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CRISIS, NATIONAL INNOVATION, AND REFORM IN SOUTH KOREA

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Abstract
The greatest strengths in South Korea's national innovation system in the early decades have become its most serious liabilities in the recent decade, as South Korea has failed to adapt itself to the rapidly changing political and economic environment. This paper first assesses the impact of the Asian crisis of 1997 on South Korea's national innovation system. The crisis has resulted in numerous negative consequences in the short-term, but also provided a rare opportunity for South Korea to fix its system in the long-term. The paper then discusses how South Korea has progressed in reengineering the various aspects of the system that has bearing on the future competitiveness of its economy. South Korea will make major changes to accommodate to globalization, but increasing globalism will be a means toward a nationalist end.

INTRODUCTION
From 1962 to 1997 South Korea achieved remarkable economic growth, an average of nearly eight percent per year. Such phenomenal growth is largely attributed to a strong national innovation system, which functioned effectively from the 1960s through the 1980s. A national innovation system reflects the strengths or weaknesses of a nation in sustaining its competitiveness through innovation by its firms in interaction with other firms and supporting institutions. But in 1997, South Korea plummeted down to a serious economic crisis. Unlike previous economic disruptions, which had been evoked by external shocks such as oil crises, the 1997 and 1998 crisis that affected South Korea stemmed from fundamental structural weaknesses in its institutions that support national innovation. The developmental state consolidated sufficient power to pick "winners" and mobilized and allocated resources to them for ambitious developmental goals, achieving phenomenal industrial growth in the early decades. However, this approach eventually led to corruption and collusion between the state and big businesses, and mismanagement of the financial sector with serious resource misallocation. The *chaebol* relied heavily on state protection, which resulted in diversification by big businesses beyond their financial and technological capabilities. Lack of transparency and accountability in the economic system was also a serious problem. As a result, the balance of payment in trade declined from $7.6 billion in surplus in 1987 to $20.6 billion in deficit in 1996 and accordingly foreign debt increased from $31.7 billion in 1990 to $156 billion in 1997. Recognizing the weak economic system and declining competitiveness, foreigners withdrew their investments from South Korea in 1997, leading to the Asian crisis.

Greek mythology gives an interesting paradox that is still seen in this industrial society. The fabled Icarus constructed powerful wings that enabled him to fly so high, so close to the sun that his artificially waxed wings melted and he plunged to his death (Miller, 1990). The paradox also applies to South Korea; greatest strengths in South Korea's innovation system in the past became its most serious liabilities in recent years (Kim 1997, 2000). South Korea's core competence through the 1980s has become core rigidity in the 1990s according to the Leonard-Barton's term (1995).

After the Asian crisis and the subsequent bailout by the International Monetary Fund (IMF), the new government, the first one in South Korean history that changed power through a democratic process, launched in early 1998 major reforms in four areas: the public sector, the financial sector, *chaebols* (family-owned large conglomerates), and the labor market. Most of the reform programs had long been discussed but never implemented because of inertia and resistance from stakeholders. Several months prior to the crisis, a major study of the SouthKorean economy by Booz, Allen, and Hamilton (1997) reported two surprises. The first is that many good studies were available in South Korea, diagnosing and prescribing the problems of its economy. The second was that none of them had been implemented. The crisis, however, provided South Korea with a rare opportunity to carry out reform programs aggressively. The crisis was painful in the short-term, but a "blessing in disguise" in the long-term.

There is no one best way to describe the different innovation systems that characterize countries of diverse sizes, stages of economic development, and historical experiences (Nelson, 1993). There are, however, many common features among different definitions (Freeman, 1995; Lundvale, 1992; Nelson, 1993). That is, firms should be at the center of a nation's innovation system because they are the organizations that translate technological resources, which the system generates, into innovations. With firms in the center, an innovation system can be seen as a set of interactions among five sectors under four critical environments. The former encompasses the industrial, global, domestic support, financial, and education sectors. The four critical environments include: market and technology, government and policy, labor market, and socio-culture.

This paper first discusses the impact of the Asian crisis on South Korea's system of innovation, and then what South Korea has done in attempts to reengineer that system in order to improve the performance of the various sectors and create a more conducive environment for innovative activities.

Innovation in the Aftermath of the Crisis

The Asian financial crisis has undoubtedly resulted in tremendous economic and social consequences in South Korea in terms of rising bankruptcies and unemployment and dwindling living standard. It also affected the various aspects of South Korea's innovation system that have bearings on the future competitiveness of the economy.

