# The Significance of Technology Policy for a Late-Industrializing Country to Sustain Its Industrial Development: Case Study of Korea's Electronics Industry

by

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ABSTRACT

Every country started industrialization under different technological circumstances. Historical account about the industrialization process of Britain, Germany, the United States, and Japan suggests that exploring technology frontier by establishing a differentiated institutional structure adequate for changing situation was a way for a late industrializing country to be a new leader of the world economy.

Korea, one of the representative countries that rapidly industrialized as late as after World War II, also suggests a new industrialization model for a late industrializing country. Strong government involvement, strict control of financial institutions, and the promotion of conglomerates typified the Korea's institutional structure. By aggressively pushing exports and strategically promoting specific industries (Heavy and Chemical industries) together with borrowing, assimilating, and modifying foreign technologies, Korea has rapidly developed its economy until the late 1970s. During the 1980s, due to the strong policy demand for the liberalization, deregulation, and internationalization of the economy, the Korean government abandoned sectoral industry policy treating specific industries and firms preferentially. Facing the changing environments, the government focused on industry-neutral, functional industry policy. In this regard, technology policy as a complementary measure for market failure became a new policy paradigm to sustain Korea's industrial development. However, under the persistent culture of industry-specific policy of the 1970s, the technology policy has more focused on the development of targeted commercial technologies with the participation of conglomerates. The development of technological infrastructure such as the promotion of higher educational institutes for training capable engineers and scientists, provision of technical and marketing information, and enhancement of small and medium size firms' technical capabilities to vitalize the Korean economy have been delayed. In addition, too many conflicts among technology-policy related ministries and the weaknesses of the central agency in coordinating relevant ministries have retarded the orchestration of nationwide consensus and policy goals. This, in turn, suggests the future policy directions to the Korean government.

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## Introduction

Technological advance is the primary means to sustain industrial competitiveness and economic growth of a nation. Industrialization is, in fact, a process of acquiring technological capability in the course of continuous technological change. This draw on both opportunities and challenges for a late industrializing country. On the one hand, a late industrializing country can exploit the latecomer's advantages. On the other, under substantial difficulties, it should chase the rapidly moving and continuously emerging new technological targets to catch-up with advanced countries. To enhance the international competency of the national economy, under different circumstances, every country has created its own peculiar industrial structure and institutional organizations during industrialization procedures. And the scope, shape, and depth of government intervention has differed from country to country, and from time to time.

Korea, as a late industrializing country, began industrialization after World War II, under extremely poor circumstances. Since Korea initially had almost no indigenous technical and financial capabilities, poor natural resource endowments, and poor establishment of institutional organizations, the government, with ability and willingness, held responsibility for initiating industrialization of the nation. At the early stage of industrialization until the late 1970s, the government strongly influenced the trajectory of industrial development while it also formulated peculiar institutional organizations and their relationships. Since the early 1980s, as the Korean economy evolves, it has experienced structural changes. Accordingly, the government's role has changed. Under the demand of liberalization, deregulation, and internationalization of the economy, in general, the government's role has been shrunk. However, the government still held, and has tried to strengthen policy measures to facilitate technical progress. The main objectives of this paper is to address the importance and adequacy of technology policy for Korea to sustain its industrial development.

First, this paper reviews the theoretical analysis on the linkage between industrial development and government technology policy. The causality between technological progress and economic development, rationale for government intervention in technological development, and government failure in technology policy are reviewed. Second, this paper addresses advanced countries' industrialization procedures, their institutional organizations, and government's role in improving indigenous technical capabilities. The analysis covers the cases of Britain, Germany, the United States, France, and Japan.

Third, the Korea's experience in industrialization is addressed. The inevitability of government intervention, the adequacy of industrial policy and subsequent institutional structure, and the evolution of technology policy are presented. Then, the adequacy of technology policy is evaluated. Finally, this paper suggests policy recommendations for the Korean government.

# Chapter 1

# Technology Policy

# and Economic Growth

## 1.1 Technological Progress and Economic Growth

Productivity growth is indispensable to growth in national income and wealth. Research carried out over the last 30 years demonstrates that technological change is an important contributor to productivity growth, and therefore to growth in the income and wealth of nations. Even though the fact that technological change has been the critical variable in accounting for the spectacular long-term growth of the western countries' economy since the First Industrialization is one of the things that all knowledgeable people supposedly know, it is still a difficult task to link the growing productivity to better-known facts and landmarks of the technological history quantitatively.

This is so because to separate out the contribution of technological change from other changes in human behavior, motivation, and social organization is an extremely complicated methodological matter. The other reason to make the task a difficult exercise is that technological improvement not only enters the structure of economy through the main entrance, as when it takes the highly visible form of major patentable technological breakthroughs, but that it also employs numerous and less visible side and rear entrance where its arrival is unannounced, unobserved, and uncelebrated. There have been persistent failures to observe the rush of activity through these other entrances and this in turn accounts for much of the difficulty in achieving a closer linkage between technological history and the productivity growth.

Rosenberg explored these neglected factors under three main issues: complementarities; the cumulative impact of small improvements; interindustry relationship.[1] Rosenberg pointed out that inventions hardly function in isolation. The productivity growth from a technical breakthrough had to await the complementary achievements in other fields. These complementary relationships and the hardly observable ways in which technologies depend on one another and interact with one another make it difficult to predict the flow of benefits from any single invention and lead to a postponement in the flow of such expected benefits.

Rosenberg also argued that slow and often almost invisible accretion of individually small improvements in innovations, rather than any spectacular technical breakthroughs, constitutes the substance of much productivity improvement and increased consumer well-being in industrial economies. There are a variety of literature to view technological change as consisting of steady cumulating of innumerable improvements and modifications, with only infrequent major innovations. An outsider has difficulty in attempting to appreciate the significance of these small and innumerable technical improvements within highly complex and elaborately differentiated technologies.

Many of benefits of increased productivity flowing from an innovation are captured in industries other than the one in which the innovation was made. This special external

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[1] See Rosenberg (1982), pp. 55-80.

economy and the inability to take these interindustry relationships fully into account is a fundamental limitation of most of the recent literature on technological innovation.

In summary, the quantitative analysis to link technological change to productivity growth in such a high level as national economy requests the formulation of an extremely elaborate methodology as a prerequisite, which may be far beyond the existing theoretical framework. However, many literature based on empirical studies on specific industries as well as Rosenberg have verified the fact that overall productivity growth would not have been possible without the establishment of technical infrastructure providing technical capability to invent complementary inventions and to persist small, invisible improvements in a national level.

## 1.2 Technological Progress and Government

Economists have identified a number of reasons in favor of government inference in scientific effort, technological development and use of technology. Markets fail to work as sufficiently adequate mechanism for allocating resources to scientific and technological effort because decisions made by firms and individuals are based on their private profits and gains and these frequently differ from social gains.

A company or an individual may not be able to appropriate an adequate share of the total gains to society from a discovery to compensate him for the cost of making that discovery even though the total gains to society significantly exceed the cost of making the discovery. The incompleteness of the patent system to appropriate proprietary technical assets of a company leads to under investments in scientific and technological research and development. Government's interference is justified to provide socially optimal investment level in this regard.

The claim that risks and uncertainties associated with scientific and technological efforts are not adequately taken into account by private groups provides another ground for government intervention. The government involvement can counterattack risk-aversion by private groups where this is appropriate and ensure that proper account is taken of collective risks to society.

In addition, the imperfections in capital markets in the provision of funds for scientific effort and technological change, social failures in the transmission of scientific and technological information, avoidance of wasteful duplication of scientific services, considerations of national security, and external industry-wide economies of a specific technological development coupled with the failure of market to coordinate and direct some large-scale desirable initiatives have supported the government's role of correcting a global problem of inadequate private R&D. However, all these justifications of government intervention as a complementary activity for market failure in scientific and technological efforts entail a significant drawback of, consequently, implying that they only focus on R&D spending level as a control variable through which governments would affect macroeconomic productivity. The justifications need to be evaluated both theoretically and empirically.

At the theoretical level, many economists have begun to believe that the relationship between competition and innovative behavior is more than a matter of some tendency to under investment or over investment in R&D. The implications for total R&D spending of imperfect appropriability are now understood to be less clear-cut than they once seemed. In a world of patents and industrial secrecy, firms in some instances have an incentive to engage in duplicative R&D in an effort to copy a rival's technology or invent around its patents. This calls into question the idea that firms necessarily engage into too little R&D. With regard to the uncertainty issue, economists have recognized that, rather than focusing on the amount of R&D that uncertainty is likely draw forth, what uncertainty really demands is the exploration of a diverse set of approaches. Economists begins to focus their attention not on the level of R&D but on the types of R&D and the portfolio of R&D projects an industry tends to generate.[2]

Empirically, the OECD studies of the differences in productivity growth among countries suggests that, in the 1950s and 1960s, the countries with the highest ratio of R&D spending to gross national product, the United States and Britain, had among the lowest rates of productivity growth (OECD).[3] Furthermore, even during the 1970s when developed countries experienced the ubiquitous slowdown in productivity growth, spending for R&D continued to be high in most developed countries.

Both these theoretical and empirical studies suggests that analyzing the adequacy of government involvement in scientific and technological efforts needs to focus on the types, mechanism, and strategies of government R&D projects as much as R&D spending level.

### 1.3 Government Failure

While there may be a need for government support for science and technology, it does not follow that government intervention will necessarily benefit the community. Just as markets are subjected to failure so is government due to imperfections in political and administrative mechanisms of decision-making. The complementation of problems of

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[2] See Nelson (1983), pp. 814-818

[3] See OECD (1980)

invisible hand by visible government interaction can lead to a crucial failure due to more invisible political mechanism.

Government policy can be distorted far away from optimal social interest by several reasons. Government departments are in a symbiotic relationship with client groups. Large and politically more active clients can influence the government policy in favor of their own interests. In the democratic political system, politicians in order to obtain votes can concentrate government support on areas where efforts more easily comes to the eye of voters. The supposed tendency of individual government department to try to maximize their budgets or command over resources can also lead to government failure. Even if government departments and politicians altruistically support the social interest in implementing science and technology policy, the difficulty of defining the social interest and a common goal still exists, and coordination and information barriers between and within departments as well as the finite capacity of individuals may prevent social interest and a common goal from being efficiently pursued. Finally, bureaucrats are often even more imperfect than company managers in the prediction of future events.

Facing with a choice between imperfect markets and imperfect political mechanisms, to make the latter superior to the former, a society needs to recognize the inherent limitations of political and administrative mechanisms and then, to improve them based on its scientific and technological capability and cultural environment.

# Chapter 2

## Advanced Countries' Industrialization, Institutional Development, and the National Innovation System

Innovation is the use of human, technical, and financial resources to find a way doing things. It requires experimentation with alternative approaches, many of which may prove unsuccessful. Even fewer will survive the test of diffusion, where ultimate economic returns are determined. Superiority at each of these levels—generating the resources required for innovation, allowing the freedom to experiment with alternative approaches, and providing the incentives to do so—provides a more advantageous environment for technical innovation and economic growth to a country.[4]

The countries belong to advanced economies such as Britain, Germany, France, the United States, and even Japan, became industrialized based on the development of peculiar institutional structure different from one another. The time when a country began industrialization strongly influenced the shape of the country's institutional structure while the peculiar institutional structure in turn influenced the trajectory of the country's industrialization process. The interaction between the two has shaped country-specific environments where technical innovations were stemmed from.

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[4] See Rosenberg (1986).

The technical innovation system has interacted with government at a nationwide level. The first relates to the harnessing of technological power for public purposes. Nations have long been major consumers of new products, particularly for military use, and the need to compete against other nations provided an important early rationale for strengthening national technological capabilities. The second arises from the system's dependence on its social context. The development and diffusion of advanced technologies requires a system of education and training as a basis for supplying technology and skills and a legal framework for defining and enforcing property rights. These are in part public goods. The benefits of investments in education are appropriated by a multitude of economic actors, and those of property rights are even more widely spread. The way these public goods are provided by the government, and the role industry plays in this respect, differs greatly from country to country due to the influence of different institutional structure. This chapter addresses the major countries' industrialization process, the characteristics of institutional structure, and the national innovation systems.[5]

## 2.1 Britain

The decline of the British economy and the hardships and unsatisfactory results in revitalizing the economy is one of the great puzzles in contemporary economics studies. Institutional economists claim that the very institutional structure that sustained industrial

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[5] The national innovation system can be defined as the array of public and private institutions and organizations within an economy that fund and perform research and development, translate the results of R&D into commercial innovations, and affect the diffusion of new technologies. Quoted from *National Innovation Systems: A Comparative Study*, R.R. Nelson, ed., 1993, New York: Oxford University Press.

development in the late eighteenth century proved inappropriate to the new industries (electricity, chemicals, and automobiles) that emerged in the 1880s and 1890s, and which underpinned economic advance in much of the twentieth century. Britain's industrialization was started around textiles where start-up costs were relatively low, and this in turn resulted in the industrial structure of many, small competing firms. Since it was easy to finance investment from retained earnings or solicitation of funds from family and friends, joint-stock forms of corporate organization and stock markets were developed while banks remained small and regional, with lending of small amounts at a time primarily on a short-term basis. The banks maintained arms-length relationship with industry, no equity share of banks in firms and no active role in firms' management, quite contrary to the bank system of Germany and France. Britain's banks were not nationally integrated enough to serve as major sources for finance for industrial conglomerates of the sort that began to dominate international commerce in the late nineteenth century.

In the late nineteenth century, when new industries like electrical engineering emerged, the long-standing dependence of industry on steam power initially limited demand for the electrical products. Furthermore, the demand from colonies drew investment to the older engineering sectors like locomotives, boilers, and heavy machine tools, and away from more modern sectors. And British firms in these new sectors could not penetrate the rapidly growing foreign markets in Germany and the United States due to the government's protection of the markets by tariff barriers. All these resulted in over investment in industries with slower technological change, and under investment in industries with faster technological change and this in turn, gave rise to the slower productivity growth of British economy in the early twentieth century.

Since Britain industrialized when the influence of craft traditions was strong, the productive process in many industries was organized around skilled workers who often controlled the pace of production, the work of other laborers, and the their own wage rates. The pivotal position of skilled workers resulted in the strong and fragmented trade union movements in Britain. Consequently managers often encountered strong shop floor resistance to the introduction of new technology that might be more productive but entail dome deterioration of wages and working conditions.

Because of the particular structure of British markets, the invisible market mechanism failed to transform the efforts of individuals to maximize their own welfare into long term benefits of all. Instead, market incentives led managers and workers to make decisions that brought slow rates of growth and a deepening circle of economic decline.[6]

Britain's innovation system has several peculiar characteristics. First, with regard to its education system, since British industrialization did not rely on mass education or formal training of managerial or engineering personnel, until the late nineteenth century, an education system did not exist in Britain. In contrast to Germany, the United States, and even Japan where the organized education system was the springboard for industrial advance, in Britain education was disorganized and lacked the strong association with the aims of economic development. The elitist education system closely connected to the Universities of Oxford and Cambridge, still provide country's political, economic, and scientific elite. But the quantity and quality of education for engineers and the social standing of engineering profession have been comparatively lower than other European

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[6] See Hall (1986), pp.25-47.

countries. The poverty of engineering education has constituted an important source of the weakness in Britain's industries.

Second, recently over the past 30 years, in the procedure of government efforts to remedy the structural problems of the British economy, the government has shown unprecedented instability in its industrial policy. Policies have peddled between excessive intervention and managerialism of the 1960s and the excessive disengagement of the 1980s. Actions in one period have tended to be reactions to the perceived failure of preceding period. This is one of the vicious cycles that have made it so difficult to reverse economic decline since the early twentieth century. Decline has engendered policy instability which has reduced state's ability to orchestrate a sustained revival.

Third, the mission-oriented R&D system of British government has not produced satisfactory results.[7] The British system of public administration with its emphasis on anonymity, committee decision making, and administrative secrecy, ensures that individual public servants have little interest in orchestrating the system. The emphasis on internal and procedural accountability also makes government reluctant to devolve major projects

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[7] Mission-oriented research can be regarded as big science deployed to meet big problems. It is of primary relevance to countries engaged in the search for international strategic leadership, and the countries in which it dominates are those where defense accounts for a high share of government expenditure on R&D (In 1994 defense R&D accounted for 51 per cent of total government R&D budget in the United States, 36 per cent in France, and 47 per cent in Britain) Though is has also been used to meet perceived technological needs in civilian markets, the link to national sovereignty provides its major rationale

The dominant feature of mission-oriented R&D is concentration. The decision making process is highly centralized. The goals of mission-oriented R&D are centrally decided and clearly set out, in terms of complex systems meeting the needs of a particular government agency. Specifying these needs and supervising project implementation concentrate a considerable amount of discretionary power in the hands of major funding agencies. In addition, by its nature, mission-oriented research is concentrated on a small number of technologies of particular government strategic importance. As a result, government R&D funding is heavily biased toward a few industries that are generally considered to be in the early stages of technology life cycle. The scale of mission-oriented efforts limits the number of projects and participants. At any particular time, only a small share of each country's firms, likely among the larger ones, will have the technical and managerial resources required to participate in these programs. (See Ergas (1987)).

to reasonably autonomous entities, so that responsibilities are tangled, decision making is cumbersome, and the organizational and cultural context is inappropriate for developing new technologies.[8]

In response, recently the government tried to innovate the country's innovation system itself. For the first time in 30 years, responsibility for coordinating all issues related to science and technology has been given to a full Cabinet Minister. A new Office of Science and Technology (OST) has also been set up within the Cabinet Office. It brought together in one organization the former S&T Secretariat of the Cabinet Office and the science branch of the former Department for Education and Science. To develop a closer partnership between industry, academia, and government which would strengthen the contribution of science and technology to the creation of wealth and to improving the quality of life, the government created a new Council for Science and Technology (CST) which replaced the Advisory Council on Science and Technology (ACOST) and ensured that the government benefits from outside independent and expert advice when deciding its policies and spending priorities for science and technology. Council members are senior people from industry, academia, and research charities and recognize well the importance of research undertaken to meet the needs of users and to support wealth creation. Then, in 1991, the government removed the two-tier system of higher education. It enabled polytechnics to achieve university status and placed higher education institutions on an equal footing for funding. This policy measure may contribute to the enhancement in the quality and quantity of British engineers. In addition, by launching special R&D programs like the LINK initiative (1988) and the Advanced Technology Programs (1992),

[8] See Ergas (1987).

the government has tried to support the collaborative research projects among companies and science based institutions and to encourage pre-competitive research in new technical fields.

### 2.2 Germany

In the literature, the Germany's industrialization is often described as an instance of the advantages of backwardness, implying that a follower country adopting new technology from abroad can move faster than a leader country, since the latter faces some retardation as a result of old vintages of capital stock and the organizational resistance associated with old technologies.[9] Germany certainly could not have industrialized as quickly as it did without the transfer of technology from countries such as Britain. But the historical account suggests that Germany could take the lead in some industries not because of the advantages of backwardness, but only because it established new institutional forms that enabled German firms to move quickly as new product areas or new processes which were opened up by inventions and by advances in its own engineering and scientific knowledge. The peculiar German institutional systems, rather than the British legend of invisible market mechanisms wisely guiding the destiny of a lot of little firms who struggle blindly with one another in the market, made it possible for Germany to achieve the great success in the second half of the nineteenth century. The German carried out industrialization, as a late industrializing country, through the establishment of articulated institutional system that covered higher educational institutions, banks, industrial associations, trade unions, and the organized government policies that deliberately rejected the excessive exercise of

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[9] See Ames (1973).

power in business enterprise. In the followings, the peculiarity of Germany's national innovation system will be described by addressing institution by institution.

First, during the eighteenth and early nineteenth centuries, Germany developed the sophisticated higher educational system for science and engineering. The dual educational system of university and the Technische Hochschulen (vocational schools) with the emphasis more on high standard of research than on just teaching, had educated and provided scientists and technicians who constituted a ground for Germany's industrial take-off based on its own technical capability.

