (Dosi, 1984; Simon and Rehn, 1988).

## 2. Political Economy and Competitive Advantages

The chatacteristics of "change,uncertainty, and complexity" in semiconductor industry have had a great impact on structure of industry and firm strategies. The pace and direction of technological change has been considered as one of the most important factors in an explanation of the semiconductor industry's structure (Dosi, 1981, p.6) the continuous technological innovation has produced a stream of new products and has resulted in rapid substitution between old and new products and a continuous fall in prices. Consequently, new players have continually moved into the industry and new markets have been established.

However great the impact of the pace and direction of technological change on the industry structure might be, the ability of countries and companies to react to this pace and direction is also important (Rushing and Brown, 1986; Howell, et al., 1988). This ability is very much dependent upon political economy of each country. If the political economy does not provide proper conditions for the firms to adapt to the constantly changing environment, this failure to adapt will be a major cause of the decline of firms, which thus lose competitive advantage.

Due to the variations in political economy, the response of the industry to the technological innovations and strategies of firms vary among different countries. While the U.S. industry structure experienced significant changes in each technological regime change, European and Japanese industry structure did not change as much as the U.S. did. This divergence mainly comes from the differences in political structure among countries. The more liberal political structure found in the U.S. is reflected in its flexible industry structure while the more rigid relationship between the state and the business in Europe was the source of centralized and inflexible structure of its industry. At first glance, it might appear that Japan is similar to Europe in that its industry structure is inflexible. However, the unique Japanese state-business cooperation and long term strategies set it apart from comparisons with Europe. Its industry structure has allowed the development of competitive industry (Patrick, 1986; Okimoto, 1989; Okimoto, 1984; Borrus, 1983).

The American structure of the industry has been very flexible and was significantly transformed in each technological regime change. During the transistor and integrated circuit periods, while the structures of Japanese and European industries were composed of vertically integrated receiving tube producers with low mortality rates, those of the U.S. industry were composed of a combination of merchant producers and vertically integrated producers with high entry and high mortality rates. The large number of new entrants was a major factor in the fostering of innovation in the U.S. This gave American industry a lead over both the European and the Japanese industries.

During the 1960s, in the U.S., new merchant producers who had not been committed to the previous germanium-alloy-mesa-discret device technology entered the semiconductor industry and became the major producers of integrated circuits by the end of the 1960s (Malerba, 1985, p. 5). The new merchant producers were able to profit from the switch in technological regimes from discrete devices to integrated circuits. This case is contrasted with the cases of Europe and Japan, where only large, established, vertically integrated electron tube producers, that dominated the industry, got involved in the production of integrated circuits. As a result, they did not progress as much as the U.S. did.

This environment of new specialized firms involved in integrated circuit production led the U.S. to become the undisputed leader in the integrated circuit market at the innovative, productive, and commercial levels. American producers not only exported their production to Europe,but also made direct foreign investments in Europe. In the 1970s, this structural change of numerous new entries in the U.S. had intensified. The new innovations transformed industry in a radical fashion. Most of the entrants into this industry consisted either of new firms which focused their activities on specific market segments, or of existing users of semiconductors which had integrated their R&D and production upstream. Until the early 1980s, American firms continued to be the technological, productive, and commercial leaders in the semiconductor industry.

This emphasis on technological innovation is not to disregard the importance of demand and public policy conditions. During the transistor and early integrated circuit periods, demand and public policy factors in the U.S. differed from those in Europe and Japan. These factors greatly influenced the rate and direction of technological change in the American industry. A growing computer demand and a large share of public procurement increased the rate of innovation and the competitive advantage of the U.S. firms. The military.R&D and procurement 'pulled' integrated circuits, while the computer industry 'pulled' digital integrated circuits (Dosi, 1981, pp. 8-19). On the other hand, the demand structure in Europe and Japan was dominated by the consumer electronics industry rather than by the computer industry. Public policy factors in these countries did not play a major role in the development of government policies in support of the domestic semiconductor industry (Howell, et al., 1988).