Government and Policy Environment

The South Korean government had been recognized as one of a few relatively successful developmental states (Evans, 1995). In 1961 a military coup consolidated sufficient state power to mobilize and allocate resources for ambitious developmental goals. The state achieved autonomy from vested interests of the stakeholders, and was competent to formulate and implement strategies and policies for rapid economic development in the 1960s and 1970s.

In the subsequent decades, however, the government changed little in response to radical transformation of the social and economic environment. The military government did make structural changes at the central government ministry level over 48 times before 1997, and many more incremental changes in operating systems and deregulations. Despite these efforts, the government sector continued to expand and became increasingly rigid. The agricultural civil service, for example, grew 500 percent despite a 33 percent decrease in the farming population over the past thirty years. The government continued to function as a developmental state, hindering the development of a free market economy by authoritative dictates, frequent intervention in the market, and unnecessary regulations. Non-transparent policies and inaccessible administration nurtured dubious collusion between the government and *chaebols*, leading to political corruption. The *chaebols* were unable to launch large-scale projects without the support of powerful politicians. Moreover, the government had to rescue many financially troubled *chaebols* under political pressures. In return, illegal contributions to politicians and bribery of bureaucrats became widespread in South Korean society. The result was serious misallocation of resources, leading to the erosion of competitiveness. In addition, the concentration of power in the central government stifled the development of local governments. As a result, the competitiveness of the South Korean government sector as a whole was ranked 34th, management efficiency 44th, and the degree of its intervention at the bottom of 46 countries under a study in 1997 (IMD, 1998).

After the Asian crisis, the elected administration of Kim Dae Jung set government reform as one of its highest priorities. Upon inauguration the incumbent administration took several extraordinary measures intended to have lasting effects on the productivity improvement of the government sector. First, the new administration established a permanent government body, the Government Reform Office (GRO) headed by an assistant minister, with the explicit mandate to reform the public sector. This office, with a powerful link to budget mechanisms, is designed to carry out reform as an institutionalized continual process of self-innovation, compared to transient ad hoc spurts of changes in the past. Second, the administration invited 19 private consulting organizations to help determine the appropriate scope and function of all central government ministries as well as selected local governments, and to review their current work and management system. This is something that had previously been unimaginable in a society where civil service comes at the top of the social hierarchy. Third, the post-crisis reform drive differed markedly from similar attempts in the past in terms of its scope, comprehensiveness, and intensity.

It is premature to evaluate the outcome of government reform in three years (1998-2001), but the downsizing of both the central and local governments has resulted in savings of approximately US$3 billion. Some of the central government functions had also been transferred to local governments, outsourced or privatized, or transformed into executive agencies. In addition, the new administration introduced an open career system (20 percent of high level positions open to the private sector), performance-based management system, various measures to improve flexibility and efficiency in public finance and eliminated half of over 11,000 regulations (Kim, 2000b). In short, the government has implemented more reform programs in two years than had been implemented in the previous 50 years. As a

result, the IMD ranking of competitiveness in the government sector has ascended from 34th to 26th in the two years (IMD, 2000).

The Asian crisis also triggered the government to restructure its administrative apparatus for coordinating public science and technology efforts. A separate Ministry of Science and Technology appears ostensibly to be an ideal structural arrangement to focus its efforts on S&T, but it has, in fact, no power to function adequately in bringing about effective coordination across different ministries. As a result, its function to formulate and implement S&T policy has been decoupled from the nation's economic and social development programs. To put S&T at the center stage of its developmental effort, responsibility to formulate and implement S&T policy across different industries should be integrated, like in some advanced OECD countries, with that to formulate and implement the nation's economic policy. For this purpose, the government established the National Science and Technology Council to be chaired by the President of the nation. Unlike a similar council chaired by the statutory Prime Minister in the past, the new organization is expected to bring about more effective coordination among fourteen different ministries in the government that are active in science and technology.

In pursuing further reform, the government faces new challenges. First, concerted efforts should be rendered to change organizational culture (a new pattern of thoughts and behavior of people in the government sector) that is compatible with the logic of the new organization and management systems that have been introduced in the past three years. Organizational culture is harder to change than a management system is. No system can be implemented as effectively as designed without support by a compatible culture. Second, in the wake of rapid economic recovery, civil servants are less willing than before to accept painful reform, making it difficult to reengineer South Korea's innovation system.