As a late industrializing country than Britain, in the early nineteenth century Germany certainly turned to foreign countries, mainly to Britain, for new machinery and skilled workers to bring advanced technology to its industries. British artisans were instrumental in transferring technical know-how to Germany in machine-building and iron and steel industries. However, to protect the technical lead of its industry, Britain prohibited by law the emigration of skilled workers until 1824 and, for many of its advanced industries, up to 1843 the export of machinery, including models and drawings, as well as tools and utensils. In this situation, the mainly government-financed system for education had a key role in the country's development. Since the early nineteenth century the German education system had raised significant number of technicians and engineers[10]: from 1820 to 1850 Prussia trained, relative to the size of population, more technicians than France; around the year 1880 in mathematics and natural sciences Germany educated about two times more university students than did Italy and eight times more than France; during the first decade of the twentieth century about 30,000 engineers were graduated in Germany

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[10] See Keck (1993).

compared to 21,000 in the United States; in 1913 there were about 10 times more engineering students in Germany than in Britain. The German education system served as stimulus for reform or for emulation in other countries like Britain, France, and the United States. In addition, central government and federal states financed at the beginning of the twentieth century some 40 to 50 research institutes for specialized research in applied areas such as weather and atmosphere, geography and geology, health, shipbuilding, hydroengineering, biology, agriculture, fishery, and forestry. In the five decades between 1860 to 1913 the government funds for higher education and scientific research increased in real terms by a factor of about nine, from 11 million mark to 102 million mark.

Second, unlike the arms-length relationship between banks and industrial business firms in Britain, the German banks have held intimate relationship with the industrial firms. By participating as a board member in the Aufsichtsrat, the Supervisory Board of a company, the German banks have influenced, supported, and supervised the management of business firms.[11] Indeed, the banks have played a major tutelary role in the German industrial system. The banks were generous in their grants of long-term credits to business firms, and supported to the limit of their strength in the issue of shares and bonds, which were crucial for the German industrial firms to accomplish industrialization around capital intensive industries like electrical products, chemicals, and machinery. The banks felt that they had a permanent stake in the businesses which they had nursed to maturity. Furthermore, the banks led in the promotion of industrial combination and rationalization

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[11] Since the early years of German industrial development, a tradition that a businessman expects his banker to have an intimate knowledge of all phases of his business has been developed. That was also the least that the banker expected, if he was to lend on the sometimes hazardous scale that German industry demanded for its rapidly expanding operations. Unlike the British banks, for example, the German banks were equipped from early in their history with technical departments whose job it was to make a judgment on clients' requests for loans on the basis of their scientific and industrial merits.

in key sectors such as mining, machinery, steel, and electrical products. The objects of sector reorganization were to get rid of troublesome competition, to combine the successive stages in the process of production, or to diminish the costs of production .[12]

Third, together with the banks, the industrial associations have occupied a special position in the German economy, and contributed to the organized efforts for the development of the economy. The industrial associations not only have represented the interests of their member firms but also have performed an important public role, as guardians of the long-term interests of the nation's interests. The coordination of industrial association, which often encouraged cartelization rather than merge and acquisitions in a specific industry, caused the relatively small size of German firms compared to that of the US firms.

The dyestuffs, synthetic fertilizers, and pharmaceutical industries are evidence that technological innovation, based on the country's educational and research systems, was the key factor that enabled the industry to establish itself as leader on the world export market. The German machine construction industry was able to free itself by the middle of the nineteenth century from dependence on British technology in some areas of machine construction, including steam locomotives. In many areas Britain and later the United States had a technological lead until the end of the nineteenth century. Toward the end of the nineteenth century, when electrical power opened new lines of machine construction and changed the design and the manufacture of many traditional machines, German firms were able to move to the technological front in additional areas. By 1913 Germany accounted for 27 per cent of world production in machinery and about 26 per cent of

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[12] See Best (1990).

domestic production was exported. Germany held a 29 per cent of world exports, compared with 28 per cent for Britain and 27 per cent for the United States.

As a result, although in 1870 German gross domestic product ($21 billion at 1970 US relative price) was less than that of Britain (30 billion), the United States (30 billion), and France (24 billion), by 1913 it was larger($72 billion at 1970 US relative price) than that of Britain (68 billion), France (47 billion) though the United States surged ahead (176 billion).

Fourth, the institutional structure established in the nineteenth century achieved momentum and has survived the period of the First and Second World War with growing in size. The government cared for educational institutions as well as public research institutions. However, the government has been hesitant in assuming responsibility for the development of specific-technologies. In contrary to Britain, France, and the United States, where the government intervened into the development of strategic technologies under the so called mission-oriented technology policy regime, technology policy in Germany has been primarily "diffusion-oriented". Clearly bound up with the provision of public goods, the principal purpose of the policy is to diffuse technological capabilities throughout the industrial structure, thus facilitating the ongoing and mainly incremental adaptation to change.[13] Although the German government also carried out programs for

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[13] The diffusion-oriented technology policies seek to provide a broadly based capacity for adjusting to technological change throughout the industrial structure. They are, in general, characteristics of open economies where small and medium size enterprises remain an important economic and political force and where the state, bearing the interests of these firms in mind, aims at facilitating change rather than directing it. The primary feature of diffusion-oriented technology policy is decentralization. Specific technological objectives are rarely set at a central level. Central government agencies play a limited role in implementation. Government funds tend to be fairly widely spread across firms and industries with high technology industries obtaining a far lower share than in mission-oriented countries. These countries view technology policy as an intrinsic part of the provision of innovation related public goods: education, standardization, and cooperative research. (See Ergas (1987)).

supporting the development of industrial technologies in nuclear power, aerospace, and electric data processing, the results were unsatisfactory.

Germany today faces a problem that the German industry shows a strong technical capability mainly in those areas where it has a long tradition of technological strength while the industry has developed less dynamism and competence in those radically new areas technology emerged after World War II, such as computers and microelectronics. This problem becomes substantial as Japan has entered into those industries such as high value-added automobiles and machinery where Germany has held distinctive competitiveness so far. Consequently, the German government began to assume a role as a manager of a national technical innovations, designed programs to strengthen cooperation and flow of personnel and information between different organizations, and fostered new institutions like Fraunhofer-Society and Max-Planck-Society. Fraunhofer-Society is supposed to links industrial firms and higher educational institutions as well as to provide by itself technical assistance to private firms, while Max-Planck-Society focuses many of its activities on basic research. The splitting up of responsibility for technology policy between the Federal Ministry of Research and Technology and the Federal Ministry of Education and Science had created a barrier for policy makers to consider the system as a whole until the late 1980s. And there has not been any significant change in the German economic structure so far.

## 2.3 The United States

The industrialization process in the United States also had its own peculiarity. First, industrial innovation in the US economy in the late nineteenth and early twentieth centuries largely built on an "American System of Manufacturing" and mechanical skills, rather than on scientific research or the institutions associated with R&D. The creation of mass-manufacturing operations of unprecedented scale, which was stemmed from the combination of the enormous, highly protected domestic market, innovations in transportation and communications, and the exploitation of foreign sources of knowledge through the skilled immigrants and the import of machinery and blueprints from Europe, supported growth in US productivity and per capita income to levels exceeding those of Great Britain by 1913.

Second, in the late nineteenth century the United States also established higher educational system for training scientists and engineers. Since the US system was influenced by the successful example of Germany, the pursuit of research was recognized as an important activity within the higher educational system. However, rather than vocational schools in Germany, public universities were established and promoted. Since the public universities were largely funded by state governments rather than by the federal government, they were under some pressure to provide economic benefits to their regions. This in turn influenced curriculum and research and therefore the US higher education in public universities were more closely geared to commercial opportunities than was true in many European systems of higher education. In the emerging sub-fields of engineering, mining, and metallurgy, state university systems often introduced new programs as soon as the requirements of the local economy became clear. An important linkage between higher education and industrial research operated through the training by public universities of scientists and engineers for employment of industry. Their large body of scientific knowledge, and not merely frontier science, was relevant to the needs of an expanding industrial establishment.[14] The Ph.D. trained in public universities also were important participants in the expansion of industrial research employment during the early twentieth century. Thereafter, the sheer scale of the US higher educational system meant that this broad based system of training scientists and engineers served as a device for the diffusion and utilization of advanced scientific and engineering knowledge. Even where it did not advance the knowledge frontier, the higher education system was an important instrument for scientific and engineering catch-up for the United States within international economy before World War II, just as it has been in the postwar Japanese economy. The rise of US scientific researchers to international eminence in a broad array of disciplines is a postwar phenomenon and seems to have lagged behind the development of strong US capabilities in industrial innovation as mentioned before. The modest attainments of the US economy's scientific research establishment nevertheless did not notably impair the nation's economic performance during the late nineteenth and first half twentieth centuries. This suggests that the linkage between excellence in scientific research and broader indicators of US economic performance is quite loose.

Third, big businesses, conglomerates dominated industrial development and research during the late nineteenth and early twentieth centuries. Since the U.S. economy was

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[14] Chandler argues that to a much greater extent in the United States than elsewhere, technically trained engineers moved into positions of industrial leadership. (See Chandler (1062) p. 317.)

developed around the capital-intensive industries, it was crucial for firms to gain the necessary economies of scale. But this could result in the over investment and excessive price competitions at the cost of social benefits. While Germany solved this problem largely through the formation of cartels, which controlled investments and prices for exploiting the best social benefits, under the influence and supervision of banks and industrial associations, the U.S. firms could not do this due to the strict antitrust regulations. Consequently, firms resorted to horizontal mergers to control prices and markets, which resulted in the rise of conglomerates. At the time, the United States also established bank-centered business groups very similar to those found in Germany. For instance, the House of Morgan was a group that included U.S. Steel, International Harvester, General Electric, and thirty-seven other U.S. firms.[15] However, this system was made illegal in the 1930s by antitrust regulations and thereafter the arms-length relationship between banks and industrial firms has been established which is similar to British bank systems. During this period, industrial research was dominated by the chemicals industry and related industries. The chemicals and related industries accounted for 40 per cent of the number of laboratories founded from 1899 to 1946, and also accounted for slightly more than 40 per cent of total employment of research scientists and engineers in manufacturing. This dominance was supplemented during 1921-46 by industries whose products and process technologies drew heavily on physics. By 1946, electrical machinery and instruments accounted for more than 20 per cent of all scientists and engineers employed in industrial research in U.S. manufacturing, from less than 10 per

[15] Historical analysis shows that firms that were part of the Morgan group had a higher rate of return than firms that were not part of some business group. (See De Long (1989) p. 1.)

cent in 1921. Before World War II, the U.S. R&D system was dominated by industry as both financiers and performers of R&D.

Fourth, after the World War II, the federal government assumed a central role as a founder of both academic and industrial research. From a share of 12-20 per cent of national R&D spending in the 1930s, federal funds expanded to account for 40-50 per cent of national R&D expenditures during the postwar period. The U.S. federal government's R&D policies could be typified by the dominance of defense-related R&D expenditures and the push of "big science". In 1960 defense research constituted 80 per cent of federal R&D funds. It declined sharply from that level and hovered around 50 per cent level until the early 1980s, and then rose again to 65 per cent in 1990. And the Manhattan Project's success contributed to rosy postwar perceptions of the constructive possibilities of large-scale science for the advance of societal welfare. The sheer size of the U.S. federal R&D funds outstripped that of other countries. Until the late 1970s, the combined total R&D expenditures of Germany, France, Britain, and Japan did not exceed that of the United States.

Fifth, the prominence of small firms in commercializing new technologies in the United States after World War II contrasts with their more modest role in the interwar U.S. economy. The postwar U.S. pattern also differs from those of both Japan and Western Europe, where established firms in electronics, pharmaceuticals, and other industries played a more significant role in commercializing new technologies. In semiconductors, computers, and biotechnology industry, small firms has played a crucial role in developing, patenting, and commercializing new technologies. This is a rather unusual phenomenon outside the United States and several factors have contributed to the prominent role of new, small firms in the postwar U.S. innovation system. The large basic research establishments in universities, government, and private firms served as important sources of scientific and technological knowledge that walked out with individuals who established firms to commercialize the innovations based on this knowledge. High levels of labor mobility and a relatively permissive legal climate facilitated the incubator role of universities and large firms. The foundation and survival of vigorous new firms also depended on a sophisticated financial system to support them during their infancy. The U.S. venture capital market played an important role in establishing new firms in microelectronics, computers, and biotechnology. In addition, the postwar antitrust climate, which contributed to the development of an unrestrictive intellectual regime in both semiconductors and computers, in which patents licensing at low royalty rates was common and patent enforcement was relatively lax, influenced the emergence of new, high-technology firms.[16] The military R&D as well as the military procurement under the provisions of the Defense Production Act and Buy American provisions, which favored U.S. over foreign suppliers, also contributed to the rise of small, entrepreneurial firms.

Although the entrepreneurial firm was widely hailed as an important contributor to dynamic innovative performance and as a source of national competitive advantage, in recent years numerous observers have argued that the startup firm may have reduced the ability of U.S. firms to compete internationally. The fragmented structure of high-

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[16] The 1956 settlement of the antitrust case, United States v. AT&T, significantly improved the environment for startup firms in microelectronics. The decree mandated liberal licensing of its large patent portfolio by AT&T, which dominated semiconductor technology at the time, and led the firm to avoid commercial activities outside of telecommunications. Another 1956 consent decree, settling an antitrust suit against IBM, also mandated liberal licensing by this pioneer computer firm of its punchcard and computer patents at reasonable rates. (See Framm).

technology industries like semiconductors, with relatively few vertically integrated firms and a large population of merchant producers that are dwarfed by their foreign competitors, is blamed for the competitive difficulties faced by U.S. firms. In addition, the capital requirements of small startup firms may make their acquisition by foreign firms easier than efforts by U.S. firms to acquire foreign-developed technologies. These criticisms raise the possibility that this component of the U.S. national innovation system is less well suited to an era of intense international competition and technological parity. If the startup firm declines in importance in the U.S. high-technology industries of the future, its role during the 1945-85 period may come to be seen as a departure from normal patterns of innovation and evolution in market structure.[17]

A number of factors may change the role of the startup firms in the commercialization of technologies in the U.S. economy. Venture markets are a less important source of support for startup firms because of the increasing costs of new product development and the attraction of alternative investment opportunities for venture capital suppliers. The changing public policies, especially the relaxation of antitrust policy, may facilitate the acquisitions of startup firms by large industrial firms, reducing the likelihood that startup firms will grow to large size as independent firms.[18] Similarly, the efforts of the 1980s to strengthen domestic protection for intellectual property may reduce the viability of startup firms in at least one industry in which they have been very important agents in

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[17] See Mowery (1994).

[18] The Reagan and Bush Administrations adopted a substantially more lenient enforcement posture, arguing that international competition had significantly reduced the need for Justice Department scrutiny of and opposition to mergers and acquisitions. Justice Department guidelines and review procedures for mergers and acquisitions were relaxed, and major federal antitrust suits against high-technology firms were dropped or settled in the early 1980s. In 1984, the administration supported the National Cooperative Research Act, which reduced the antitrust penalties for collaboration among firms in precommercial research, and in 1993 the NCRA was extended to cover joint production ventures.

commercializing new technologies. The greatest interest by foreign firms in the technological assets of U.S. startup firms and collaborative ventures involving startup and established U.S. and foreign firms, which frequently focus on technology exchange and marketing, often resulted in the acquisition of the startup firm by its established partner. Finally, the contribution of military R&D and procurement to civilian technological innovation appears to have declined, in the face of continuing reduction in U.S. defense spending.

Finally, the recent U.S. government's technology policies have had noteworthy features. The recent reorganization of technology-related agencies in the United States provides striking evidence of the degree to which the emphasis has been placed on technology. With the arrival of the Clinton Administration, several bodies dealing with science and technology at the highest level have developed: the Office of Science and Technology Policy (OSTP), directed by the Scientific Advisor to the President; the National Science and Technology Council, which has taken over the role of the FCCSET (Federal Coordinating Committee for Science and Engineering and Technology) and which has added decision-making powers to its consultative role. The NTSC was created by a presidential executive order in 1993 and it consolidates the responsibilities previously carried out by the Federal Coordinating Council for Science, Engineering and Technology, the National Space Council, and the National Critical Materials Council. Its principal objectives are to establish clear national goals for federal science and technology investments and to ensure that science, space and technology policies and programs are developed and implemented to contribute to those goals. The NTSC is chaired by the President and includes the Vice-president. Cabinet secretaries and agency heads with responsibility for significant science and technology programs (i.e. the Director of the National Science Foundation, and the administrators of the National Aeronautics and Space Administration, the National Oceanographic and Atmospheric Administration, and the Environmental Protection Agency) and other key White House officials (i.e. the Director of the Office of Management and Budget, the National Security Advisor, and the assistants to the President for economic and domestic policy) are members of the NTSC. The NTSC is undertaking an across-the-board review of federal R&D expenditures and will prepare coordinated R&D budget recommendations for accomplishing national objectives in areas ranging from information technologies to health research, from improving transportation to strengthening fundamental research and international science and technology programs. Besides this, the 1988 Omnibus Trade and Competitiveness Act created the Technology Administration within the Department of Commerce. With official recognition of technology as essential to economic growth has come increased emphasis on the coordinating role of that agency. The administration's technology policy is fostered through tax incentives, export controls, R&D investments, technology transfer, investments in worker skills, defense conversion, and the promotion of a modern information infrastructure. Partnerships between government, industry, and academia are also being used to implement this technology policy. A recent example is the Partnership for a New Generation of Vehicles, in which Technology Administration leads government-wide efforts to collaborate with automobile makers in developing technologies for a new generation of vehicles up to three times more fuel-efficient than today's cars. In addition to the restructuring of government agencies related to technology policies, the U.S. government seems to emphasize technology policies to promote industrial competitiveness and economic growth. The government is now funding science itself with greater prudence, as the recent abandonment of the Superconducting Super Collider project demonstrates. Rather than performing "mega science" within the national boundary, the U.S. government is trying to enhance international collaborative research in this field. Ironically, the recent changes in the U.S. system may increase its resemblance to the innovation systems of other industrial economies, especially those of Japan.[19]

## 2.4 France

The current national innovation systems of France is essentially a creation of the post World War II period.[20] The education sector, with its dual component - the universities and the Grand Ecoles - dates back to the late eighteenth century but otherwise today's institutions and mechanisms have all evolved out of those that were just the Liberation from 1945 to 1949 and again from 1958 to 1966 during the first phase of the Fifth Republic. The system has several characteristics that are quite specific to France: (i) the organization and funding of the largest part of fundamental research through a special institution, the CNRS, distinct from the higher education sector entities, which are funded by the state and governed by scientists in an uneasy relationship with public authorities; (ii) a dual higher education sector producing at least one type of technical senior person little known elsewhere, namely the Grand Ecoles technical experts elite of engineers cum

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[19] Even as the importance of some historically unique characteristics of the U.S. national innovation system may be declining, one sees policy debates in other industrial economies about the wisdom of developing R&D organizations and institutions that in some respects resemble those that were long important in the U.S. Thus, for example, Japanese policy makers and managers are considering policies to strengthen university research, industry-financed basic research, and military financed research in ways that may reduce the salience of some of the unique structural characteristics of the Japanese system. (See D.C. Mowery, and N. Rosenberg, *Technology and the Pursuit of Economic Growth*, 1989, New York: Cambridge University Press.)

[20] See Chesnais (1993).

industrial managers, cum high level of political and administrative personnel; (iii) a pervasive element of state involvement in the production not just of general scientific and technological knowledge, but of technology per se in the form of patentable and immediately usable products or production processes. The French national innovation system consists to a large extent of a set of vertically structured and fairly strongly compartmentalized sectoral subsystems often working for public markets and invariably involving an alliance between the state and public or private business enterprises belonging to the oligopolistic core of French industry.

During the nineteenth century, when Germany and the United States fiercely caught up with Britain under their own technological capabilities based on sophisticated higher educational system and pioneering new technologies, France's industrialization was handicapped by a combination of several reasons. First and the most importantly, the educational system failed to provide needed engineers for industrialization. The Grand Ecoles, the professional school supposed to provide a ground in engineering and science, has raised experts, civil servants, and managers for a particular ministry, rather than research engineers who could make substantial advances in the state of the art. Therefore, in contrast to the German Technische Hochschulen, the French mode of engineering school had lacked in general spirit of modern scientific research even until the early twentieth century. In addition, the discrepancy between science and industry is clear because of the almost total absence of the industrial R&D laboratories developed from the 1890s onward in Germany and the United States and so a weak French position in science-push industries. By contrast, in sectors where technological development took the form of pragmatic, step-by-step innovations as in automobiles and aeronautics, French inventors and entrepreneurs were very active. Up to World War II the French automobile industry was the second largest world producer.