Although the success of the U.S. semiconductor industry was attributed, in large part, to the consistent and immediate support from the government and to demand conditions, the industry structure was a more important cause of the industry's success. New American merchant producers were quick to adapt to, and innovate in, the new silicon-planar-integrated circuit technology. On the other hand, the existing vertically integrated receiving tube producers in Europe and Japan, changed their strategies slowly and were slow to adapt to the new technological regime (Borrus, 1988).

In case of Europe, a more strong state orientation and a more authoritarian tradition did not help the industry become competitive in the world market. Zysman has argued in case of France that the protective tradition of French political culture blocked the flexible firm organization required for the micro-electronics industry (Zysman, 1977). Throughout Europe, the new integrated circuit technological regime of the 1970s was met by the same industry structure that had characterized the previous transistor period. In this structure, firms were slow to change routines and shift to the new silicon-planar-integrated circuit technology.

During the LSI period of the 1970s, American firms dominated the world LSI device market and European producers were able to survive in the European semiconductor market by producing discrete devices and linear integrated circuits and by specializing in custom and specialty products. Japanese firms, on the other hand, had begun to accumulate both technological capability and productive experience in MOS LSI integrated circuits as a result of demand and public policy factors. The demand for calculators was big, and computer demand was also rapidly increasing. The Japanese government targeted semiconductors as a strategic industry and favored R&D co-operation among domestic firms (Howell, et al., 1988, pp. 35-105).

However, the public policy factor itself can hardly be seen as an independent variable. During the second half of the 1970s and early 1980s, European governments launched several programs in support of the domestic semiconductor industries, but few of them were successful (Malerba, 1985, p. 226). However, with similar types of government supports such as R&D funds and investment subsidies, Japan was more successful than European countries at supporting its domestic industry (Okimoto, 1989, pp. 55-111).

The Japanese case is unique. Although existing vertically integrated firms have continued to dominate the industry since its inception, unlike European case, the Japanese strategies have been dynamic and innovative. The system of cooperation between private firms and the government has led the firms to continue to seek long-term objectives rather than immediate results. With regard to the difference between the European and Japanese cases, Dosi has written,

> [The difference between Europe and Japan] exists in the philosophy of planning. While European planning seems generally to adapt to the existing structure and strategies of the industry, the impression is that in Japan, given certain long-term objectives, part of industrial policy is the task of removing the structural constraints which would make those objectives unprofitable for private companies.... These policies allowed a definition of company strategy consistent with the national objectives (Dosi, 1981, p. 42).

He argues that the successful Japanese performance in this industry has relied upon a set of structural and institutional factors. These, he notes, are derived from not only government policies but also Japanese political economy (Ibid., p. 42)

As the case of Japan demonstrates, large firms are not necessarily less innovative. As Schumpeter has emphasized, large existing corporations may remain a important source of innovation (Schumpeter, 1976, p. 96). These large corporations have extensive R&D laboratories, and have learned how to deal with change and with new technologies. While new firms are associated with radical innovations, existing large firms are associated with incremental innovations in established technologies. Generally, in recent times, the international trend is that large established and successful firms in high-tech industries have routinized the scanning and search for radically new technological alternatives. They have become more prompt to adapt and to commit themselves to new technologies that threaten their supremacy in existing technologies. This trend results from the realization by most firms that in these industries, change is not the exception, but the rule of life (Malerba, 1985, p. 43).

While the Schumpeterian remark still applies to the high-tech industry, innovation in the R&D laboratories of large firms is not possible until the existing firms prove that they can adapt and survive successfully in the continually changing technological conditions. The danger faced by large firms is that they are always prone to adhering to old technologies and incremental technological change, thus disregarding new radical alternatives and resisting major technological changes. The majority of European firms demonstrated this tendency (Zysman,1977).The argument here is that regardless of the size and age of firms, a flexible structure of industry is critical for successful innovations and crucial for the firm's adaptation to the rapidly changing technological environment. The successes of U.S. and Japanese firms attest to this.