Second, since demographic growth was very weak and the peasantry-dominated economic structure offered a very limited demand for industrial products, domestic demand was not inherently dynamic. And in contrast with Britain, French industry was not faced with any large external demand but it did nothing to create it until later it accepted without much difficulty a very reactionary approach to the management of colonial possessions. The small and rather conservative businessman is largely a natural outcome of this overall situation. Consequently, industrialization came about in successive bursts on the basis of exogenous market pull in the form of government guaranteed and bank financed demand, notably for railroad building, ships, and arms.

Third, since World War II, the French economy has followed a pattern of state-led growth. Consequently, the government held a critical role in developing institutions for technological innovations. The government and the oligopolistic core of large public and private firms operating in the high-technology sectors typifies the current French institutional structure. Especially, the government established research agencies in strategic technology sectors to develop technological strategies, to prompt technological development, and to supervise R&D procurement. For instance, CEA in nuclear power, CNET in telecommunications, CNES and ONERA in aerospace, and DRET in defense electronics are established for this purpose. Together with the promotion of national champion firms and the establishment of particular research agencies in strategic industries, the French government has focused on the development of strategic technologies. In this regard, the France's technology policy could be considered as “mission-oriented”. However, the French system has resulted in structural problems. The emphasis on hierarchy, the difficulty of cooperating, the antagonistic relationships between management and workers, together with the particular rigidities of state-led system have eroded the industrial competitiveness of France. Except for pharmaceuticals and aerospace, the French industry has shown structural deficiencies.

During the 1980s, in response to the structural problems, the French government has implemented several noteworthy policies, which were more like diffusion-oriented in that the policies aimed at facilitating the training in higher educational institutions or strengthening the technical capabilities of small and medium size firms (SMF). Such programs like ‘Industrial Training through Research Agreements (CIFRE), Training Agreements for Higher Technicians (CORTECHS) were introduced to prompt doctoral training. The Ministry of Research and Higher Education, through intensive discussions with industry and academia, established a plan to encourage the SMF to use technological resources for enhancing their competitiveness. The plan included several policy measures: to strengthen incentives to recruit staff (technicians, engineers or researchers) who could be pivotal between research and the SMF’s other activities; to develop technology support points at which SMF could consult a technology development counselor about problems and receive guidance about who might be the right potential partner to approach.

### 2.5 Japan

Japan represents another peculiar model for accomplishing industrialization. Although Japan’s industrial development, to a greater extent than Germany and the United States, depended on borrowing and assimilation of foreign technologies, it is much more different from other Asian countries that shared similar tradition and culture with Japan, in that it started industrialization and established modern institutional structure much faster than those countries. By the mid-1910s many firms had been established in heavy industries including steel, machinery, and chemicals and therefore the Japanese economy already took off around the time of World War I. Japanese paradigm for industrialization can be described as follows.

First, Japan's own indigenous technical capability started to be established in the late nineteenth century. In 1883 Japan already established a modern higher educational institute of Kogakuryo (the college of Engineering) with the advice of a British engineer, H. Dyer, which later in 1886 became the Engineering Department of Imperial University (later renamed the University of Tokyo). Quite unlike the British system, the university education emphasized the interaction between classroom studies and on-site training at the laboratory works within the university. It is noteworthy that the Japanese government emphasized engineering education at the time when more developed countries regarded pure science as superior to engineering. The university produced educates who later founded many of major Japanese manufacturing firms. Thereafter more universities and vocational schools were established by the public as well as the private sector. During the early twentieth century until 1930, 38 public research institutes were founded by the government. In 1923 there were 162 private R&D laboratories affiliated with companies, cooperatives, and other private foundations. Of these 71 were in chemicals, 27 in metals and machinery, and 24 in food although most of them were small and include testing and development sections within factories which may not deserve to be called laboratories in the present sense.[21] In 1930 national R&D expenditures accounted for about 0.2 per cent

[21] See Odagiri (1993).

of the GNP and this increased to 1 per cent in 1942. These increased R&D activities enabled some of the Japanese manufacturing industries to start world-class production facilities and developing advanced products; for instance, large-scale furnace and open hearth for steel production, aircraft, ships, alloys, and communication equipment. However, even these industries depended on European and U.S. technologies in many aspects. The stoppage of technological inflow from abroad during World War II had a serious impact, and consequently, despite the increased domestic R&D efforts, the technological gap from the Western countries widened in such key industries as aircraft and shipbuilding.

Second, as of the firm structure, Japan's industrialization started by industrial groups, Zaibatsu, in the early twentieth century, and accomplished by industrial groups, Keiretsu, in the second half of twentieth century. Keiretsu is different form Zaibatsu, in that individual group firms are more loosely linked to one another through the small amount of cross-ownership while the member firms in Zaibatsu are more tightly linked through the ownership of its founder and family members.[22] However, the industrial group, whether it is Zaibatsu or Keiretsu, with the structure of highly diversified into unrelated businesses, surrounded by a network of smaller suppliers, under the support and supervision of a commercial bank, which is also a member of an industrial group, dominated the Japan's industrial development throughout the twentieth century. This organizational mode of firms has helped the development of the Japanese economy. First, the intense competition among industrial groups encouraged early entry into new markets. Then, the financial

[22] Unlike the Zaibatsu, as a group, Keiretsu members have the advantages (size and coordination) of being a conglomerate with minimizing the disadvantages (excessive centralization and inefficiency) of being a conglomerate. (See The Economist, February 2, 1991, p. 63.)

capability of the industrial group made strategic, long-term commitments for specific business possible and this in turn enabled market share competitions and productivity-enhancing investments in firm-specific skills. Finally, each group, as it moved to new business areas, sought to shift its suppliers with it.

Third, especially after the World War II, the government played a key role in the rehabilitation of the Japanese economy by efficiently supporting and coordinating the Japanese firms. Japan entered the 1950s with an strong economic bureaucracy able and willing to deploy an active strategy for industrial transformation and development. Compared to the present day, the bureaucracy was at the time powerful relative to other institutional actors. Despite the devastation of the production facilities during World War II, the Japanese economy regained the prewar peak production level in manufacturing industry within 5 years, and thereafter grew at an annual rate of approximately 10 per cent until the early 1970s. It is true that the technological base accumulated since the early twentieth century and the favorable international economic environment provided a ground for the rapid economic growth. However, the government's industrial policy - especially the MITI's role in export expansion and targeted industrial promotion, facilitation of technology diffusion among domestic firms through the control of technology importation and collaborative R&D activities -, was a crucial factor for this rapid revitalization of the Japanese economy. During the early 1970s, as Japan became a world-class competitor in the international market, the technology importation became less favorable and therefore, the government began to emphasize technology policies to promote domestic R&D capabilities. The government provided packaged incentives through tax breaks, subsidies, and low-interest loans to promote private firms' R&D

efforts. However, interestingly, the size of the incentives were much smaller than that of other advanced countries including the United States, Germany, France, and Britain. In 1965 the amount of the government support accounted for 6.3 per cent of industrial R&D expenditures and this ratio reduced to just 3.1 per cent in 1980. Given this modest government policy measures, it is often argued that most of the R&D projects which the government supported would have taken place anyway. However, rather than this argument, it may be more cautious judgment that the Japanese government, within the peculiar Japanese culture and institutional structure, could more efficiently orchestrate the nationwide R&D efforts with much smaller amount of incentive packages than other advanced countries did. Indeed, the government's industrial policy has been judged as market-conforming, which means the government has seldom picked winners and losers. The industrial development strategies have been industry-led strategies where government was a participant rather than a dictator. Private firms could reject government initiatives as shown in the auto manufacturers' rejection of a consolidation plan of the MITI in the 1960s. The principal goals of Japanese government's industrial policy have been to focus on those industries with high rates of growth in productivity, high income elasticity of demand, and high value added per employee to sustain the economic development and high wage economy.

Fourth, one policy measure that has attracted considerable interest is collaborative R&D efforts especially under the support and supervision of the MITI during the 1960s and 1970s. MITI officials, in their public pronouncements and interviews, stress the necessity of pooling R&D efforts in order to make the most efficient use of scarce scientific manpower and research funds.[23] Japanese system may be viewed as important components of a technology adoption policy, in a sense that the projects had focused less on advancing the scientific or technological frontier than on diffusing advanced technology among participants. However, with regard to this viewpoint, several drawbacks in MITI's joint research policies have been notified. It is doubtful whether the coordination of the MITI to exchange technological information among participants was effective and successful. Among 87 joint research projects, executed during 1961-1987, only two projects had joint research facilities, and in all other cases, each member firm simply took its share of research funds and carried out the research in its own laboratories.[24] Given that each firm inevitably tried to minimize the disclosure of its proprietary technologies in this situation, and that the MITI, which was involved in crucial struggle with the Ministry of Communication to grip the hegemony in technology policies around information industry, also had a motivation to shape the collaborative R&D projects without articulate evaluation, the effectiveness of this coordination system of diffusing technology among participants needs to be evaluated more precisely.

Finally, nowadays, the Japanese government is attaching increasing importance to the provision of funding for stimulating and internationalizing the creativity of its basic research system, showing less concern over industrial competence. This is quite contrary to other advanced countries like Britain, the United States, and France which have tended to more emphasize technology goals of increasing its industrial competence. This has been resulted by both the international criticism of Japan as "a free rider" in basic

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[23] See Yamamura (1993).
[24] See Odagiri (1993).

technology and Japan's own recognition of the need for basic technology as a seed to further its technology frontier.[25] In addition, the government is emphasizing the international cooperation in R&D activities by participating such programs as the International Thermonuclear Experimental Reactor (ITER) and the Space Station Program, and by launching Japanese Fellowship Programs.[26]

## 2.6 Summary of Chapter

As a summary, Table 2-1 represents the peculiar features of the advanced countries in their institutional structure and government's role around their industrialization. As discussed in above sections, each country developed its own economic institutions and innovation systems. However, as economic environments changed, the strength of a country's unique system has resulted in weakness in new circumstances. Therefore, recently, the innovation systems and institutional structures of a country has more and more increased its resemblance to those of other countries.

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[25] Negotiations over renewal of the U.S.-Japan Agreement on Scientific Cooperation, U.S. and Japanese participation in the Intelligent Manufacturing Systems projects, and Japanese contributions to the U.S. based Superconducting Supercollider all have been affected by the concerns of U.S. policy makers that Japanese public agencies and firms do not contribute to the global pool of scientific knowledge in proportion to the economic benefits that they derive from it.

[26] The ITER project is an international collaborative program jointly undertaken by Japan, the European Union, the United States, and the Russian Federation in order to demonstrate the scientific and technological feasibility of fusion energy for peaceful purposes. The Space Station Program is and international project conducted by the United States, member nations of the European Space Agency (ESA), Canada, and Japan under an Intergovernmental Agreement. This program is the principal step to manned space activities of long duration. And the Japanese Fellowship Programs were established in 1988 to invite foreign researchers to carry out research in Japan. Approximately 210 foreign researchers were accepted by Japanese national research institutes and public research organizations under this program in 1993.

TABLE 2-1 Comparison of Innovation Systems

| | Basis of Innovation | Prominent Type of Firms | Role of Government | Type of R&D efforts |
|---|---|---|---|---|
| Britain | .artisan /craftsmanship | .small size, large number of firms<br>.arms-length relationship with banks | .laissez-faire<br>.ban of technology transfer to other countries | .mission-oriented |
| Germany | .science /new technology<br>.craftsmanship | .big business<br>.coordination of industrial association<br>.close relationship with banks | .moderate but articulate intervention | .diffusion-oriented<br>.promotion of higher educational institutes |
| The United States | .new technology<br>.mass-production paradigm | .conglomerates<br>.small and medium size firms after world war II<br>.close relationship with banks (arms-length relationship after the early 20th century) | .moderate but articulate intervention | .mission-oriented<br>.mega-science<br>.promotion of public universities |
| France | .new technology<br>.craftsmanship | .national champions (conglomerates) | .strong presence<br>.shaping of the economy | .mission-oriented<br>.strong presence of research agencies for strategic industries |
| Japan | .borrowing /assimilation of foreign technology<br>.process innovation | .business group<br>.cross ownership between banks and industry | .strong presence<br>.productive relationship with private firms | .mission-oriented<br>.diffusion-oriented<br>.collaborative research |

# Chapter 3

## Korea's Industrialization

## and the Government

As shown in Chapter 3, Germany and the United States started industrialization under the British hegemony of the world economy. Although both countries also relied on borrowing technologies from Britain, they became world industrial leaders by generating pioneering technologies in newly emerging industries. It was possible since those two countries established peculiar institutional structures different from British systems, and , under the institutional structures, they could exploit late comer's advantages and build indigenous technical capabilities exceeding Britain in emerging industries. They either invented new products and processes or were first to commercialize them on a unprecedented large scale.

By contrast, Korea's industrialization during the past three decades depended on technical learning form advanced countries. Since Korea initially held very poor technical capability, until recently before Korea emerged as a potential international competitor in some industries, the Korean economy has developed by borrowing, assimilating, and improving foreign technologies that has already been commercialized by experienced firms from advanced economies.[27] Even though Korea held the comparative advantage in wage levels, the low wages could not solely be an sufficient asset against the higher productivity levels of more advanced countries. Given the inadequacy of low wages and the absence of pioneering technology, governments inevitably intervened. The Korean government, rather than passively remedied for institutional shortcomings or market failures, actively formulated nationwide economic development plan and influenced the formation of the Korea's institutional structure.[28] However, the Korean government's policy has evolved continuously in the scope and extent to which the government intervenes into the market according to changing environments.

During the early period, from the Liberation in 1945 to the late 1970s, it may be safe to assume that the government initiated the industrial development of Korea. The government provided comprehensive incentive packages to induce firms to invest into export-businesses (1960s) and strategic heavy and chemical industries (1970s).[29] In particular, the Heavy and Chemical industry Promotion Plan provided domestic firms, especially conglomerates with a ground to directly confront with the world-class firms from advanced economies in such capital-intensive, high-risk industries like shipbuilding, automobiles, and, a little later in the 1980s, semiconductors. Since those industries hardly fell into Korea's comparative advantage of the time, the government back-up was a

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[27] See Amsden (1989).
[28] See Fishlow (1987).
[29] Policy instruments for promoting Korean industry are as follows: targeted and subsidized credit allocation; protection of domestic import substitutes, firm-specific export targets and subsidies; financial support of government-owned banks, development of export marketing institutions, wide sharing of information between public and private sector; cartel rationalization against antitrust regulation, preferential government procurement toward domestically developed new products; public investment in applied research, and tax benefit package (See World Bank (1993)).

prerequisite.[30] The unyielding spirit of a leader, President Park, provided a ground around which the Korean government pursued industrial policies consistently and persistently.[31]

However, since the early 1980s, the circumstances have changed and there arose a strong demand for structural adjustment of the Korean economy. The main thrust of the demand could be characterized by liberalization, deregulation, and internationalization of the economy on the perception that further heavy government intervention would be neither desirable nor effective in light of the already sophisticated and large-sized Korean economy. The increasing pressure from advanced countries to abolish the industry-specific policies and to open domestic markets has also changed the directions of the government policies. In addition, as Korea gradually entered into high-wage economy, Korea needed to go upscale in technology to the higher-productivity activities that can support the high-wage economy. This required massive investments in technology, skills, and infrastructure together with an aggressive efforts to raise productivity. However, getting the technology necessary to move upscale was difficult. Easy access to technologies from advanced countries became a thing of the past. The U.S. firms began to guard their technologies more carefully and demand much bigger license fees. The Japanese firms were also reluctant to transfer technologies in a fear of boomerang/flying geese effects as the Korean firms emerged as potential competitors in the international markets.

[30] See Amesden (1994).
[31] Don't listen to "comparative advantage" advice. Whenever we wanted to do anything, the advocates of comparative advantage said, "we don't have comparative advantage." In fact, we did everything we wanted, but whenever we did, we did well. - President Park-, (See Alagh (1989)).

Under the circumstances, in the mid-1980s, the Korean government started to view science and technology as indispensable to sustain the country's economic development and its competitive position in international trades. The government aims to increase R&D expenditures to 3 to 4 per cent of GNP by 1996, equal to or exceeding the share in Germany, Japan, and the United States, and well above the OECD median of. By 2000, Korea's supposed goal is to compete with the major industrial powers in areas ranging from pharmaceuticals to high-definition television. The question is "how?"

### 3.1 Initial Conditions: 1950s

The primary concern for Korea in the 1950s was rehabilitating the infrastructure and manufacturing capacity that was virtually destroyed by the Korean War (1950-1953). Korea held low level of technological capability and knowledge stock, lack of human resources, negligible science and technology investment, and inefficient science and technology development systems. In 1948, Korea had only one university that had a school of engineering, some engineering colleges, public research and test centers. There were only 100 scientists and 1,000 technicians. During the 1950s per capita income remained at a level of $60 to $70, placing Korea among the poorest countries in the world. Primary industry and the services industry accounted for about 85 per cent of the total output. The services industry comprised the highest ratio, 40-50 per cent, mainly attributable to a large number of less skilled workers hidden in retail and other services industry that did not require expertise. The primary industry output was also high at 47.3 per cent in 1953, with this percentage being maintained until the mid-1950s and thereafter declining slightly. During this period, two-thirds of exports were traditional products and primarily crude materials such as unprocessed minerals. However, elementary and secondary school enrollment in Korea outstood compared with other less developing countries of the time. This will be discussed in detail later.[32]

### 3.2 Export-Push and Diversification: 1960s-1970s

In 1962 Korea adopted its First Five-Year Economic Development Plan, the first systematic long-term economic development plan in Korea.[33] One of the most salient features of the Development Plan was to regard exports as the locomotive of growth, with a large part of government policy efforts being put on the promotion of exports. A lot of, noteworthy policy measures were undertaken for the promotion of exports. The government provided tax, tariff, and financial incentives to exporters. Korean currency, won, was devaluated to enhance the price competency of export products.[34] A very complicated exchange rate system was revamped into a simpler unitary exchange rate system. In addition, in 1967 the government shifted the import control system from a positive list system to a negative list system, to lessen the difficulties of exporters in importing necessary intermediate materials and capital equipment for producing exportable goods. From 1962 to 1970, total export increased 18-fold from $50 million to $8.4 hundred million while imports also sharply increased, reflecting the rapidly increasing

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[32] See p. 56.

[33] During the 1962 to 1992, seven Five-Year Economic Development plans were executed continuously. However, in 1993, by the newly elected President Kim's Administration, further execution of the Five-Year plan was abolished on the grounds that this kind of centralized planning would not be adequate for the further development of the Korean economy. Instead, the new Administration planned and implemented "the New Economic Development Plan", emphasizing the "small but powerful, efficient government".

[34] During the 1950s, won was mostly overvalued. In the 1960s, the currency was devaluated. The most dramatic devaluation came in 1964 when won was devaluated by almost 100 per cent from 130 won per US dollar to 255.77 won per US dollar.

demand for intermediate materials and capital goods to support dynamic capital formation (Table 3-1).

TABLE 3-1: The Development of the Korea' International Trade
(unit: hundred million $, %)

| | GNP | Exports | Imports | Total Trade | Exports/GNP | Total Trade/GNP |
|---|---|---|---|---|---|---|
| 1962 | 23.0 | 0.5 | 4.2 | 4.7 | 2.4 | 20.6 |
| 1970 | 81.0 | 8.4 | 19.8 | 28.2 | 9.9 | 34.6 |
| 1980 | 605.0 | 175.1 | 222.9 | 398.0 | 28.9 | 65.8 |
| 1990 | 2,22.0 | 650.2 | 698.4 | 1,348.6 | 26.8 | 55.7 |

Source. Bank of Korea, *Economic Statistics Year Book*; National Statistical Office, *Major Statistics of the Korean Enonomy*, various issues.

In addition, Korea's economic structure changed rapidly. The trade ratio (a combined ratio of exports and imports as a percentage of GNP) rose sharply, from 20 per cent in 1962 to 34 per cent in 1970. There was also a large change in industrial structure, with the portion of primary industry declining in total output, while manufacturing and services picked up. Accordingly export structure also became increasingly dependent upon manufacturing goods, mostly light industrial products such as textiles and footwear.[35]

In the 1970s, the Korean economy experienced significant changes in trade, industry, and finance. The 1970s began with tremendous changes in financial markets, particularly money and capital markets. 1n 1972, with the promulgation of the Presidential Emergency Decree, the government declared that all borrowings by business corporations from unofficial financial markets would be subject to a payment moratorium.[36] With this measure, the government intended to reduce the debt burden of the business firms in order

[35] In 1972 light industrial products accounted for 75 per cent of Korea's total exports. The share was about 40 per cent in 1965.

[36] At that time, largely because of underdevelopment of official financial markets and government intervention interest rate determination in official financial markets, unofficial curb markets were flourishing. Business firms heavily relied upon curb market where loan rates were very high and business practice was not organized. This caused aggravation of the financial status of business firms. Under the circumstances, the government promulgated the Decree which was unusual and extraordinary.

to boost their production and investments. The Investment and Finance Companies were established to undertake short-term dealings in commercial paper issued by business companies. Financial reforms continued throughout the 1970s including the 1972 creation of corporate bond market.

The next policy move was to develop the heavy and chemical industries (HCI). In the 1960s, the light industry (textiles, footwear, small appliances) had grown rapidly, playing a key role in boosting exports, generating employment and increasing national output. However, there were inevitable reasons for Korea to drive HCI promotion. Korea might lose its price competitiveness in light industrial products to other developing countries, especially the Southeast Asian countries where labor wages were much lower and similar export-oriented economic development were pursued. In addition, Korea needed to develop export substitutes for light industrial products which faced increasing import protections from advanced countries after the first oil shock. The light industry oriented industrial structure created a relatively small amount of added value due to its heavy reliance on imported raw and intermediate materials. Along with this disadvantage, increased investments in the light industry expedited the import of capital goods, which aggravated the balance of payments. Therefore, to address these potential problems, in 1973 the government announced the Heavy and Chemical Industry (HCI) Development Plan. The HCI plan outlined the need, scope, and implementation program for developing strategic industries, including shipbuilding, automobiles, steel products, machinery, nor-ferrous metals, electronics, and petrochemicals. To promote the HCI, the government provided varied incentives to the firms which initiated HCI projects. However, at this time, the incentive system was totally different from those to be provided to promote exports. While the incentives to exporters were industry-neutral in that all industries or firms were treated equally, the incentives for promoting HCI were industry-specific and sometimes firm-specific as well. The strategically targeted industries (consequently firms) were provided with preferential credits.[37] Entry into certain areas of heavy and chemical industry was controlled by the government to achieve the needed economies of scale for international competition. In fact, during the HCI promotion drive, import restrictions on targeted infant industries were intensified mainly through the high tariff barriers to protect these industries from competition with imported products from advanced economies. An empirical study suggests that this previous period of import substitution was an inevitable prerequisite for the successful adoption of export promotion in HCI.[38] The noteworthy point is that Korea was much faster than other late industrializing countries, especially Latin American NICS, in shifting to the phase of HCI exports. In this regard, throughout the 1960s and 1970s, the Korean government were continuously encouraging exports while protecting infant industries; therefore, to merely characterize Korea's HCI promotion period as a classic import substitution experiments is incorrect.

All these efforts of the government substantially contributed to rapid development of the heavy and chemical industries. The share of heavy and chemical industries in the total output of manufacturing sector rose from 29 per cent in 1970 to 51 per cent in 1980, and to 60 per cent in 1989. The value-added share of HCI in manufacturing industry also rose

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[37] As for the financial incentives, the government established the National Investment Fund which provided long-term loans to strategically selected heavy and chemical industries to help finance their capital formation. While the Fund was partly funded by the government source, much of it was funded through a compulsory transfer of private deposits from the commercial banking institutions to the Fund. Real interest rates on preferential credits or policy loans for the sector were mostly negative. These industries held a privilege in accessing to bank loans during the credit rationing. Consequently almost 60 per cent of total bank loans went to HCI sectors during the HCI promotion period.

[38] See Gereffi (1990).

from 36 per cent in 1970 to 51 per cent in 1980. In addition, HCI accounted for 36 per cent of employment in manufacturing industry in 1980 rising from 26 per cent in 1970. This share rose to 55 per cent in 1989 (Table 3-2).

TABLE 3-2: Structural Change in Manufacturing Industry
(unit: %)

| | Year | Light Industry | HCI |
|---|---|---|---|
| Total Output | 1970 | 70.5 | 29.5 |
| | 1980 | 48.4 | 51.6 |
| | 1989 | 39.6 | 60.4 |
| Value-added | 1970 | 64.0 | 36.0 |
| | 1980 | 48.6 | 51.4 |
| | 1989 | 39.4 | 60.6 |
| Employment | 1970 | 74.2 | 25.8 |
| | 1980 | 63.6 | 36.4 |
| | 1989 | 44.7 | 55.3 |

Source. Bank of Korea, *Input-Output Tables*, various issues.

Accordingly, exports in HCI increased during the 1970s. In 1977 the share of HCI exports in Korea's total exports was 39 per cent, rising from 12 per cent in 1967. Electronics, machinery, ships, and iron and steel products were leading export products of the time.

### 3.3 Changing Environments and Structural Adjustment: 1980s-1990s

Given the prevail poverty and widespread unemployment, the growth of the nation's economy had been a kind of national motto throughout the 1960s and 1970s. And this "growth-first strategy" had constituted a basic philosophy for Korea in aggressively pushing exports and actively promoting HCI during the early stage of industrialization. However, while the strategy had contributed to the rapid development of the Korean economy, it also resulted in potential problems. It caused an excessive demand situation, high inflation, and accumulation of foreign debt.[39] More explicit, in the early 1980s, most of firms in the HCI were suffering the excess supply capacity and under utilization and this in turn resulted in enormous business loss and heavy debt-service burden. The government's aggressive promotion of HCI, anyway, constituted a primary cause of these problems. In addition, the second oil shock and the subsequent world economic slowdown aggravated the problems of over investment and under utilization for most firms in targeted HCI.

Under the circumstances, in a belief that the heavy government intervention would not be desirable for furthering the economic development, liberalization, deregulation, and internationalization became a norm of the Korean government's policy direction, replacing the past industry-specific policies. The government took several important steps toward deregulation and internationalization of the economy. First, to open domestic markets and to stimulate competition in the economy, it reduced import barriers to a considerable extent by lowering tariff rates and increasing the numbers of importable items without any authority's approval. The average tariff ratio was down to 20 per cent in 1985 from 39 per cent in 1978 while the import liberalization ratio, i.e., the percentage of the importable items without prior approval in the total commodity items classified for custom use, rose from 68 per cent in 1979 to 92 per cent in 1985. Next, financial incentives given to export industries and the HCI were reduced dramatically to heighten the self-sustaining capability of these industries. In fact, policy-based loans had occupied a substantial portion of total domestic credit. This brought about a distorted allocation of financial resources, impairing

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[39] The increase in rate of consumer price index reached 16-17 per cent annually in the 1970s, and outstanding external debt expanded from $2.3 billion in 1970 to $27.2 billion in 1980. A fast increase in foreign debt since the mid-1970s to finance active investment in the HCI apparently led to a sharp increase in the debt service burden.

the independent operation of commercial banks and preventing flexible monetary policy. Together with a drastic reduction of financial incentives, liberalization of financial sector was initiated through privatization of the five commercial banks and the lowering of barriers set against foreign banks' entry into the Korean financial markets. Another important change in macroeconomic policies in the mid-1980s was to emphasize the stabilization of the economy, compared with the previous policy in the 1960s and 1970s, which had focused on economic growth. Money supply had kept a high growth rate in the 1970s and early 1980s; however the growth rate in M2 sharply declined from 1983 onwards. In addition, the government spending was cut, leading to a dramatically lowered budget deficit ratio as a percentage of GDP. Along with this tight monetary and fiscal policy, inflation came down from a double digit rate to less than 5 per cent from 1983 onwards. In addition, in microeconomic policy, the government abandoned industry-specific policies by abolishing seven industry-specific promotion acts, such as the Electronics Industry Promotion Act. Subsequently the government enacted the Industrial Development Act in 1986. Under this act, some of government interventions including permissions, approvals, and instructions were eliminated and the government pushed forward to develop industrial technologies to cope with the changing situation.

The structural adjustment and stabilization efforts in the 1980s were thought to be successful. Since the mid-1980s, the Korean economy had demonstrated dramatic price stability and huge surpluses in the current account, while maintaining high-growth momentum. From 1986 to 1988, exports began to increase by about 30 per cent per year, resulting in large trade surpluses. Several factors accounted for these sharp increases in exports. First, a radical appreciation of the Japanese yen occurred in 1985, corresponding to the Plaza Accord of the Group-7 countries. The appreciation played an important role in improving the international price competitiveness of certain Korean products, steel, cars, electronic consumer durable, and semiconductors, which were competing with Japanese products in the international markets. The second factor was the improved quality of Korean manufacturers, ascribed to technological development, research and development efforts and government's support for the HCI in the 1980s, which stimulated production of new exportable goods.

However, the rapid increase of real wages since the late 1980s drew on imminent, new challenges to the Korean economy.[40] Until then, Korea had basically relied on the comparative advantage of low labor costs, than on technical or marketing competitive assets in international trades. Therefore, the rapid wage increase which exceeded the productivity growth rate caused the erosion of the international competitiveness of the economy. Korea still lacks in technical and marketing competency for competing against advanced economies in high-end products. But Korea has rapidly been caught up with by the South East Asian countries in low-end products. Because of the sharp Yen appreciation following the Plaza Accord, the Japanese firms rapidly shifted manufacturing facilities into the South East Asian countries. The combination of low labor costs of the region and high-technology and the sophisticated quality control systems of the Japanese firms threatened the Korean economy seriously. How to overcome this circumstances and

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[40] The average monthly real wage in Korea's manufacturing industry was $941 in 1991, much bigger than in such countries where per capita income is higher than Korea like Singapore ($898), Taiwan ($918), and Hon Kong ($781). From 1988 to 1992, real wage in manufacturing industry increased 11.2 per cent per annum in Korea, compared to 3.9 per cent in Hon Kong and 8.1 per cent in Taiwan. Two factors caused the rapid increase of Korea's wage: one is the rapid progress of democratization since 1987 Presidential election and subsequent emphasis of employee welfare; the other is the shortage of work forces due to the rapid expansion of the Korean economy until the mid-1980s. The latter, the shortage of work force, drew on more impact on the wage increase.

how to enter into more high value-added, high-technology industries have been major tasks for Korea to further its economic growth since the late 1980s.

## 3.4 Late Industrialization Paradigm of Korea

### 3.4.1 Noteworthy Features in Korea's Industrial Development

*Favorable Initial Conditions in Education and Income Equality*

Regarding initial conditions that preceded economic take-off, Korea clearly stood out in educational attainment and income equality before its performance started to diverge from other less developing countries. In the case of Korea, the indicator for education judged by primary and secondary school enrollment and literacy ratio, and the indicator for income and land distribution evaluated by gini coefficients, were outstanding among East Asian and Latin American developing countries.[41] In particular, the successful land reform carried out in the late 1940s leaded to favorably equal wealth distribution and political stability where the subsequent economic development plans could be built on with consistency. The favorable educational situation, later, provided a ground for efficient transfer of advanced technology from abroad, more productive investment, establishment of efficient business management, and capable public administration to be achievable.

A sufficiently equal income and land distribution can be argued a prerequisite for industrialization. In societies where inequities are large, there will be more pressure to redistribute income and wealth, and this pressure in turn results in various kinds of redristributive policies that are harmful to private investment and to growth. This can results in policy instability and distrust of firms in government policies. Considering that,

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[41] See Rodrik (1994).

in Latin America, educational achievement was comparatively low and government policies often proved to be unstable and switched to another set of policies due to the pressure from middle class aiming for equal income and land distribution, it can be a reasonable hypothesis that the favorable initial conditions of education and income and land distribution are causally linked to Korea's subsequent remarkable performance.

*Control of Financial Institution and Credit Policy*

In 1961 the government nationalized private commercial banks.[42] In addition, the government established a number of state-owned special banks and expanded existing specialized state-owned banks. In 1962 the government amended the Bank of Korea Act to facilitate the central bank's cooperation with the nation's long-term development efforts. Since then until 1980, the government held complete control over Korea's bank-dominated, formal financial system. As an owner-manager, the government hired personnel and determined budgets and credit ceilings for all commercial banks. Even since the privatization measures of the 1980s, the government still sets interest rates, rations policy loans, allocates operating funds, and chooses the banks' top personnel. As a result, the Korea has been described as a country that "exhibits the most extreme case of banks' dependence upon the state.[43]

Korean monetary authorities have relied primarily on direct control for implementing monetary policies. The most essential of these direct controls has been the government's ability and willingness to set interest rates at artificially low levels for selected borrowers, effectively reducing the risks involved in targeted industrial or exporting ventures. By

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[42] This is, in fact, a kind of de facto nationalization. In 1961 a temporary law was introduced to limit private shareholders' voting rights so the government could exercise control without owning majority shares.

[43] See Woo (1991).

both design and default, the primary beneficiaries of these consessional rates have been the conglomerates, chaebol. At times charging as little as half the ordinary bank rate, the government was able to assure chaebol participation in government-promoted ventures in exchange for continued receipt of these policy loans. During the 1960s and 1970s, this difference between the general lending rates and preferential export rates averaged eight to fifteen points in Korea, compared with a spread of only five to seven points for Taiwan during the same period.[44] Since 1983, when the government began to phase out policy loans, bank rates have remained roughly half of curb market rates, indicating a continued scarcity of funds and a brokering position for the state.

The financial policy together with the protection of domestic markets is the most powerful policy measure that the government used in encouraging private firms to invest into more capital-intensive, large-scale, and high-risk strategic industries like shipbuilding, automobile, and petrochemicals. Since the scale economies were large and the worldwide markets were dominated by a few huge foreign firms from advanced economies, local firms were reluctant to invest without the government's back-up. At the same time, by these policy tools, the government could rationalize the infant industries, limiting the number of new entry of local firms. In these industries, as Germany shows, cartels could be an efficient mechanism to overcome the negative feedback among excessive production, severe price competition, and overall costs to economy. It is well known that even the Japanese MITI, regardless of its willingness, failed to rationalized specific industry like petrochemicals (1950s), automobiles (1960s), and computer industry (1970s) due to the opposition of private banks, the major stock holders of relevant companies.

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[44] See Cho (1989).

Korea's experience shows that for a late industrializing country, financial policy and market protections can be used as efficient tools to induce investments and to rationalize the industry.

*Support under Monitoring and Protection under Competition*

As for the export-push as well as the HCI promotion, the government not only supported the private firms with export incentives but also checked the performance and penalized poor performers. Unlike the Latin American countries where the incentives were given-away, this monitoring system continuously placed domestic firms to survive the fierce international competitions.

Even in the early import substitution stage in HCI, while the Korean government's industrial policies provided the strong protection of targeted infant industries from the potential competition with foreign products in domestic market, the protection was provided under the condition of necessary competition. Most importantly, by permitting more than two firms in a targeted industry, the government formulated oligopolistic market structure encouraging competitions among local firms. And shortly later by encouraging firms invested in HCI to export, the government let them compete with foreign firms internationally. Consequently, Korea could overcome the classic problems of managerial inefficiency usually happened in protected business sectors. The managerial inefficiency was a major problem of Latin American countries where subsidies were given-away without adequate checking and monitoring and where import-substitution strategy survived comparably for a long period.

*The Promotion of Conglomerates*

The industrialization of the USA and Germany was accomplished by the technical innovation in the context of mass production and conglomerates with multidivisions.[45] Similarly, Korea's industrialization were also dominated by conglomerates, *Chaebols*, around the development of heavy and chemical industries.

The chaebol dominate the Korean economy and have gained increasing international recognition as well. In 1974, the top ten chaebol had sales equivalent to 15 per cent of GNP. In 1986, the top ten chaebol had total sales of over $65 billion, more than 65 per cent of Korea's 1986 GNP. That same year, among the fifty largest firms in Korea, thirty were owned by the ten largest chaebol. In 1991, the top five chaebol had revenues of $116 billion, equivalent to just under half of Korea's 1991 GNP. Internationally, Fortune's 1992 "Global 500" listing of the world largest industrial corporations includes nine Korean chaebol. The huge size of these groups relative to the Korean economy has led to a high degree of concentration at all levels. In addition to chaebol's dominating the whole economy, their affiliates control most of the specific industries in which they participate.

Since the early 1980s, in a perception that further concentration of the Korean economy on chaebols would cause a critical structural problem, the government has tried to adjust the chaebol-dominated economic structure. The government has strengthened antitrust regulations. In addition, the government bounded the net amount of bank loans to chaebols at a given time and tried to reduce the bound-level. Accordingly, the

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[45] See Amsden (1989).

relationship between the government and chaebol has changed continuously.[46] Today's situation is subtle. As the government tried to remedy the structural problems of too much concentration of the Korean economy on chaebols by strengthening antitrust regulations, there have happened a lot of conflicts between the two. However, at the same time, as Korea has tried to move into more technology-intensive industries, chaebols are supposed to play a more important role. In this respect, there still are intimate cooperation between the two, and the government still supports chaebols with such policy measures as R&D funds.

Throughout the early stage of Korea's industrialization, the industrial policy, especially the HCI promotion, contributed to the rise of big companies by providing comprehensive, preferential incentive packages to small number of selected firms. The size of chaebol and their broad diversification have allowed them to survive the hardships of late industrialization, to penetrate the numerous foreign markets, and to supplant the need for multinational firms to undertake major investments in targeted businesses such as shipbuilding, automobiles, and semiconductors where international markets had oligopoly structure and entry barriers were high. In this regard, the promotion of chaebol was an adequate and inevitable choice for Korea at that time.

*Productive Interministry Relationships*

During the early stage of rapid economic growth, Korean government maintained productive Interministry relationships less exposed to sectionalism under the consistent

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[46] Cho divides government-chaebol relations into four periods, reflecting major shifts in the political institutional environment surrounding the chaebol: 1945-1960 (laissez-faire); 1961-1972 (mercantilism); 1973-1979 (paternalism); 1980-1991 (constitutionalism). (See Cho (1992) pp. 48-55.)

leadership of the President. This relationship enabled economic planning authorities, the Economic Planning Board in macroeconomic policies and the Ministry of Trade and Industry in microeconomic, industrial policies, to employ a full range of policy instruments. Industrial policy can be coordinated with important policy instruments, especially with credit policy of the Ministry of Finance. Even though the Taiwan government also had powerful authority over credit allocation, the government agency in charge of planning industrial policies has little clout over the conservative financial agency that controlled actual policy tools; therefore, there has been little linkage between the plan and instruments, and this in turn resulted in the distrust of private firms about the government's sectoral industrial policy. Due to this, Taiwan government failed to rationalized capital intensive industries like automobiles and semiconductor memories to achieve economies of scale for international competition. Without government's promised long-term payoffs, it seems almost impossible to develop such industries with high risks in market entry in developing countries. In this case, companies refrained from long-term, large scale ventures, and concentrated their efforts on dividing up the existing market and exploring the emerging niches with relatively low entry barriers. This provides one of the reasons of why Korea is competitive in large-scale, capital-intensive businesses - like shipbuilding, automobiles and memory semiconductors - while Taiwan is proud of medium and small scale, niche businesses - like PCs and customized semiconductor designs-.[47]

[47] See Chu (1994).

*Desirable Relationship between the Government and Private Sectors*

In the early stage, the relationship between the government and private firms could be represented as close and productive. It may not be right to argue that the government unilaterally disciplined private firms. The relationship was bilateral in that while the government supported and sometimes penalized firms by such policy measures as credit allocations and market protection (stick and carrots), the planning of industry policy largely depended on private firms' information and advice. During the early stage of Korea's industrialization (1960s-1970s) as mentioned before "the growth-first strategy" was a Korea's nationwide motto. This spirit prevailed not only in the government but also in private sector. President Park regularly held a monthly meeting to facilitate the coordination and to induce nationwide consensus and strategies for industrial development. In the monthly meeting not only government officials and bank managers but also top managers and even the production line workers participated. Under the circumstance the classic problems of "information asymmetry" between the government and private sectors as well as the "moral hazard" of the private firms, which constituted major reasons for government failure, could be minimized. In addition, since the Korean economy was small, and since the development of economic institutions was poor, the centralized planning under the intimate relationships with business firms could be an desirable choice for Korea to facilitate the Korea's industrial development.