### 3. Korea: Concentration and Technological Dependence

The Korean semiconductor industry, as in many other Korean industries, lacks structural flexibility. The industry has been dominated by a few giant conglomerates. Korean political economy has produced industrial concentration which affects the strategies of all large firms. Many small and medium firms which once were involved had withdrawn from the industry or incorporated into *Chaebols* (Soh, 1991). Unlike Japan, Korean political economy did not allow the large firms to cooperate and pursue long-term technology policies. They tend to pursue only low price-oriented strategies in order to realize mass production efficiencies. These price-oriented strategies did not help the industry innovate. Innovation, as has been discussed earlier, is an absolute requirement for further development of this industry. Thus, it appears that the structure of Korean political economy to date has not been compatible with the flexible industry structure upon which the future of the semiconductor industry depends.

A Far Eastern Economic Review article argues that the semiconductor industry is a victim of Korean predilection for big companies,

> Memory chips play on South Korean industry's penchant for *gigantism*....South Korean companies have thrived on *bigness*. That puts them in sharp contrast to rivals in neighboring Taiwan, which until recently have steered clear of volume products such as memory chips in favor of niche markets (FEER, Aug. 24, 1989, pp. 50-51).

As a result of government needs and business needs, the electronics industries including semiconductor were dominated by *chaebols*. There is widespread disagreement about whether this system is appropriate for overall industrial competitiveness. Mody argues in his comparison between Korea and Taiwan that Korean large firms are more appropriate because they can sustain competition against large foreign firms, although the smaller Taiwanese electronics firms historically have been quicker to respond to new opportunities (Mody, 1989). However, Korean *chaebol* structure have potential weaknesses. The high levels of unrelated diversification associated with the *chaebol* structure proved to be detrimental to the performance of the American conglomerates of the late 1960s and 1970s. The *chaebols'* product lines are not based on any common technology, production capability, or marketing assets, beyond global name recognition in a few consumer product lines (Mowery and Steinmueller, 1991, p. 47).

To be successful in high-tech industry requires innovation capability rather than just the adoption and diffusion of foreign technology (Byun and Ahn, 1990, pp. 637-640). The Korean firms, given the industrial concentration, have not revealed innovation capability. The firms have increased their technological dependence and vulnerability. This has resulted in a concentration of their production on small, non-related areas of standard memory chips, which are mostly mass-producible (MTI, 1990, pp. 1-19).

Although strategies differ among Korean firms, their patterns of investment and production, and technological level indicate that regardless of the degree of strategy difference among them, they all geared toward price strategies, utilizing economies of scale and borrowed technologies. For example, Korean semiconductor firms invested high percentage (70.2 percent in 1985) of their total investment on facility equipment directed toward memory chip making (KDI 1985, p. 44). All firms have been pursuing the high-volume VLSI memory market. Korean firms adopt short-term price strategies rather than a long-term technological strategies, or the market niche approach. The export-oriented mass-production policies has resulted in technological dependence and has placed Korean firms in very vulnerable position. They have relied either on licensing or outright purchase of foreign chip designs. These productions in most cases are not related to domestic needs.

The Korean technological level assessed by the Korean Industrial Bank proves that the firms' strategies have been in high-volume production of mass-producible memory chips. As shown in the following Table 2, the Korean technological level is high only in assembling and in some memory chips such as DRAM, SRAM, and ROM. The same is true for the other types of ICs (KIB, 1990). In spite of their technological disadvantages, Korea became the world's third largest chip producer. However, without

<**Table 2**> Technology Level of Korean Semiconductor Production (1990)

| | Unit | Technology level | | | | | Korea | Best |
|---|---|---|---|---|---|---|---|---|
| | | A* | A | B | C | D | | |
| Design | % | | Over 95 | 70 | 40 | | C | US, |
| Fabrication | µm | 0.3 | 0.7 | 1.2 | 2 | 3 | B | Japan |
| Assembling | % | | Over 95 | 90 | 85 | | A | Japan Korea |
| DRAM | Bit | 16M | 4M | 1M | 256K | 64K | A,B | Japan |
| SRAM | Bit | 4M | 1M | 256K | 64K | 16K | A | Japan |
| ROM | Bit | 16M | 4M | 1M | 256K | 64K | A,B | Japan |
| Gate Array | GateNo. | | 20K | 10K | 8K | | C | US,Japan |
| Standard Cell | Cell | | 10K | 500 | 100 | | C | US, Japan |
| $\mu$-Processor | Bit | 64 | 32 | 16 | 8 | | C | US |
| Hybrid IC | µm | | 50 | 100 | 150 | | C | Japan |
| Linear IC | % | | 100 | 60 | 20 | | C | Japan |