### 3.4.2 Evaluation of Industry-Specific Policy

Almost all literature emphasized the effectiveness of Korea's outward-looking growth strategy for its economic take-off. However, despite a large body of research, there is little consensus on the role that industrial policies have played in this performance. Some have seen in Korea's experience the vindication of market-oriented ideas while others have emphasized the role of government interventions in the trade and industrial arenas.

The World Bank, through The East Asian Miracle: Economic Growth and Public Policy (1993), finds in the East Asian experience a confirmation of "market-friendly approach to policy. It provides to debunk industrial policy's impact on East Asia's economies:

> We find very little evidence that industrial policies have affected either the sectoral structure of industry or rates of productivity change. Industrial policies were largely ineffective.

A recent comparative research of Korea and Taiwan about the productivity growth and structural change in the manufacturing industries also made a similar conclusion[48]:

> Policies in Taiwan and Korea have been quite similar in the areas of monetary policy, interest rates, education, and exchange rates. Concerning incentives targeted to specific industries, on the other hand, policies in the two economies have been quite different; however, the aggregate performance of the two economies have been remarkably similar. This outcome is consistent with the hypothesis that industry-specific interventions (industrial targeting) have not been an important cause of growth in either economy.

Many economists have expressed skepticism about the ability of governments to undertake successful targeting although they admits the desirability of industrial targeting. The influence from interest groups, information asymmetry between the government and its clients, and the tendency of individual government to maximize their bargaining power may result in distorted targeting rather than an optimal solution.

Yet there are many counter arguments about the World Bank's point of view of industrial targeting. Particularly, the underlying assumptions of neoclassical theory in

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[48] See Dollar (1994).

evaluating the productivity growth - constant returns to scale, perfect competition, long-run equilibrium with variability of all factor inputs, including capital stocks - are typically unsuitable for the estimation of rapidly growing dynamic economies like Korea in the 1970s and early 1980s.[49] The new growth theory stress the importance of nonconstant scale economies in explaining the sustained high growth of newly industrialized economies.

Amsden, Wade, and others cite the experiences of Japan, Korea, Taiwan, and China as prime examples of how governments can counter market failures by fostering growth by governing markets and getting price wrong to facilitate the establishment and growth of industrial sectors that would not nave thrived under the workings of comparative advantages.[50] Amsden points out that in the case of late industrialization which is driven by borrowing technology or learning, low wages even in the labor-intensive sectors like textiles, usually fail to provide a cost advantage at market determined prices. Amsden stress that persistent problems of competitiveness even after sharp exchange rate devaluation have compelled the state to play a more active role than in the past.[51] Amsden also argues that the World Bank report on "East Asian Miracle" is largely a failed attempt to defend the neoclassical position in explaining the success of East Asian economies and that industrial policies have been effective and non-neoclassical tools for economic development with government complementing market factors by creating an environment conductive for economic growth.

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[49] See Kwon (1994) pp. 635-644.
[50] See Amesden (1989), Wade (1990).
[51] See Amesden (1989).

In deed, the industry-specific policies until the late 1970s resulted in several problems such as the concentration of the Korean economy on chaebols, the distortion of financial resource allocation as well as the poor viability of financial institutions, and more explicitly, the over investment in HCI and subsequent suffering. However, on the other hand, the original target of the HCI promotion drive (making HCI products to account for 50 per cent of total manufactured commodity products by 1980) was almost achieved by 1980. As a matter of fact, the major products leading the development of the Korean economy today are products of HCI such as electronic products, steel products, automobiles, chemical products, ships, and machinery. In addition, chaebols have developed managerial, technological, and financial capabilities to survive the international competitions. They are, and will be leaders of Korea's industrial development. In this regard, the industry-specific policies was worthwhile to drive for Korea despite the undesirable side effects

# Chapter 4

# Technology Policy

# as a New Paradigm

During the 1980s, the major philosophy of the Korean government in prompting industrial development was shifted to functional industry policies complementing market-failures, from the past, industry-specific policies. As discussed in Chapter 1, since, on the one hand, technological development accompanies, by its nature, reasons for market failures, and, on the other hand, the Korean industry still needs government's back-up to move into high-value-added and technology-intensive sectors, technology policy became a new paradigm of the government as an adequate industry policy. The past 15 years is a period when the government aggressively strengthened technology policy and, at the same time, struggled to establish an optimal mechanisms to execute technology policy according to changing environments. This chapter addresses the evolution of Korean government's technology policy and its adequacy.

## 4.1 Evolution of Technology Policy

### 4.1.1 Establishment of Elementary Technical Infrastructure: 1950s-1970s

The Division of Vocational Education established in the Ministry of Education in July of 1948 was the first administrative institution dealing with technology policy. In 1966 by establishing the Ministry of Science and Technology (MOST), Korea held a central coordinating body for the national science and technology policy in the ministry level. In that time, the primary missions of the MOST were to establish a elementary technological infrastructure by strengthening scientific and technical education and by establishing legislative regulations for supporting research and development. Under these missions, the MOST established the Korea Advanced Institute of Science (KAIS) as a specialized graduate school of engineering for long-term human resource development. This school has been one of the national leaders in engineering research and education. In addition, the Korea Institute of Science and Technology (KIST) was inaugurated as an integrated and multidisciplinary research and development institute in 1966. The MOST started to legislate science and technology related acts and regulations, and the Science and Technology Fund was created by the Science and Technology Promotion Act in 1968.

During the 1970s, the government established strategic industrial technology research institutes in order to facilitate the transfer of foreign technology and to strengthen indigenous technological capability (including the Korea Ship Research Institute, the Korea Electronic Technology Institute, the Korea Machinery and Metal Research Institute, the Korea Institute of Chemistry, and the Ocean Development Research Institute) based on the Specific Research Institute Supporting Act enacted in 1973. Interestingly, large portion of these institutes were under the supervision of action-oriented ministries, which were in charge of the promotion of specific industries, like the Ministry of Trade and Industry and the Ministry of Communication, rather than solely under the control of the MOST. The Korean government regarded the linkage between the industry and technology more importantly during this period. And as discussed later, the role of the MOST as a coordinator in technology-related policies was substantially weak during this period.

In 1974 the government started to construct Daeduk Science Park to encourage mutual coordination among public and private research institutes. The first tax incentive system for technology development, the Technology Development Reserve System, which required firms to put a portion of their profits into reserves earmarked for technology development, was introduced in 1976. In addition, as the first financing institution exclusive for industrial technology development, the Korea Technology Promotion Corporation was established to support venture businesses in 1976. In the same year, Korea Development Bank started a loan program for technology development.

### 4.1.2 Technology-Driven Industrial Development: 1980s-1990s

The 1980s were the period when the government really started to view science and technology as the most important factor to sustain industrial growth. As Korea began to move into high value-added and technology-intensive industries, and as Korean firms had caught up with frontier firms from advanced economies, it became more difficult to acquire technology from abroad. The Japanese firms, in particular, were said to be rethinking their strategy of helping Korean firms acquire technical expertise. As Korean products began competing directly with Japanese makers on the local and international market, that boomerang phenomenon was very bothersome. And Japanese firms became reluctant to help Korean partners since all too rapidly, they became rivals.[52] In addition, products in these high-technology industries were highly differentiated by their features, quality, brand name, and level of technical sophistication. New technologies were

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[52] Asian Business, May 1984, p. 64.

constantly being developed, often at high costs and risks. The US and Japanese firms competed fiercely for global markets and closely guarded their technological advantages. Therefore, for the Korean government, the emphasis on technical policy was an inevitable, imminent choice.

Accordingly, throughout the 1980s, a large body of policy measures were newly introduced. Many tax benefits for supporting technology development such as tax reduction system for technical manpower development, tax exemption for real estates used by private research institutes, income tax exemption for foreign scientists and engineers, and preferential taxes for investment from venture corporation were established. Furthermore, a reduction of tariff and Special Consumption Tax for research instruments, facilities, and product samples were implemented.

In addition, the government enacted the New Technology Commercialization Financing Promotion Act in 1986, by which it promotes and invests in the formation of financial institutions specifically catering to the needs of new technology-based firms.

The import of technology has been liberalized in all sectors of industry to stimulate the import of foreign technologies. In the 1970s, royalties paid to foreign firms could not exceed 10% of sales, and the term of the contract had to be under 10 years. Every contract had to be explicitly approved by the relevant government ministry, usually those of trade and industry, or science and technology. In the early 1980s, these regulations were gradually loosened so that, by 1987, all licenses were automatically approved unless the relevant ministry asked for changes within 20 days of notification: the screening system on the import of technology by the government was changed to a reporting system. In reviewing licensing contracts, the government followed guidelines issued by Fair Trade

Agency, which did not like so-called restrictive clauses that: (i) obligated the licensee to purchase inputs from the licensers; (ii) restricted exports by the licensee; (iii) controlled the licensee's quality and price levels; (iv) prohibited the licensee from handling competing products; (v) unilaterally obligated the licensee to provide information on any technical improvements it developed. However, despite the government's serious concern about these issues, many technology licensing contracts contained such provisions. It is argued that the government sometimes strengthened the hand of the Korean firms in negotiations with foreign licensers. If a contract proposal was rejected because of restrictive clauses, the Korean firm could go back to the licenser with the government's backing. But in many cases, the restrictive clauses would still be included in side-letters to the formal contract.[53]

For inward foreign direct investment, the system of positive list - listing industries open to foreign direct investment - was switched to that of negative list - listing those that were prohibited -, raising the number of 4 digit ISIC industries from 521 to 660. Terms and conditions have also been relaxed very much. As Korea become an important world competitor, it found it increasingly difficult to obtain foreign technologies it needs unless it allowed foreign suppliers greater ownership control or favorable terms.

During the 1980s, one of the most important change was that the action-oriented ministries, such as the Ministry of Trade and Industry (MTI), the Ministry of Energy (merged with the MTI in 1993), and the Ministry of Communication (MOC), began to emphasize technology policy. In 1986, by enacting the Industry Development Act, the MTI started supporting R&D subsidies for technology development. Based on the same

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[53] Quoted from Harvard Business School Case Materials, *Korea's Technology Strategy*, 1988

law, the MTI established Industrial Development Fund, which is a long-term, low interest-rates loans for technological development of private firms. In 1988, the MTI formed the Small and Medium Industry Promotion Fund as a loan for supporting the technology development of small and medium size firms. In 1992 the Data Communication Promotion Fund was established by the MOC to facilitate R&D efforts in the telecommunications and related industries. With the R&D subsidies and loans, the government started national research and development projects with the participation of private firms, public research institutes, and universities. On the one hand, the increasing efforts of individual ministries in technology policies resulted in the rapid expansion of the government's budget base for technical development. However, on the other hand, this resulted in undesirable conflicts among ministries around technology policies and increased duplicative efforts, causing serious inefficiency.

Since the mid-1980s, individual ministries began to plan long-term technology policies under the culture of national economic development plan. But the effects of this plan has been largely negligible as presented below. In 1985, the MOST published a Long-range Science and Technology Plan that was based on the results of conferences held over two years among 500 specialists from private and public sectors. The plan called for Korea to place among the world's top 10 most technologically advanced countries by the year 2000. It targeted five fields as follows: (i) Income Earning: microelectronics, Information and automatic systems, and fine chemistry; (ii) Potentially Successful: new materials and genetic engineering; (iii) Industrial Support: systems engineering, project management, quality control, research methods; (iv) Public Welfare: health and environment; (v) Future Potential; oceanography and aerospace. The plan forecasted that by the year 2000 Korea would have caught up with developed countries in the first field and substantially closed the gap in the second and third fields. The plan's policy guidelines covered three areas: manpower development, R&D spending, and international cooperation.[54] By strengthening educational programs and encouraging study abroad, the number of scientists and engineers in the country would grow from 37,000 to 150,000 between 1986 and 2000. Through direct spending by the state and incentive packages to private firms, the country's R&D spending would increase from 2% to 5% of GNP. Finally, international investment and licensing in Korea would be encouraged as a means of acquiring technology from abroad. The plan itself was not quite successful due to the lack in specific implementation programs and the failure in inducing cooperation from other ministries. However, the basic philosophy was inherited to later projects.

Similarly, the MTI made a plan for promoting high-technology industries in 1988. It was also developed under a variety of advice and consultancy from academia and industry. It chose five industries as a target to strategically promote: microelectronics; mechatronics; biotechnology; new materials; and environment. But the MTI also failed to enact a relevant law, the High-Technology Industry Development Act, due to the chronic problem of territorial struggle and sectionalism among technology-related ministries.

During the 1980s the MTI, MOC, and MOST respectively tried to enact a law to facilitate the computerization of Korea and to promote the information industry. However, the relevant act was just enacted as later as in 1995. During the 1980s, unlike the past, the government exposed a serious problem in coordinating interministrial cooperation.

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[54] The plan offers only general guidelines. Because of limited R&D and investment resources, Korea has to be selective within the broad fields. The plan let the future five-year economic development plans to set stricter priorities according to criteria such as economic rates of return, probability of success, industrial and technological linkages, and national security and public welfare needs. (See HBS 1988)

### 4.2 Evaluation of the Technology Policy

Until the late 1970s when export-push and HCI promotion policy relying on borrowing technology dominated the industrial development, the voice to emphasize technology policy had been relatively weak. However, during the 1980s and 1990s technology policy became a new paradigm for prompting industrial development of Korea. The emphasis on technology policy during the past 15 years has contributed to the quantitative increase in Korea's technical capabilities. However, it included lots of potential problems as well.

#### 4.2.1 Positive effects of the Past Industry Policy

As shown in section 4.3, the Korean government pushed industrial policy to protect the infant industry and to promote exports. Both created strong demand for foreign technologies. Since there was no local capability to establish and operate production systems, local firms had to rely completely on foreign sources for production processes, product specifications, production know-how, technical personnel and component parts. Studies in the electronics, machinery, steel, computer industries demonstrate that import substitution under protection was a most powerful instrument that has facilitated technology transfer from abroad, leading to the emergence of new industries, and the introduction of more sophisticated products in the existing industries.[55] As for export promotion, since the government not only supported the firms with export incentive packages but also checked the performance, this continuously placed pressure on firms to acquire foreign technology and to use it effectively in order to be able to compete in foreign markets. However, despite demand for foreign technology, the government policy on the supply side of formal technology transfers such as inward direct foreign investment

[55] See Kim (1992) pp. 437-452.

and foreign technology licensing was quite restrictive during this period. In the early stage of industrialization, technology is not a critical factor and the necessary mature technologies could be acquired through other mechanisms. Instead, the government promoted technology transfer through the procurement of turnkey plants and capital goods. This policy led to massive imports of foreign capital goods at the cost of retarding the development of local capital good industry. Protection of machinery industry was relatively low until the early 1970s, giving capital good users almost free access to foreign capital goods. In addition, the tariff exemptions on imported capital goods and the financing of purchases by supplier's credit which carried low interest rates relative to those on the domestic market all worked to increase the attractiveness of capital good imports. As a result, inward direct foreign investment had a minimal impact on Korean economy.

### 4.2.2 Quantitative Enhancement in R&D Capabilities

Although the Korean economy has recorded one of the highest GNP growth rates, R&D expenditures rose faster than GNP, increasing its share of GNP from 0.38 in 1970 to 0.77 in 1980, and to 2.33 in 1993 (Table 4-1).

TABLE 4-1 Annual R&D Spending
(unit: billion won, %)

| | 1965 | 1970 | 1980 | 1985 | 1990 | 1993 |
|---|---|---|---|---|---|---|
| Total R&D Spending | 2 | 11 | 283 | 1,237 | 3,350 | 6,153 |
| - by government | 1.7 | 7.7 | 153 | 309 | 637 | 1,056 |
| - by private firms | 0.3 | 3.3 | 130 | 928 | 2,713 | 5,107 |
| Government : Private | 87:73 | 70:30 | 54:45 | 25:75 | 19:81 | 17:83 |
| R&D as percent of GNP | 0.26 | 0.38 | 0.77 | - | 1.95 | 2.33 |
| Annual Growth Ratio | - | 40.0 | 39.0 | 34.3 | 22.0 | 22.5 |
| - of government | | 35.3 | 34.8 | 15.1 | 15.6 | 18.4 |
| - of private firms | | 61.5 | 44.1 | 48.2 | 23.9 | 23.5 |

Source. the MOST, 1994 Annual Report for Science and Technology

The government funds increased significantly from 7.7 billion won to 153 billion won and to 1,506 billion won during the same period. But more impressive fact is that there was a massive increase in private R&D efforts. In the face of increasing market competition in both domestic and international markets and with various government incentives, private R&D investment rapidly increased form a mere 3.3 billion won in 1970 to 130 billion in 1980 and to 5,107 billion won in 1993, raising its share of total R&D expenditures from 30 per cent to 45 per cent and to 83 per cent during the same time. Yet the corporate R&D still heavily relied on government's preferential financing for R&D activities. For instance, in 1987 about 64 per cent of the total R&D expenditures in manufacturing corporate R&D was accounted for by the preferential financing.[56] Preferential financing has come from several sources: technology development fund earmarked within the National Investment Fund; Industrial Development Fund; the Korea Development Bank's Technology Development Fund; Industrial Technological Promotion Fund earmarked for Automation and New Material Development; and the Small and Medium Industry Promotion Fund. In addition, a lot of tax incentives have contributed the rapid increase in R&D investments of the private firms.

In this regard, the government's technology policies can be said to contribute to the overall strengthening of Korea's R&D capacity. The rapid increase in Korea's R&D expenditures until the early 1990s has a significant meaning. In 1995, the World Trade Organization (WTO) introduced an international agreement that would restrict the government's support of R&D funds: today, governments can support only 75 per cent of total R&D expenditures of industrial research projects, and 50 per cent of pre-competitive

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[56] See Kim (1991).

research projects. This new regulation directly restricts the government's funding in commercial technology developments, which have been the main goals of the Korean government's technology policies. Therefore, there can be an argument that the Korean government should have increased the R&D funds more rapidly and have supported the private firms' commercial R&D projects more widely in the past. But this may be unfeasible given the limited size of the Korean economy and its budget. More important matter is the adequacy of the goals and mechanisms of the government's R&D projects. This will be discussed later.[57]

### 4.2.3 Failure in Developing the Higher Educational System

As shown in Chapter 2, the establishment of higher educational institutes for training engineers and scientists provided a foundation to Germany and the United States in surpassing the industrial power of Britain in the early twentieth century. However, the past 15 year efforts of the Korean government failed to establish the higher educational institutions and to develop in time an adequate stock of highly trained scientists and engineers who should be able to play a key role today and in the near future. The student-professor ratio has retrogressed from 22.6 in 1966 to 35.8 in 1985, and to ?? in 1993 making all universities primarily undergraduate teaching-oriented rather than graduate research-oriented. In 1993 Korea had 244 universities (including vocational schools) which had science or engineering schools, and these schools spent 445 billion won for R&D, about 2 billion won (about $2.3 million) per university. This is undoubtedly lower than that of the advanced countries. The R&D expenditures of universities in Korea

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[57] See p. 85.

accounted for 7.2 per cent in 1993. Not only the net amount but also the share is lower than that of advanced countries (Table 4-2). As a result, Korea is now facing the problem of weak linkages between university education and educational demands from industry. Universities also expose serious weakness in basic research capabilities.

TABLE 4-2 The Share of R&D Expenditures for Each Research Institute
(unit: %)

| | Korea | Britain | Germany | France | USA | Japan |
|---|---|---|---|---|---|---|
| Universities | 7.2 | 17.0 | 16.6 | 15.9 | 16.1 | 12.2 |
| Public Institutes | 4.4 | 16.1 | 15.2 | 22.2 | 10.3 | 8.7 |
| Non-profit institutes | 16.9 | 4.1 | 0.4 | 0.8 | 3.7 | 4.3 |
| Private Firms | 71.5 | 62.8 | 67.8 | 61.1 | 69.9 | 74.8 |

Source. the MOST, 1994 Annual Report for Science and Technology, 1995
1993 data for Korea and the USA, 1992 data for the other countries

In addition, in the distribution of R&D personnel Korea faces a structural problem. As shown in table 4-3 and 4-4, about three fourth of Ph.D. in science and engineering belong to universities and only about 9 per cent in private firms while the latter spend 10 times more R&D funds than the former.

TABLE 4-3 The Share of R&D Personnel (1992)
(unit: %)

| | No. of total R&D personnel | University | Private Firms | Research institutes |
|---|---|---|---|---|
| Total | 88,764 | 26.2 | 57.5 | 16.3 |
| Ph.D. | 22,484 | 73.7 | 8.4 | 17.9 |
| Masters | 25,717 | 23.3 | 50.6 | 26.1 |
| Bachelors | 36,962 | 1.7 | 88.8 | 9.5 |
| etc.* | 3,601 | 1.6 | 93.1 | 5.3 |

Source. the MOST, 1994 Annual Report for Science and Technology, 1995
etc*: graduates from vocational schools

TABLE 4-3 The Share of R&D Expenditures (1992)
(unit: %)

| Total R&D Expenditures | University | Private Firms | Research institutes |
|---|---|---|---|
| 6,153 billion won | 7.2 | 67.3 | 25.5 |

Source. the MOST, 1994 Annual Report for Science and Technology, 1995

Furthermore, Korean universities have depended more on private firms than on the government in sourcing R&D funds (Table 4-4). In 1993 R&D funding from the private firms accounted for 75 per cent of total R&D expenditures in the universities while the government funding accounted for only 25 per cent.[58] By contrast, in the advanced countries like the United States and Germany, the universities sourced about 90 per cent of their R&D expenditures from the government. This does not represent that in Korea the linkage between the university and industry is closer than in other advanced countries. Rather than this, the structure points out that the university research in Korea is in embryonic stage and the government have preferred firm-initiated research projects to university researches.

TABLE 4-4 The Funding Source of University R&D (1993)

| | Total Expenditure | Government (A) | Industry (B) | Ratio (A:B) |
|---|---|---|---|---|
| Korea (billion won) | 303 | 76 | 226 | 25:75 |
| USA (billion $) | 19.0 | 10.9 | 1.4 | 89:11 |
| Germany (billion mark) | 11.6 | 10.7 | 0.9 | 92:8 |

Source. Korean Industrial Technology Association, Major Indicators of Industrial Technology, 1994. (1991 data for Germany)

The number of students with bachelor degree is comparable with that of advanced countries. Indeed the number exceeds that of Germany and Britain, and Japan in physical science field. But the number of students with higher degrees is smaller than that of

[58] Among the R&D funds from private firms, some portion comes from the government's funding for private firms' R&D projects. This means that universities have often participated as subcontractors of government-supported, private firms' R&D projects. In this respect, the government supported more than 25 per cent of universities R&D expenditures practically.

advanced countries, and there is still a significant gap in the number of Ph.D. students in particular. (Table 4-5).

TABLE 4-5 Degree Granted by Field of Science

| | Type of Degree | Physical Science | Engineering |
|---|---|---|---|
| Korea ('93) | Bachelor | 26,835 | 34,604 |
| | Master | 2,381 | 3,493 |
| | Doctor | 489 | 700 |
| USA ('89) | Bachelor | 57,898 | 120,025 |
| | Master | 13,985 | 38,282 |
| | Doctor | 8,927 | 5,691 |
| Japan ('91) | Bachelor | 14,176 | 87,404 |
| | Master ('90) | 2,984 | 13,117 |
| | Doctor ('90) | 835 | 1,967 |
| Germany ('89) | Bachelor | 14,338 | 12,086 |
| | Doctor | 4,886 | 1,400 |
| Britain ('89) | Bachelor | 23,800 | 16,900 |
| | Master/Doctor | 7,600 | 4,900 |

Source. Korean Industrial Technology Association, Major Indicators of Industrial Technology, 1994. (1991 data for Germany)

In this regard, Korea has failed to develop the research-oriented science and engineering manpower needed in the 1990s to sustain its industrial development.

### 4.2.4 Failure in Developing the Small&Medium Size Firms' R&D capability

Korea's industrial R&D investments have been dominated by large size firms due to the prominent role of the chaebols in the industrial development. In 1992 the Korean industry invested 3,154 billion won in research and development. Of this the small and medium size firms accounted for 13 per cent and big firms shared the rest 87 per cent (Table 4-6).

TABLE 4-6 R&D Expenditures by Firm Size (1992)
(unit: billion won)

| | Large Firms (A) | Small & Medium Firms (B) | Ratio (A:B) |
|---|---|---|---|
| Industry Total | 3,154 | 472 | 87:13 |
| - Manufacturing Ind. | 2,633 | 396 | 87:13 |

Source. Korea Industrial Technology Association, Major Indicators of Industrial Technology, 1994. (The criteria for distinguishing a large size firm is the number of employees that exceeds 1,000)

The comparison of the R&D concentration level with other countries shows the relative weakness of medium and small size firms' R&D activities in Korea. As Table 4-7 shows, the top 20 companies accounted for about 50 per cent of total industrial R&D investments in Korea in 1992 while the share is 30 per cent in the United States (1987 data) and 36 per cent in Japan. The top five firms shared as much as 30 per cent of industrial R&D investments in Korea comparing with 17 per cent in the other two countries.

TABLE 4-7 Concentration of R&D Expenditures
(unit: %)

| | Korea | USA | Japan |
|---|---|---|---|
| Top 5 companies | 30.1 | 17.0 | 17.1 |
| Top 10 companies | 39.1 | 22.8 | 26.6 |
| Top 20 companies | 49.8 | 30.6 | 36.3 |

Source. Korea Industrial Technology Association, Major Indicators of Industrial Technology, 1994.

The number of research laboratory is 2,502 in 1993 in Korea. Of these the number of firm laboratory is 1,690 (67.5%); public institutes 83 (3.3%), and university laboratories 729 (29.2%). Among firm laboratories one third is those of big companies. In addition, about two third of the laboratory of small and medium size firms is established in the 1990s while there is no research laboratory of small and medium size firms before 1982 (Table 4-8). All these observations suggest that the technology policy has little contributed to the enhancement of small and medium size firms' technical capabilities.

TABLE 4-8 Establishment of Industrial Research Institutes by Firm Size

| | Large firms | Small & Medium Size Firms | Accumulated number |
|---|---|---|---|
| ~1981 | 47 | 0 | 235 |
| 1985 | 32 | 10 | 624 |
| 1990 | 34 | 108 | 966 |
| 1991 | 74 | 161 | 1,201 |
| 1992 | 37 | 197 | 1,435 |
| 1993 | 45 | 210 | 1,690 |

Source. Korea Industrial Technology Association, Major Indicators of Industrial Technology, 1994.

### 4.2.5 Problems in Administrative Procedures

As shown in Chapter 2, recent years have been marked by widespread, worldwide major institutional changes, when compared with the situation of the 1980s. The main developments are of two kinds in the matter of administrative structure: changes in policy coordinating structures at the highest level of government; and reorganization of administrative structures that support science and technology.

In this respect, Korea's current administrative structure is exposing several problems. First, the coordination of technology policies has been inefficient in Korea. The Ministry of Science and Technology (MOST), a normative central coordinator, has failed to coordinate the technology policies of other ministries effectively. During the early stage of industrialization until the early 1980s, comparing with other ministries, especially the Ministry of Trade and Industry (MTI) that have shaped industrial policies, the voice of the MOST had been relatively weak. Each ministry had carried out technology-related policies under the coordination of the Economic Planning Board (EPB) rather than the MOST. During this period, it may be safe to assume that the MOST's technology policies were not integrated into national development plan.[59] Since the mid-1980s, as other ministries, especially the MTI and the Ministry of Communication (MOC) regarded technology policies as a major underlying factor in the promotion of trade and industry, there have been territorial conflicts among ministries to grip the hegemony in technology

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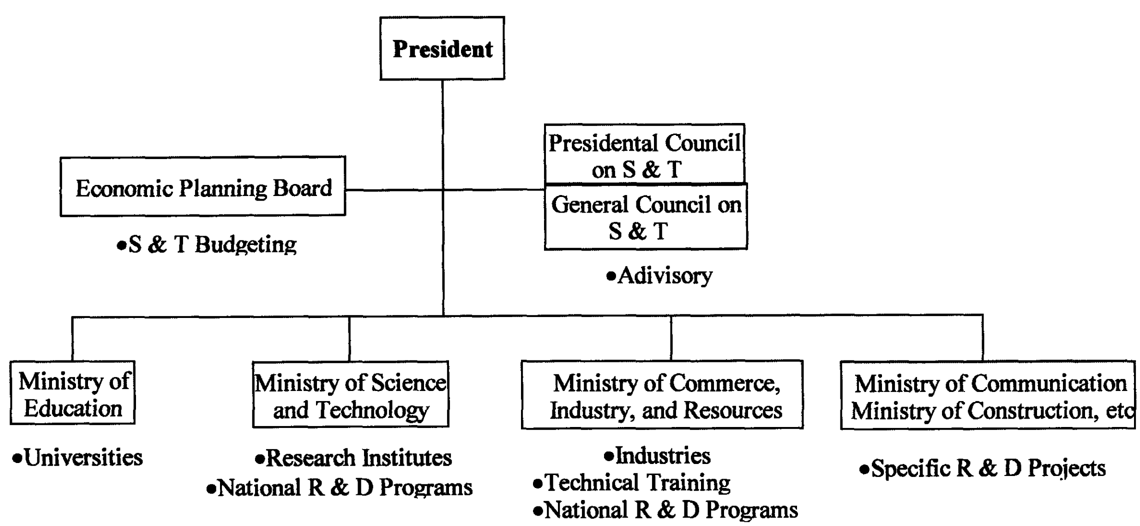
[59] See Kim (1992).

policies. However, as long as the MOST executes its own technology policies, it seems difficult to expect other ministries' cooperation.

In Korea there have been several trials to establish a coordinating agency at the highest government level. However, they have not been satisfactory. The National Council for Science and Technology was established in 1973 to bring about interministrial coordination, but met briefly only once upon inception and never functioned thereafter. In 1982 the Korean government introduced a quarterly Presidential Conference for Promotion of Science and Technology, similar to a pattern adopted in the 1970s to achieve export promotion. However, this was scaled down in 1990 to a President's Science and Technology Advisory Council whose role is restricted to advice and consultancy without any explicit tool to evaluate each ministry's policies and to enforce coordination. The figure 4-1 represents the current administrative structure of Korean government's technology policies, which requests sophisticated restructuring.

Figure 6-1 The Administrative Structure of Korean Government's Technology Policy



Second, at the ministry level, the Korean government entails a fundamental reason to give rise to territorial conflicts. Normatively, the MOST is in charge of promoting basic research capabilities. However, recently, as the Ministry of Education (MOE) began to strengthen the technology policies to support the research activities of higher educational institutions, key actors in basic research, there have happened territorial conflicts between the two ministries around basic research related policies. Furthermore, nowadays it becomes more and more difficult to distinguish basic research from applied or industrial research, especially in high-technology sectors. Even though the distinction is possible, the transition time for the results from basic research to be exploited for commercial purpose becomes shorter. In this respect, the definition of the MOST's role inevitably results in policy conflicts with other ministries that are in charge of prompting the development of high-technology industries, especially the MTI and MOC.

### 4.2.6 Weakness in Basic Research Capability

For a late industrialization country like Korea, it is an important but difficult task to decide which technologies of industries are to be supported as strategic sectors that fit best to its particular stage of industrialization process. Accordingly, the country inevitably faces the strategic choice about how much it needs to focus on basic research and how much on industrial technology. Basic science has stronger externalities with weak marketability while industrial technology is more market-oriented.

In this regard, a OECD report points out that a large number of countries show a shift in policy emphasis towards support for technology rather than for basic science, with government allocating funding to innovation in order to maintain economic competitiveness and stimulate growth. This is particularly evident in the countries with Anglo-Saxon traditions, where governments are attempting to capitalize on their existing science bases. The most significant undertaking in this respect is the Technology Initiative launched by the Clinton Administration in the United States, which signals a major shift in US policy towards industrial technology. However, Japan represent a quite contrary trend in that it strengthens the basic research more and more.

In Korea the government technology policy has tended to concentrate on commercial projects and almost ignored the enhancement of basic research capabilities. This constituted one of the reasons of poor development of university system and academic research. Despite the increase in overall R&D expenditure, amounts spent on basic science remain small and spread thin. Basic research in Korea is supported by the Korean Science and Engineering Foundation (KOSEF), which is modeled after the US National Science Foundation (NSF). Its R&D budget has risen from just over $1 million in the mid-1980s to 140 million in 1992.

### 4.2.7 Problems in National R&D Projects

Today the targets of Korean government's R&D subsidies can be categorized into two groups. One is for a kind of mega-projects, and the other is for small and medium-size firms' R&D projects. About 40 per cent of the subsidies is provided to mega-projects.

In 1993 the MOST under the cooperation with other ministries, initiated a specific program, the Highly Advanced National (HAN) project, which is intended to mobilize scientific and technical resources to help reach the country's goal of equaling the major industrialized countries by 2000. Overall funding of 3,476 billion won will be provided by private firms (43 per cent), public enterprises (18 per cent), and the government (39 per cent). Emphasis will be placed on developing selected industrial technologies: high-definition television (HDTV), electric motor vehicle, pharmaceuticals and integrated services digital networks (ISDN). It will also support essential basic technologies: basic technologies for 256M DRAM and 1Gigabit DRAM, new forms of energy, new generations of nuclear reactors, biotechnology, the environment, new materials for electronics and information technology, and flexible manufacturing systems technology.

The HAN project have several significant aspects: (i) they were selected by a committee of civilian experts; (ii) they were selected by a top-down approach; (iii) they were selected through consensus building, using a collection of ideas from researchers and discussions with the pertinent government officials; (iv) they were examined and planned to full-fledged projects within a very intensive four months of work; (v) they emphasized the importance of international technological cooperation by planning to allocate between 5 to 20 per cent of the annual R&D budget for this purpose.

However, the HAN project can be criticized in several points. First, the criteria for selecting projects is not clear. Historically, the Korean government has tended to emphasize the development of commercial technologies and this tendency still alive in the administrative process with inertia.[60] Together with inefficiency in the administrative structure dealing with technology policies, the inadequacy of the criteria suggests the question that whether funding lots of portions of precious government budget into this sort of projects is an optimal policy for exploiting the nationwide best results. Second, almost all major participants in the HAN projects are conglomerates, especially four

[60] Despite the goals presented by the government, which targets the development of basic, generic, or pre-competitive technologies, it is difficult to say that, for instance, the 256M/1G DRAM and HDTV projects are categorized into this area.

largest chaebols. As shown above, the weakness of the technical capability of small and medium size firms, and the poor research capacity of higher educational institutes are another, but very serious structural problems to overcome for furthering industrial development. In addition, since the mid-1980s, the government has tried to correct the structural problem of too excessive concentration of the Korean economy on several chaebols. Under the circumstances, it may not be an optimal policy to concentrate large portion of R&D subsidies on the projects executed by the chaebols. There can be an argument that the chaebols still need the government support to compete with foreign firms from advanced economies. However, the question is that given the above mentioned, so many structural problems of the Korean economy, to increase the chaebols' technical capacity is a so critical policy goal above all the other issues. The answer is rather "no".

With regard to the R&D subsidies for small and medium size firms (SMF), the situation is the same as that of mega-projects except for the small amount of funding. The problem of the SMF in carrying out their own R&D is caused by the shortage of highly educated research manpower and lack of market information as much as by their poor financial capabilities. Under the circumstances, less than 500 SMF are newly selected and each firm is provided with about 80 million won (About $100 thousand) on average per annum.[61] This presents the same question that whether to directly subsidize small number of SMF with small amount of money is more efficient than to support the same funds to a more fundamental policy goal such as the refining of the high educational institutes, which may

[61] The number of manufacturing firms was 71,889 in 1994. Therefore, only 0.7 per cent of small and medium size firms were selected as beneficiaries of the government R&D funding. The government subsidies accounted for about 8 per cent of Small and medium size firms' R&D expenditures in 1992. Both of these percentage numbers are too small to resolve the structural problem of Korea's small and medium size firms in enhancing technical capabilities.

contribute more broadly and fairly to the strengthening of the SMF's technical capability. The answer is also "no".

### 4.2.8 Problems in Collaborative Research

Since the seemingly successful management of cooperative R&D projects of the Japanese Ministry of International Trade and Industry (MITI), the economics of collaborative research even among rival firms have received considerable attention. Collaboration in research may allow firms to lower costs and risks, and it may reduce the disincentives to invest in intrafirm R&D that result from appropriability problems and spillovers among firms. The greatest difficulty in appropriating the returns to basic research means that this hypothesized advantage will be greatest for collaboration in basic research. R&D collaboration can also reduce duplication in the R&D investment of participating firms, and may allow participants to exploit economies of scale in the R&D process.

However, given the two natures of collaborative R&D among rival firms, i.e., the necessity for collaboration to fully use the limited technical resources on the one hand, and the reluctance to disclosure their proprietary technological knowledge on the other, firms participating in a joint R&D project face prisoner dilemma-like situation, where it is theoretically optimal for everybody to cooperate, but each firm finds it most comfortable to be isolated to the extent possible.

The output of collaborative research must be absorbed by the participant firms and transformed into commercially relevant knowledge. However, in order to exploit externally performed research, whether this research is performed in a multi-firm consortium, a federal laboratory, or a university, participant firms must invest in the creation of in-house expertise or "absorptive capacity". Some duplication of the in-house research investments of firms thus is inevitable even among participants in collaborative research projects.

Therefore, even in participating in a collaborative research project, it is inevitable for a firm to invest in the same in-house research project. The matter is how to balance the two. The problem of the collaborative projects supported by the Korean government, for instance the HAN projects, is that they were mainly carried out in the in-house research centers of individual participating firms.[62] Even though the government-sponsored public institutes supervised the projects and provided research facilities for executing collaborative basic researches to encourage the diffusion of technical knowledge among participants, the results in terms of cooperation have not been satisfactory. Since the projects targeted the development of commercial technologies, the participants inevitably tried to minimize the disclosure of proprietary technical knowledge. Since the participants were not complementary with one another in their technical expertise, this also minimize the motivation for cooperation. Under the circumstance the public institutes, which the government delegated the responsibility for supervising the project, faced limitations in facilitating the cooperation, and consequently their roles were superficial and unsatisfactory. If the collaborative projects can be said as nothing but supporting individual participants, usually chaebols, for executing same research in their in-house research facilities, it would have been more desirable to invest the money in other policy

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[62] In the case of HDTV and 64M DRAM projects, almost all major research activities were executed in individual firms' in-house research center. In the case of TDX-10 (electronic telecommunication switching equipment) and TICOM (medium size computer) projects, the government sponsored research activities were carried out by using the common research facilities in ETRI (Electronics and Telecommunication Research Institute; government sponsored public research institute), which was a supervisory agency. However, in this case, the firms have been criticized for sending relatively low quality researchers and for executing their in-house research respectively.

goals. For instance, top 11 chaebols accounts for 83 per cent of the patents registered in the United States. Furthermore, the top 4 chaebols, Samsung, Hyundai, Lucky-Goldstar, and Daewoo, which have been major participants in the Korean government's collaborative research projects, shares 50 per cent of the patents registered in the United States. Given this concentration of technical capabilities on small number of chaebols and the poor technical capabilities of other institutions (such as small and medium size firms and universities), it seems difficult to justify the current collaborative research systems of funding individual chaebols to execute similar research activities.

#### 4.2.9 Summary

The government's technology policy has contributed to the enhancement of Korea's technical capabilities. R&D investments, the number of research laboratories, and research manpower have increased rapidly. However, under the persistent inertia and culture of industry-specific policy of the 1970s, the technology policy during the last 15 years has more focused on the development of targeted commercial technologies (like the HAN project with the participation of conglomerates) than on the development of technical infrastructure. The promotion of higher educational institutes and the enhancement of small and medium size firms' technical capabilities have been delayed. Furthermore, even the national research projects like the HAN project have exposed substantial problems due to inefficient administrative processes. The Korean government needs to reconsider the goals and mechanisms of technology policies.

# Chapter 5

## Case Analysis of the Korea's Electronics Industry

The electronics industry has been a driving force of the Korea's economic development. In this respect, the analysis of the electronics industry provides detailed empirical evidences about the adequacy of the government's industry policy and technology policy as well.