Source: Korea Industrial Bank (1990)

indigenous R&D capability, Korean firms, it would appear, will remain as manufacturers in the stages of assembling and fabrication at best, and will not have full capability of design.

One of the important strategies which can enable developing countries to compensate for their technological disadvantages in the semiconductor industry is to develop market miche strategies in order to acquire design capabilities. This strategy focuses on market niches rather than on high volume markets for standardized products. Market niche requires considerable sophistication in terms of indigenous design capabilities as niche-oriented firms must be able to customize their equipment to satisfy specialized user needs, a design-intensive process. Therefor, this strategy also requires a flexible industry structure. In other words, a highly concentrated market structure constrains the firms into pursuing this strategy. It has been noted that Korean firms lack this strategy, although this has been said to be the most appropriate for developing countries to acquire indigenous innovation capacity in the long run (World Bank, 1987, p. 200).

Moreover, the increasing demand of custom and semi-custom ICs in the recent world market requires quick response and a flexible manufacturing system. As electronics products become more complex and the life-cycle of products decrease, the importance of ASICs increase. In near future, these devices will be applied to all industries. Without the possession of ASIC technologies, the industries cannot be competitive. Hobday pointed out that "more and more of a given system's functionality and performance is located on the application-specific component" (Hobday, 1989, P. 18).

Considering these trends in the world market, the Korean firms' concentration on a few memory chips may cause serious problems for its industrial competitiveness in the future. Indicative of the lack of design capability among Korean semiconductor firms is their passive manufacturing activities of custom integrated circuits. Table 3

<**Table 3**> Production Patterm Korean Semiconductor Firms (1986-1989)

| | 1980 | 1987 | 1988 | 1989 | Annual Average Increase Rate |
|---|---|---|---|---|---|
| Total Semiconductor Production (A) | 1,470 | 2,300 | 3,580 | 4,500 | 45.2% |
| Standard ICs (B) | 303 | 475 | 1,389 | 1,823 | 81.9% |
| Custom ICs (C) | 10.8 | 13.2 | 18.4 | 23 | 208% |
| A/B(%) | 20.6 | 20.7 | 38.8 | 40.5 | — |
| C/B(%) | 3.6 | 2.8 | 1.3 | 1.3 | — |

Source: Ministry of Trade and Industry in Korea(1990)

〈**Table 4**〉 Ratio of Export/Production and Import/Production in Korean Semiconductor Industry (1981-1986)

| | | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 |
|---|---|---|---|---|---|---|---|
| ICs | Es./Prod. | 100 | 100 | 99.5 | 96.0 | 93.8 | 94.8 |
| | Im./Prod. | 100 | 100 | 98.2 | 85.7 | 81.8 | 89.5 |
| Discretes | Ex./Prod. | 87.0 | 79.7 | 81.5 | 84.0 | 83.6 | 82.6 |
| | Im./Prod. | 73.4 | 58.4 | 48.1 | 69.7 | 69.6 | 75.8 |
| Total | Ex./Prod. | 96.0 | 96.3 | 95.5 | 93.6 | 91.9 | 92.3 |
| | Im./Prod. | 88.8 | 84.7 | 86.1 | 80.6 | 78.6 | 85.8 |

Note: Ex.: Export, Im.: Import, Prod.: Production.
Source: Park (1987), 241.

shows the increasing trend toward production of standardized ICs and the decreasing trend in production of custom ICs between 1986 and 1989. The annual average increase rate of standardized ICs was 81.9 percent while that of custom ICs was just 20.8 percent. In 1989, the production of standard ICs accounted for 40.5 percent of the total semiconductor production. In contrast, custom ICs accounted for only 1.3 percent of production in 1989. This is a decrease from 3.6 percent in 1986.

Korean firms' high-volume production and export-oriented strategies have also made the industry extremely vulnerable. Production has rarely been related to domestic demand. Most semiconductors produced have been exported, and most semiconductors consumed have been imported. In the absence of a strong 'demand pull' effect the firms have been export-oriented. This makes the Korean firms vulnerable. A comparison of Export/production ratio between Japan and Korea indicates the extent of vulnerability faced by Korean industry. In 1985, whereas the export/production ratio was 20.2 percent in Japan, it was 91.9 percent in Korea (Japanese Electronics Industry Annual, 1986). Table 4 shows the high rate of both export/production and import/production in Korea.

There are some positive indications for the future of the industry, particularly in the area of research and development. The increasing emphasis on R&D placed by the government and business in the 1980s may provide a favorable environment for the industry in the future. For example, the government emphasized the development of the labor force in order to support the growth of existing industries and infant high-tech industries throughout 1980s. As a result, the number of graduates in electronic engineering increased from 2,000 in 1981 to 6,300 in 1986, providing the semiconductor industry with a growing domestic pool of highly-qualified human resources (Krieder, 1986). The R&D expenditure has also increased significantly. It was about 1 percent of GNP in 1983, and reached about below 2 percent in 1989 (Park, 1991, p. 8).

However, innovative capacity depends upon how firms are organized and behave (Utterback, 1979; Roman and Puett, 1983). Without appropriate firm organization and strategies, the increased human resources and R&D expenditure will not be able to be adequately utilized. Recall that firm organization and strategies are a function of industry structure which is shaped and constrained by the political economy. The structure of Korean political economy has produced the industrial concentration which caused firms to pursue the short-term price strategies rather than long-term technological orientation. Even though there are positive advantages which large firms can exploit, as Mody pointed out, without more flexible industry structure and long-term and technology-oriented firm strategies, indigenous innovative capability can hardly be expected (Mody, 1989). In Korea, despite the enormous growth of the semiconductor industry, production remains concentrated on a few memory chips. As a result, technological dependency and its resulting vulnerability has increased.

## V. Conclusion

Up until now, Korea has lacked indigenous innovative capabilities, and most technologies employed have been borrowed from other countries. Korea has been successful in many mature industries which were developed in advanced countries. Industrial concentration and large firms organization have been favorable conditions for late-industrialization. High-tech industries, a focus since the 1980s, have also been developed in the same environment of industry structure and firm organization. Despite the enormous growth in terms of production, as seen in case of the semiconductor industry, the outlook for the future is not so promising. In order to develop competitive technology-intensive industries, the structure and organization need to be adjusted to meet the requirements of innovations.

Korean industrialization has been based on imitation rather than on innovation. It has been based on investments that employ foreign designs, borrowed technologies and economies of scale. This pattern calls to remind Amsden's "learning" thesis; that "learning" is a new mode of industrialization for the late industrializing countries (Amsden, 1989). She attributed the growth of Korean economy to the competence of Korean firms at mastering foreign technology through technical assistance and/or imitation of the production process of foreign firms.

Korea has, indeed, proved an excellent student. However, the overriding question is if Korea can now move from learner to innovator. The Korean political economy was perfectly fitted to the learner's requirements and to the learner mentality. But, a different set of conditions are necessary for innovation. The institutional arrangements that brought to Korea rapid late industrialization based on borrowed technologies now began to press against the limits of technological knowledge. Unsuited to innovation, these institutional arrangements are likely to circumscribe further development.

Korea's technology problem is a product of the structural vulnerability which has been induced by political economy. As long as the structure stays as it has been, the technology problem is likely to continue. Government's efforts of increasing R&D funds alone will not be the answer for the problem. The conscious efforts from both the government and business are required for the structural adjustment. The slow adaptation would not be tolerated because the speed of change in markets and technology creates an enormously high level of adjustment costs.

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