### 5.1 Brief Review of the Development

Korea's electronics industry can be said to begin in 1958 when Goldstar began the assembly of the AM radio in small scale garage-operation. In the mid-1960s, Korea began the production of black and white TV sets through the international transfer of production technology. Since domestic firms had no capability to establish production operations, entrepreneurs who had previous trade contacts with foreign firms imported packaged technology from overseas which included assembly processes along with product specifications, know-how, technical personnel and component parts.[63] International transfer of packaged technology provided an initial ground for the development of domestic electronics firms.

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[63] See Kim (1980).

During the 1970s, domestic firms accumulated expertise in product design and production operation which provided a basis for indigenous efforts for the assimilation of imported technology. Then, increased competition in domestic and international markets and increasing capability of local researchers led to gradual improvement of foreign technology. Until the 1970s, inward foreign direct investment held a key role in developing the industry. Although the role was diminished rapidly during the 1980s, the foreign firms contributed to the expansion of exports and training of domestic work forces.

During the 1980s, Korean electronics firms began to diversify into more technology-intensive sectors. In 1983, Samsung succeeded in developing 64K DRAM through the technology transfer from Micron Technology, a US entrepreneurial, start-up company of the time. In the early 1990s, however, Samsung, Hyundai, and Goldstar succeeded in developing 16M DRAM based on domestic technological capability. In 1986, the four conglomerates co-developed the full-electronic switching equipment, called TDX-1, under the support and supervision of Korean Telecom, a state-owned telecommunication service company. TDX-1 was upgraded to TDX-10 in 1989. The same four conglomerates also co-developed a medium-range compute, TICOM, in 1991. During this period, Korea's electronics industry gradually entered into the technical development stage of producing at forefront of existing technology based on indigenous technological capability. Accordingly, domestic research and development efforts have been strengthened significantly throughout this period.

Since the late 1980s, Korean electronics firms have been internationalized rapidly. The firms established manufacturing facilities in the developed countries to avoid the trade conflicts. They also shifted manufacturing facilities for producing low-end products into South East Asian countries to maintain cost competence. They purchased foreign firms or established research centers in the developed countries, especially in the United States, to absorb the state-of-the-art technologies. For instance, Hyundai purchased several entrepreneurial firms in the Silicon Valley including Maxter, a hard-disk driver manufacturer while Samsung acquired HMS, an opto-electronic semiconductor company. In 1995, Goldstar even purchased Zenith, one of the last US consumer electronics firms, to acquire the high-technologies and brand reputations. Furthermore, in 1995, both Samsung and Hyundai announced the plan to build semiconductor manufacturing plants for producing 16M DRAM in the United States, which costs more than $1 billion respectively.

The government strategically promoted the electronics industry since the 1960s. Early in 1969, specific measures to promote the sector's development were incorporated in the Eight Year Electronics Industry Development Plan (1969-1976). This plan was integrated into the successive Five Year Economic Development Plan. In 1969 the government enacted the Electronics Industry Promotion Law that provided explicit policy measures to support the development of the industry. Among the policy measures in that law was the establishment of the Electronic Industry Promotion Fund. The fund was lent at preferential rates to firms investing in high priority areas. In particular, firms establishing R&D subsidiaries overseas were to be given preferential access to loans. The Fund was abolished in 1986, as the government has shifted in focus to functional incentives like

R&D subsidies from sector -specific industry policies. Since the mid-1980s the electronics industry has been a major beneficiary of the government's R&D funds.[64]

## 5.2 Major Features of Korea's Electronics Industry

### 5.2.1 Leading Industry of the Korean Economy

Since the mid-1980s, the electronics industry has been the major driving force to lead the Korea's industrial development and economic growth.[65] In 1994 the exports of the electronics industry accounted for 32.2% of Korea's total exports. Its value-added accounted for 14.0%, and its employment shared 11.6 per cent, of that of manufacturing industry respectively (Table 5-1).

TABLE 5-1 Basic Indicators of Korea's Electronics Industry

| | 1985 | 1990 | 1992 | 1994 |
|---|---|---|---|---|
| Total Exports (A) | 30,283 | 65,016 | 76,632 | 96,013 |
| - Electronics Exports (B) | 4,780 | 17,658 | 21,145 | 30,953 |
| Ratio (B/A, %) | 15.8 | 27.1 | 27.6 | 32.2 |
| VA in Manufacturing (A) | 24,530 | 52,351 | 60,001 | 69,536 |
| - Electronics VA (B) | 1,365 | 5,932 | 6,885 | 9,768 |
| Ratio (B/A, %) | 5.6 | 11.3 | 11.5 | 14.0 |
| Employment in mfg (A) | 3,504 | 4,911 | 4,828 | 4,696 |
| - Electronics (B) | 300 | 477 | 436 | 544 |
| Ratio (B/A,%) | 8.6 | 9.7 | 9.0 | 11.6 |
| R&D invest. in mfg (A) | 751 | 2,374 | 3,626 | 4,398 |
| - Electronics (B) | 292 | 993 | 1,216 | 1,769 |
| Ratio (B/A, %) | 38.8 | 41.8 | 33.5 | 40.2 |
| No. of researcher in mfg (A) | 18,996 | 38,737 | 51,074 | 54,078 |
| - Electronics (B) | 6,161 | 15,923 | 18,777 | 20,064 |
| Ratio (B/A, %) | 32.4 | 41.1 | 36.8 | 37.1 |
| Patents registered in mfg (A) | 2,268 | 7,762 | 10,502 | 11,683 |
| - Electronics (B) | 469 | 3,407 | 4,969 | 6,303 |
| Ratio (B/A, %) | 20.7 | 43.9 | 47.3 | 54.0 |
| R&D centers in industry (A) | 183 | 966 | 1,435 | 1,980 |
| - Electronics (B) | 50 | 346 | 562 | 774 |
| Ratio (B/A, %) | 27.3 | 35.8 | 39.1 | 39.1 |

Source. The Bank of Korea, Electronic Industry Association of Korea
Unit. exports: million $; Value Added and R&D investments: billion won; employment and researchers: thousand people (1993 data for R&D investments and number of researchers in 1994 column)

[64] About 40 per cent of the government subsidies for R&D has been provided to the electronics industry since the mid-1980s.
[65] In 1987 exports in electronics industry surpassed that of textiles industry, the leading sector since the 1960s.

The electronics industry also leads the research and development activities of the Korean economy. Since 1985, the R&D investments in the electronics industry accounted for more than 30 per cent of total R&D expenditures in the manufacturing industry. It has also employed more than 30 per cent of research personnel working for manufacturing industry. In the number of patents registered by the electronics industry was 469, only 20 per cent of the patents registered in manufacturing industry in 1985. The share rapidly increased so that in 1994 it reached 54 per cent. In addition, the electronics industry established 774 research centers by 1994, which accounts for 39 per cent of research centers established by all industry.

Korean electronics industry's status in international trade also enhanced gradually. The world market share of the Korea's electronics industry increased to 4.6 per cent in 1994 from 1.1 per cent in 1980. In the case of consumer electronics products, Korea's market share was 9.8 per cent in 1994, which is the second largest after Japan. In electronic components and parts, Korea's world market share was 8.2 per cent in 1994. This is remarkable development in that in 1980 the share was only 2.2 per cent. The rapid industrial development in components and parts area has been based on the successful entry into semiconductor businesses during the early 1980s. In industrial electronic products, however, the Korea's world market share was just 2.1 per cent in 1994 (Table 5-2). Considering that industrial electronic products are more technology-intensive, high value-added, and having the largest market size in the electronics industry, the poor performance of Korea this field represents that the Korea's electronics industry still lack in technical capabilities.

TABLE 5-2: The World Market Share of Korea's Electronics Industry
(unit: one hundred million dollar)

| | 1980 | | | | 1994 | | | |
|---|---|---|---|---|---|---|---|---|
| | Total | C | I | C/P | Total | C | I | C/P |
| World Market (A) | 2,615 | 383 | 1,610 | 622 | 7,289 | 726 | 4,502 | 2,601 |
| KoreanProduction(B) | 29 | 11 | 4 | 14 | 334 | 71 | 93 | 170 |
| Ratio (B/A,%) | 1.1 | 2.9 | 0.2 | 2.2 | 4.6 | 9.8 | 2.1 | 8.2 |

Source. Elsevier Advanced Technology, Electronic Industries Association of Korea
C: consumer electronics, I: industrial electronics, C/P: electronic components and parts

Korea's leading products in the electronics industry have evolved into more technology-intensive areas gradually. From the assembly operation of radios or semiconductors in the 1970s, the manufacturing of VCR, color CRT, and video tape dominated the industry's development in the mid-1980s. Today, the manufacturing of semiconductor memory chips, electronic telecommunication switching equipment, camcorders, and CDP are emerging as new leaders leading the development of Korea's electronics industry (Table 5-3).

TABLE 5-3: The Evolution of Major Products in Korea's Electronics Industry

| | 1970 | 1975 | 1980 | 1985 | 1990 |
|---|---|---|---|---|---|
| Consumer | .radio | .cassette<br>.B/W TV | .car stereo<br>.color TV | .VCR<br>.microwave oven | .camcorder<br>.CDP |
| Industrial | .mechanical switch | .CB transceiver<br>.electronic watch | .telephone<br>.semi-electronic switch | .CRT terminal<br>.cordless-phone | .computer<br>.electronic-switch<br>.facsimile |
| Component | .semiconductor assembly | .capacitor<br>.transmitter | .B/W CRT<br>.audio tape | .color CRT<br>.TV tuner<br>.video tape | .semiconductor memory<br>.electro-magnetic head |

Source. Korea Institute for Industrial Economics and Trade

### 5.2.2 Export-oriented Development

Export-pushing is a major driving force of Korea's economic development. The electronics industry has been a strategic sector for expanding Korea's exports. In 1975 when the subsidiaries of foreign firms still dominated Korea's exports in the electronics industry, exports accounted for almost 80 per cent of total production. During the 1980s, the period local electronic firms replaced the subsidiaries of foreign firms in the dominance of exports, the export ratio still exceeded 60 per cent. In 1994, export ratio again increased to 65 per cent due to the surge of semiconductor memory chip exports (Table 5-4).

TABLE: 5-4: Export Ratio of the Electronics Industry
(unit: million $)

| | 1975 | 1980 | 1985 | 1990 | 1994 |
|---|---|---|---|---|---|
| Production (A) | 736 | 2,911 | 7,475 | 29,352 | 47,008 |
| Exports (B) | 582 | 2,105 | 4,532 | 17,658 | 30,953 |
| Ratio (B/A, %) | 79.1 | 72.3 | 60.6 | 60.2 | 65.8 |

Source. Electronic Industry Association of Korea

Electronic components and parts has led exports in the electronics industry. Of the electronics industry's total exports, components and parts constitutes 57 per cent in 1994, increasing from 38 per cent in 1985. However, the share of consumer electronics industry in exports decreased from 42 per cent in 1985 to 24 per cent in 1994 while the share of industrial electronics did not change much from 20 per cent (Table 5-5).

TABLE 5-5: Export Structure by Sectors
(unit: %)

| | 1985 | 1988 | 1990 | 1994 |
|---|---|---|---|---|
| Components & Parts | 38 | 38 | 46 | 57 |
| Consumer | 42 | 41 | 33 | 24 |
| Industrial | 20 | 21 | 21 | 19 |

Source. Electronic Industry Association of Korea

However, the rapid expansion in the electronics industry's exports has been accompanied by structural problems. It has been heavily relied on OEM-based exports so that in 1993 about 40 per cent of color TVs, 55 per cent of VCRs, and 75 per cent of microwave ovens were exported with OEM brand. Except for this, Korea still heavily relied on imported key components for manufacturing export-leading products. This will be discussed in detail next.

### 5.2.3 Domestic Firm-Oriented Development

During the early stage of industrial development in the 1960s and early 1970s, inward direct foreign investment from the US firms like Motorola, Signetics, Fairchild Semiconductors and Control Data and series of joint ventures between Japanese and local firms played a major role in the development of the industry. The best indication of the importance of foreign enterprises is the proportion of bonded processing of total electronics exports in 1972, which amounted to 72 per cent (Table 5-6). However, the US firms used Korea as an assembly basis, exploiting the low labor costs, while the Japanese companies manufactured low-end electronic components which would export to Japan. Therefore, both the US and Japanese firms held little connection with Korea's domestic industry, and had little intention of shifting their Korean assembly base into more technology-intensive sectors.

TABLE 5-6: Electronics Exports by Company Classification

| | Total Export (million $) | Company Classification and Share of Exports (%) | | |
|---|---|---|---|---|
| | | Local Firms | Joint Ventures | Foreign Firms |
| 1968 | 20 | 21 | 8 | 71 |
| 1972 | 142 | 29 | 17 | 55 |
| 1975 | 582 | 26 | 23 | 51 |
| 1978 | 1,359 | 39 | 18 | 43 |
| 1980 | 2,003 | 48 | 15 | 37 |
| 1985 | 4,780 | 66 | 12 | 22 |
| 1990 | 17,658 | 76 | 9 | 15 |
| 1991 | 19,788 | 79 | 12 | 9 |

Source. Korea Exchange Bank: Industry in Korea

Since the mid-1970s the most significant feature of the industry has been the progression of domestic firms in the export business, so that by 1980 they were handling 48 per cent of electronics exports. In 1990 local firms shared 76 per cent of electronics exports. Local firms in the industry have accumulated experiences in product design and production operations that provided a basis for limited indigenous efforts for the assimilation of imported technology. Then, increased market competition in local and international markets and increasing capability of local personnel together with assimilation of foreign technology led to gradual improvement of foreign technology. This transition from relying on inward FDI to domestic mastery of existing technology was greatly facilitated by the transfer of skilled local staff from foreign-invested to domestically owned firms. Most production executives commenced work for foreign firms and then turned to domestic firms, bringing their skills with them.[66] Local components and parts manufacturers emerged in response to the local demands while four conglomerates in Korea, Samsung, Lucky-Goldstar, Daewoo, and Hyundai, aggressively expanded their electronics businesses.

### 5.2.4 Conglomerate-dominated Development

The development of the electronics industry in Korea has also been dominated by the big companies, especially the chaebol. In 1993 big companies which employed more than 300 workers accounted for 76 per cent of total sales volume in electronics industry, 77 per

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[66] See Michell (1988).

cent of value-added, while less than 3 per cent of company numbers and 55 per cent of employment (Table 5-7).

TABLE 5-7: The Structure of Korea's Electronics Industry (1993)
(unit: billion won, %)

| | company | | employment | | production | | value-added | |
|---|---|---|---|---|---|---|---|---|
| | number | share | number | share | amount | share | amount | share |
| Small&medium | 4,933 | 97.4 | 142,663 | 44.1 | 7,749 | 23.4 | 3,156 | 22.6 |
| (5-49) | 4,244 | | 72,266 | | 2,725 | | 1,282 | |
| (50-299) | 689 | | 70,397 | | 5,024 | | 1,874 | |
| Large (300- ) | 131 | 2.6 | 180,805 | 55.9 | 25,305 | 76.6 | 10,815 | 77.4 |
| Total | 5,064 | 100 | 323,468 | 100 | 32,054 | 100 | 13,971 | 100 |

Source. Bank of Korea, Statistics of Korean economy, various issues

However, of the large companies, many firms are the affiliates and subsidiaries of the conglomerates, Samsung, Lucky-Goldstar, Daewoo, and Hyundai. As shown in Table 5-8, the top three companies, which are members of chaebol groups, accounted for 58 per cent of Korea's total production of the electronics industry in 1990. And the share increased to 65 per cent in 1993.

TABLE 5-8: The Concentration of Korea's Electronics Industry
(unit: billion won)

| | 1990 | 1993 |
|---|---|---|
| Electronics Industry Production (A) | 21,718 | 32,847 |
| . Samsung | 5,998 | 10,888 |
| . Lucky-Goldstar | 4,731 | 7,315 |
| . Daewoo | 1,896 | 3,203 |
| . Subtotal (B) | 12,625 | 21,406 |
| Ratio (B/A, %) | 58.1 | 65.2 |

Source. Korea Institute for Industrial Economics and Trade, Strategies for Korea's Electronics and Information Industries towards 21st Century, 1995.

Furthermore, the conglomerates also dominated R&D activities. In 1992 the R&D expenditures of top 5 electronics firms accounted for 74 per cent of total R&D expenditures in electronics industry, top 10 companies, 86 per cent, and top 20 companies 92 per cent. These numbers are far larger compared with the situation in manufacturing industry: top 5 companies shared 30 per cent in total R&D investments in industry total, and top 20 companies, 49 per cent. In the distribution of R&D personnel, top 5 companies possessed 56 per cent of total R&D work force in electronics industry, while the ratio is just 28 per cent in industry total (Table 5-9).

TABLE 5-9: R&D Concentration on Large Firms (1992)
(unit: billion won, %)

| | Electronics Industry | Industry total |
|---|---|---|
| R&D expenditures (A) | 1,135 | 3,626 |
| - top 5 (ratio:top5/A) | 848 (74.7) | 1,092 (30.1) |
| - top 10 (ratio:top10/A) | 986 (86.8) | 1,417 (39.1) |
| - top 20 (ratio:top20/A) | 1,044 (92.0) | 1,804 (49.8) |
| No. of R&D personnel (A) | 15,923 | 35,473 |
| - top 5 (ratio:top5/A) | 8,917 (56.0) | 9,933 (28.0) |
| - top 10 (ratio:top10/A) | 10,391 (65.3) | 12,378 (34.9) |
| - top 20 (ratio:top20/A) | 11,730 (73.7) | 15,284 (43.1) |

Source. Korea Industrial Technology Association, Major Indicators of Industrial Technology, 1994.

### 5.2.5 Mass-Production-oriented Development

Since the Korea's electronics industry has been developed around large companies, its major products have been concentrated on capital-intensive, mass-production sectors, where financial capabilities to expand capacity rapidly to achieve substantial scale economies and R&D capabilities to continuously carry out incremental improvement of technology and product quality, are crucial.[67] Indeed, the conglomerate organizational mode, together with the large size of the individual firms which make up the conglomerate, has provided lots of advantages in penetrating such sectors where entry

[67] In this respect, Korean electronics industry's development procedure has been quite contrary to that of Taiwan, where small and medium-sized firms have played a key role by exploiting worldwide niche markets based on their flexible management, nimble decision-making, and sophisticated information networks. However, recently, Taiwan's electronics industry is experiencing structural adjustments, being more concentrated on several large firms, such as Tatung, Nan Ya, and Acer while Korea is trying to promote small and medium size firms that have technical capacity to compete both internally and externally.

barriers are high and the uncertainty of new ventures is substantial. Consequently, as shown in Table 5-10, the top 10 leading export-products locate in these capital-intensive, mass production sectors, except for measuring equipment.

However, the mass-production oriented structure, together with conglomerate mode organizational structure, exposes several problems. As the economies of scale and scope become less and less important, as improved telecommunications lead to a large decline in marketing and information gathering costs, and as capital markets become more and more sophisticated, the advantages of Korean electronics industry based on big firms and mass-production skills will be gradually reduced. Furthermore, the mass-production schemes relying on several big firms has been easily exposed to advanced countries' import restrictions. Almost all export leading products listed in Table 5-10 were involved in anti-dumping or patent infringement suits in the United States and European Union markets. Without complementing small and medium-size firms with technical competence and marketing capability to exploit worldwide niche markets, it is difficult for Korea to further the development of the electronics industry.

TABLE 5-10: Top 10 Export Leading Products (1994)
(unit: $ million, %)

| Products | Exports (share) |
|---|---|
| Semiconductors* | 12,265 (39.6) |
| Computer Peripherals | 2,856 (9.2) |
| Color TV | 1,622 (5.2) |
| VCR | 1,480 (4.8) |
| Color Picture Tube | 900 (2.9) |
| Magnetic Tape | 872 (2.8) |
| Microwave Oven | 780 (2.5) |
| Cassette Recorder | 757 (2.4) |
| Car Stereo | 464 (1.5) |
| Measuring Equipment | 381 (1.2) |
| Sub-total | 22,377 (72.3) |

Source. Electronic Industry Association of Korea, 1995

*most of semiconductors exported by Korea are memory chips which are sensitive to scale-economies and mass-production capabilities. Korea has been weak in MPU/MCU or customized chip production which requests sophisticated design capabilities.

### 5.2.6 Assembly-based Development

The Korea's electronics industry has heavily relied on imported components and parts. The focus on assembly process was an inevitable and effective choice for Korea given that it lacked in technical and financial capabilities to develop key components in parallel. It has also gradually localized components and parts. For instance, about 90 per cent of components is localized for color television manufacturing, and 70 per cent for VCR. However, recently, as the Korean electronics industry entered into more technology-intensive industries, and as the product life cycle became shorter, the situation as a whole has not improved. As shown in Table 5-11, the import-dependency rate of electronic components and parts is not improved below 55 per cent. Furthermore, the dependency of general components except for semiconductors increased through the late 1980s and 1990s due to the rapid increase of key components imports.

This shows the late comer's disadvantages of chasing moving technical targets. At the same time, it represents that Korea as a whole has failed to promote key components industry which is critical to sustain the competitiveness of the electronics industry. For instance, in terms of price, Korea still relied 50 per cent of components on imports in camcorders, 35 per cent in CDP, and 30 per cent in high quality VCR. Custom semiconductors, electro-optical components, and CCDs, and small size motors are key components that Korea cannot localize.

TABLE 5-11: Supply/Demand Structure of Electronic Components and Parts
(unit: million $, %)

| | | 1988 | 1991 | 1994 |
|---|---|---|---|---|
| Production | Total | 9,747 | 14,946 | 25,703 |
| | - semiconductors | 3,066 | 6,397 | 16,130 |
| | - general comp.&parts | 6,681 | 8,549 | 9,573 |
| Imports | Total | 5,414 | 6,973 | 9,665 |
| | - semiconductors | 3,152 | 4,757 | 6,466 |
| | - general comp.&parts | 2,262 | 2,216 | 3,199 |
| Exports | Total | 5,850 | 9,385 | 17,827 |
| | - semiconductors | 3,178 | 5,586 | 12,984 |
| | - general comp.&parts | 2,672 | 6,966 | 4,843 |
| Domestic-demand | Total | 9,311 | 12,534 | 17,541 |
| | - semiconductors | 3,040 | 5,568 | 9,612 |
| | - general comp.&parts | 6,271 | 6,966 | 7,929 |
| Trade surplus | Total | 436 | 2,412 | 8,162 |
| | - semiconductors | 26 | 829 | 6,518 |
| | - general comp.&parts | 410 | 1,583 | 1,544 |
| Export-rates | Total | 60.0 | 62.8 | 68.2 |
| | - semiconductors | 103.7* | 87.3 | 80.5 |
| | - general comp.&parts | 40.0 | 44.4 | 50.6 |
| Import-dependency | Total | 58.1 | 55.6 | 55.1 |
| | - semiconductors | 103.7* | 85.4 | 67.3 |
| | - general comp.&parts | 40.0 | 31.8 | 40.3 |

Source. Electronic Industry Association of Korea

* Semiconductor production relied much on assembly of imported chips in 1988. Since the production only counts value-added while exports counts export prices, exports exceeded the production value until the late 1980s.

### 5.2.7 Rapid Internationalization

Since the late 1980s, Korean electronics industry has rapidly internationalized. As Korea's big-push of exports resulted in trade conflicts with advanced countries, especially the United States and European Commissions, and consequently as those countries raised trade barriers against Korea's electronic products, the Korean firms, especially the conglomerates rapidly invested in those countries to sustain and to further market share in those countries. At the same time, due to the rapid increase of real wages since the mid-1980s, Korean electronics industry has lost its traditional comparative advantage of low labor costs against South East Asian countries, where labor costs are much lower while Japanese electronic firms' investments provide the needed technologies for manufacturing electronic products. In the face of this new challenge, Korean firms rapidly increased investments in these countries to manufacturing low-end products. As a result, foreign subsidiaries of Korean electronic firms increased to 661 in 1994 from 131 in 1989. In the case of manufacturing subsidiaries, slightly more than 50 per cent of subsidiaries were located in Asia, which represents that not only large firms but also small and medium-size firms invested in those areas (Table 5-12).

TABLE 5-12: Number of Outward Foreign Direct Investment

| | ~ '89 | '90 | '91 | '92 | '93 | '94 | Total |
|---|---|---|---|---|---|---|---|
| Total | 131 | 74 | 67 | 76 | 116 | 197 | 661 |
| For manufacturing | 48 | 43 | 47 | 52 | 89 | 164 | 443 |
| . Asia | 26 | 31 | 39 | 40 | 69 | 142 | 347 |
| . North America | 6 | 5 | 5 | 6 | 10 | 18 | 50 |
| . Europe | 12 | 5 | 3 | 5 | 9 | 2 | 36 |
| For Sales | 78 | 24 | 18 | 21 | 24 | 28 | 193 |
| . Asia | 25 | 8 | 5 | 6 | 7 | 10 | 61 |
| . North America | 27 | 9 | 4 | 4 | 7 | 10 | 61 |
| . Europe | 19 | 6 | 8 | 10 | 8 | 4 | 55 |
| For R&D | 5 | 7 | 2 | 3 | 3 | 5 | 25 |
| . Asia | - | 2 | 1 | 2 | 1 | 1 | 7 |
| . North America | 4 | 4 | 1 | 1 | 2 | 4 | 16 |
| . Europe | - | 1 | - | - | - | - | 1 |

Source. Electronic Industry Association of Korea

Consequently, the share of foreign production has been increased. In the case of color TV sets, the share of foreign production in total production has increased from 19 per cent in 1992 to 28 per cent in 1995. In VCR the share was 16 per cent, and 20 per cent respectively at the same year.

At the same time Korean firms' outward FDI for acquiring the state-of-the-art technologies and marketing assets has been also increased. This type of FDI is mainly concentrated on semiconductors and computers, and on the United States geographically. Major cases are illustrated in Table 5-13.

TABLE 5-13: Outward FDI of Korean Firms for Acquiring Competitive Assets

| Company | Contents | Location | Major Figures |
|---|---|---|---|
| SAMSUNG | Acquisition of HMS | Silicon Valley (USA) | .100% acquisition ($4.2million), '95.4,<br>.III/V semiconductor manufacturing |
| | 16M-DRAM manufacturing | Austin, Texas (USA) | .100% investment ($1.5billion)<br>.'96.4 construction beginning |
| | 4/16M-DRAM manufacturing | Portugal | .Joint venture with Texas Instrument<br>.'94.8 operation beginning ($30million) |
| | AST's Equity acquisition | Silicon Valley (USA) | .40.24% of equity |
| Hyundai | Acquisition of Maxter | Silicon Valley (USA) | .100% acquisition ($150 million)<br>.Hard-disk manufacturing/marketing |
| | Acquisition of AT&T/GIS | Colorado (USA) | .100% acquisition ($340million) '95.2<br>.Non-memory semiconductors (MPU/MCU) |
| | 16M-DRAM manufacturing | Oregon (USA) | .100% investment ($1.3 billion)<br>.will begin construction in '96. |
| Goldstar | Acquisition of Zenith | - | .100% acquisition<br>.Flat screen TV technology/Brand reputation |
| Daewoo | research center establishment | New Jersey | .Development of Digital semiconductors for multimedia ($100 million) |

### 5.3 Evaluation of the Technology Policy in the Electronics Industry

Until the mid-1980s, Korea's electronics industry had poor indigenous capability to develop advanced technologies while it faced imminent need to upscale into high value-added products. Under the circumstances, since the revenue base of the Korean government were relatively small compared with that of advanced countries, it was imperative that, to the extent feasible, Korea be highly selective in their choice of research projects in an effort to maximize the effectiveness of the expenditures. In this respect, in general, the government's technology policy for accelerating technical learning in the electronics industry has targeted product modifications, development of commercial technologies, and process development than the creation of new product design ideas and basic research. Consequently, as shown in Chapter 4, together with other incentives such as tax benefits and low interest loans for facilitating private firms' R&D efforts, the government has intended to focus its R&D budget on small number of selected projects carried out by limited number of firms. This can be reasonable choices given that the Korean electronic firms in the mid-1980s did not so much stressed the importance of developing their indigenous technical capability as they do now. Therefore, the government needed to stimulate private firms' R&D efforts by selecting model-case projects and firms. However, the problem is that this basic philosophy has not evolved according to changing circumstances. It prevails in current government's decision-making mechanisms and officials' minds as an undesirable inertia. Basically, the potential problems of the technology policies for the electronics industry are the same as those discussed in Section 4.2: inefficient administrative structure; poor development of higher educational institutions; weakness of small and medium size firms' technical capabilities; weakness in basic research capabilities; potential problems entailed in national R&D projects. Detailed discussion of several issues in the case of the electronics industry may suggest a yardstick to measure the adequacy of the government's technology policies.

The Korean government has potential problems in the administrative procedures for selecting national R&D projects: conflicts among technology policy-related ministries;

inefficient interministrial coordination mechanisms; and unclear criteria for selecting projects; inefficient mechanisms for diffusing technical information among participants and to third parties. The Very Large Scale Integrated Circuits (VLSI) project, which aims to develop Dynamic Random Access Memory (DRAM) semiconductor chips, represents the problems well. The VLSI project have supported and will support the development of five generations of DRAM product from 1986 to 1997. Of 460 billion won (about $6 hundred million) of total R&D expenditures, the government supports 40 per cent. The government extended the project in 1993 to co-develop 256M DRAM and 1G DRAM by 1995 and 1997 respectively. However, at that time, the Korean semiconductor industry already had international competence in DRAM business. Samsung became the world's largest provider of DRAM in 1994, surpassing the formidable Japanese semiconductor manufacturers such as NEC, Toshiba, and Hitachi. The combined sales revenues of three Korean semiconductor firms (Samsung, Goldstar, Hyundai) accounted for about 30 per cent of the world DRAM market. Under this situation, the Korean semiconductor firms seem to hold sufficient motivation and capability to carry out the R&D with their own financial resources. Furthermore, ironically Goldstar made a contract with Hitachi in 1991 to cooperate in technical development and manufacturing of DRAM without any connection with the national R&D project. Based on this contract, Goldstar imported DRAM manufacturing technology from Hitachi. Samsung is now also seeking for international partner to develop 256M DRAM. All these activities verified that, on the one hand, the technology diffusion procedures of the national project has not been sufficient to upscale the technical capability of local firms to even level. And on the other hand, the government does not establish manifest mechanisms to integrate international R&D cooperation into its national projects. Given that the government had lots of other policy goals, the survival of the VLSI project in 1993 implies the current mechanisms for national R&D projects have some potential problems.

The Ministry of Trade and Industry (MTI) launched the Mainframe Computer Development project in 1994 while the Ministry of Communication was pursuing a similar project. The four largest conglomerates (Samsung, Goldstar, Daewoo, Hyundai) are the major participants, and therefore the major beneficiaries, of this project. The execution of two duplicative projects with same firms throws a question that whether there is interministerial level criteria to select national R&D projects. Rather than higher government level decision rules, spontaneous negotiations and compromises among relevant ministries seem to dominate the selection of the projects.

Furthermore, the government has executed HDTV and Cellular-phone Communication System development projects.[68] In both of the two projects, international standardization threw a subtle but critical implication to successful execution of research. As well known, the Japanese and European HDTV technologies, which had lead the technical competitions based on the improvement of existing analog technologies, became outmoded when the United States chose digital techniques as its standard for high-definition televisions. Since the digital technology is more efficient than analog technology in transmitting and processing signals and information, Japan and European Union inevitably followed the digital techniques as its standard. In cellular phone systems as technology evolved form analog to digital, there have been fierce competitions among

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[68] The HDTV project has been carried out from 1990 to 1993 under the government's R&D subsidy provision with participation of three major consumer electronic firms, again Samsung, Goldstar, and Daewoo. About $100 billion was invested in the project and the government provided 45 per cent of this investment.

the United States and European Union to dominate international standard based on its own digital technology. In addition, a small US venture firm, Qualcom, suggested another digital technology, CDMA, which is technically and conceptually more excellent than existing TDMA digital technology. However, the CDMA technology has been commercially unproved until now. In addition, international standard has not established so far. Under the circumstances, the Korean government initiated the R&D projects in both of these two fields. In 1993 Korea succeeded in developing HDTV prototype based on digital technology, which, however, needs continuous technical improvements by monitoring international trend of standardization. In cellular phone system, the MOC launched CDMA-type system development project while later the MOC started a R&D project to develop a TDMA-type hand-held telephone. All these projects were again executed by the same four conglomerates (Samsung, Goldstar, Hyundai, and Daewoo).

If looking at just the projects themselves, all have their own rationale to justify their presence in the government's national R&D projects. The four conglomerates still lacks in international competence against US, European, and Japanese firms, which dominate world markets and are very reluctant to transfer technologies to potential future competitors like Korean electronic firms. However, if looking at the projects at the highest level of government, the National R&D projects are exposing potential problems. The point is that the Korean government needs to evaluate objectively whether it has clear criteria at the highest level for selecting national R&D projects, whether it has not been excessively exposed to the interjection of interest-group politics, especially from the conglomerates, and whether the struggle among technology policy-related ministries has somewhat distorted the decision-making process.

The underdevelopment of higher educational institutions for training scientists and engineers draws on one of a significant problem in furthering the development of the electronics industry. As shown in Table 5-14, a survey conducted by a industry association for the perspective of supply and demand structure of researchers in the electronics industry suggests that Korea may face a serious researcher shortages, especially in higher degrees: masters and Ph.D.[69] However, there will be researcher surplus with bachelor degree.

TABLE 5-14 Perspective on the Supply/Demand of Researchers in Electronics Industry

| | | 1994 | 1996 | 1998 | 2000 |
|---|---|---|---|---|---|
| Bachelor | Demand | 8,315 | 8,686 | 9,132 | 9,913 |
| | Supply | 9,834 | 10,009 | 10,149 | 10,203 |
| | Surplus | +1,519 | +1,383 | +1,017 | +290 |
| Master | Demand | 3,296 | 3,484 | 3,831 | 4,653 |
| | Supply | 2,445 | 2,474 | 2,505 | 2,114 |
| | Surplus | -851 | -1,010 | -1,326 | -2,539 |
| Ph.D. | Demand | 752 | 831 | 1,136 | 1,274 |
| | Supply | 617 | 669 | 762 | 834 |
| | Surplus | -135 | -162 | -374 | -440 |

Source. Information and Communication Industry Association of Korea, *Computerized Society*, 1995

Given that Koreans, in general, have strong preference for higher degrees , the structure of surplus in bachelors and shortage in masters and Ph.D. implies that the current university educational systems can not accommodate enough numbers of masters and Ph.D. students that the industry needs. In this respect, Korean government's technology policies during the 1980s and the early 1990s have failed in raising enough number of researchers, one of the most fundamental and important policy agenda.

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[69] In this survey, software and telecommunications industry, together with electronics (hardware) industry, were included.

In responding to the "computerization wave", the deregulation/reregulation of relevant legal systems for establishing new business environments is a crucial factor for upscaling the electronics industry. Indeed, the refining of legal systems is a important policy measure to establish and implement articulate technology policies. Therefore it must interact with the technology policies. The rapidly progressing deregulation in telecommunications, press media, and broadcasting in the United States represents the importance of this task. However, the Korean government again faces a potential problem and the problem again is stemmed from territorial struggle among relevant ministries. As a less developing country, unconditional liberalization and deregulation are not always desirable for the development of the Korea's electronics industry and the economy as well. Given that the telecommunications, information, and even electronics industries are now being dominated by a few number of huge multinationals from advanced economies, gradual deregulation procedures can be more desirable for the Korean industries. However, regardless of this fact, the current government structure does not well meet the policy demands under new environments. The role is too fragmented and dispersed into too many ministries. For instance, broadcasting and press media industries are under the control of the Ministry of Information, while the Ministry of Communication is in charge of telecommunications and data communications with unclear distinctions. In Addition, the Ministry of Trade and Industry assumes the responsibility for promoting manufacturing industry. Very often, the conflicts among those relevant ministries have resulted in time-consuming, and distorted administrative procedures.

# Chapter 6

## Discussions and Conclusions

The Korean government's sector-specific industry policy during the 1960s and 1970s can be said successful. During those days, since the Korean economy and the institutional organizations were small in size and simple in structure, and since the industrial development was the most important national goal with strong support and supervision from the President, the strong government intervention under centralized economic development plan could be effective and efficient. By contrast, the Korean government's technology policy has been developed and implemented under different circumstances. During the 1980s, the sophisticated structure of the Korean economy did not request excessive government interventions. In this regard, the government faced a potential problem in establishing centralized technology policies in that time. However, even though the government, at the macroeconomic policy level, pronounced liberalization, deregulation, decentralization, and internationalization as basic policy directions, the past centralized and domestic-oriented culture has dominated planning of microscopic technology policies. As a result, rather than policy tasks for strengthening the technological infrastructure (facilitating technology diffusion based on decentralized plan), selecting strategic technological projects and focusing limited budgets on those projects (picking winners based on centralized plan) has been the major shape of the Korean government's technology policies during the 1980s. As pointed out before, those selective policy could be desirable since the Korean government's budget base was much smaller than that of advanced countries, and since the government needed to be more selective in its choice of projects. Yet the absence of powerful coordinating agency to orchestrate a nationwide technology policy together with the too excessive territorial conflicts among technology policy-related ministries have prohibited the government from establishing and implementing optimal policies. Under the circumstances, the execution of other policy tasks (such as the establishment of higher educational systems for raising qualified engineers and scientists and the construction of technical infrastructure where small and medium size firms' technological capabilities could be built on) have been delayed. In this regard, the Korean government's technology policy during the last 15 years can be judged as continuous failures not to meet the substantial, but tacit demands for correcting the structural problems in Korea's technological environments. The Korean government now needs to reconsider the goals, tools, and mechanisms of technology policy .

First, Korea needs to reorganize the administrative process for technology policies. Most importantly, at the highest level of government, the establishment of a powerful coordinating agency is requested. The agency needs to hold explicit policy measures to enforce the technology policy-related ministries to cooperate. The agency also needs to establish more rational decision-making criteria and rules to prioritize research projects. It also needs to establish a mechanism through which technology policies are integrated into other national plans such as economic, educational, and environmental programs. To carry out this task, it needs to set-up a high profile committee constituted by ministers in charge of government budgets, finance and tax systems, education, science, industry, communications, and defense.

Second, Korea needs to promote the research capabilities of higher educational institutions. As described in Chapter 2, the sufficient provision of highly educated engineers and scientists constituted one of the most crucial factors for Germany and the United States to catch-up with Britain in the early twentieth century. Today's negligence of this task will compromise the future progress of Korea's industrial development.

Third, as for the big national projects, Korea needs to establish more rational decision-making rules for selecting projects to avoid the government failure due to the influence of small number of politically more powerful clients. Given the limited budgetary capability of the Korean government, if it is difficult to rationalize the administrative procedures under the current system, it is more desirable to shift the funds for the national projects into the programs for promoting technical infrastructure so that the benefits are shared more widely and fairly. In addition, given the limited technical capabilities of Korea, it is impossible to achieve technical competitiveness in almost all high-technology industries such as semiconductors, new energy sectors, biotechnology, aerospace, and telecommunications as aimed by the HAN project. Therefore, Korea needs to narrow the scope of the national projects

Fourth, with regard to basic science research, the Korean government need not to hurry to strengthen relevant policies. The benefits of basic science usually come in a indirect way and are not totally appropriable by a country to invest. In this respect, even the advanced countries like the United States tends to minimize the expenditures in basic science. In addition, as shown in the industrialization of the United States in the late nineteenth century, the enhancement of scientific capabilities often lags the industrial development and technological advances. Given the limited budgetary base of the Korean government, it may be inevitable to minimize the resource allocation in basic science research.

Fifth, As for the enhancement of small and medium size firms' technological capabilities, rather than selective subsidizing of R&D funds to small number of firms, other policy measures like education and training, the supply of researchers, and the provision of market and technological information, are more desirable. A low interest rates loans can substitute the R&D subsidies for selective research projects.

Sixth, the government needs to minimize the arbitrary encouragement of collaborative research among rival firms. As long as the goal of the research is closely related to commercialization, which is an inevitable choice for Korea for the time being, the past experience has proved the deficiencies of this system. Under the current circumstances, Korean firms have enough motivation to collaborate with rival firms for developing commercial technologies without the government's coordination and financial supports, whether they are large, medium, or small firms.

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