The Financial Sector

The financial sector has long been a tool of collusion between the government and the *chaebol*s, resulting in major resource misallocation and huge non-performing loans, particularly after the Heavy and Chemical Industry program in the 1970s. This had long been recognized as one of the most serious problems in the South Korean economy. But moral hazards on the part of technocrats and politicians have kept the sector from correcting the problems. Such weak financial infrastructure including poor prudential oversight allowed excessive foreign borrowing on the short term, leading to panic by foreign investors and financial crisis.

The Asian crisis has enabled the new government to take bold steps and to introduce a major reform program in the financial sector. At the outset of the Asian crisis, the National Assembly passed legislation to reform the financial system. The law, among other things, has created two public agencies—the Financial Supervisory Commission (FSC) to review, design and supervise the financial system and Korea Asset Management Corporation (KAMCO) to buy non-performing loans to recapitalize financial institutions—and made the Bank of South Korea independent of the government. The FSC not only has regulatory powers but also operates instruments of financial reform. It closed 16 merchant banks, five

commercial banks, and over 700 secondary financial institutions, giving a shocking signal to the public that even banking institutions can fail. The government rescued the "relatively better managed" remaining financial institutions by turning non-performing loans into equity so that they in turn could negotiate with corporate borrowers. Several large commercial banks have merged into three giant banks. One large commercial bank has been sold to foreign interests, and another is under negotiation with foreigners.

Foreign equity participation in the banks, both large and small, is expected to introduce more modern market-oriented banking techniques, accountability, and transparency in operations. This should result in a more rational allocation of financial resources.

A major concern in the financial sector is that the injection of public funds to rescue banking institutions has resulted in a drastic increase in government ownership of large commercial banks and investment trust companies. The result is that the government now has decisive power in the financial sector. Government intervention in Korea's banking system was necessary to achieve stability following the crisis. The government plans to privatize its ownership by 2002 to enable commercial banks to operate on the basis of market principles. But its intervention might have the unintended effect of retarding reforms if bank managers continue to hesitate to make decisions without a nod from the appropriate government official.

Industrial Structure: Chaebol Restructuring

Multi-sector, family-controlled business groups were dominant in pre-war Japan and are prevalent in many Asian countries today. But nowhere else have they been so consistently aggressive in diversifying businesses and developing technological capabilities than in South Korea. The South Korean government deliberately created and nurtured *chaebols* to use them as locomotives for rapid economic development. These *chaebols* were the backbone of industrialization in the labor-intensive industries during the early decades. They also played a major role in expediting technological learning in industry, upgrading South Korea's technological capability and globalizing South Korean business. They consequently generated the lion's share of production and exports from South Korea.

Behind the successful story of *chaebols*, there are, however, serious divergences from free market principles. Collusion with powerful government forces resulted in resource misallocation and economic inefficiency at the macro level. The concentration of economic power in the hands of a small number of *chaebols* also resulted in monopolistic exploitation at the micro level (Kim, 2000a). They also stifled the healthy growth of small and medium enterprises (SMEs).

Over diversification, extremely high debt to equity ratios and the subsidization of unprofitable businesses made many *chaebols* vulnerable to the fluctuation of the international economic environment. Several minor *chaebols* including the Hanbo, Sammi, Jinro, Haitai, Halla, New Core and Kia were in receivership prior to the onset of the Asian crisis, giving a serious if unheeded warning of just how vulnerable South Korean *chaebols* were.

At the outburst of the Asian crisis, which hit the remaining *chaebols,* the administration of Kim Dea Jung set five principles of corporate restructuring: down-scope to focus on core businesses, the reduction of debt to equity ratios to below 200 percent by the end of 1999, the dismantling of cross-credit guarantees among subsidiaries, management transparency, and greater management accountability.

The government has three techniques to force the *chaebols* to comply with its directives: threats to undertake a comprehensive tax audit, the legal prosecution of family owners, and withdrawing credits to those debt-ridden firms (Krause, 2000).

To meet the mandate requirement to down-scope and reduce the debt to equity ratio for core businesses, *chaebols* had to sell off many of their unprofitable businesses to foreign firms. Hyundai, for instance, decided to focus on five core businesses — automobiles, electronics, construction, heavy industry, and financial services. Samsung concentrated on four core businesses — electronics, finance, trade, and services. LG announced that its main business segments would be chemicals/energy, electronics/telecommunications, services, and finances. Daewoo, in the middle of its restructuring, had gone bankrupt. Other smaller *chaebol*s were also in the process of a major restructuring of their businesses.

The dominance of *chaebols* prevented the development and healthy growth of small and medium enterprises (SMEs). In the early 1980s the government belatedly began promoting SMEs by establishing SME sanctuaries and by requiring banks to comply with a compulsory lending ratio program. Such programs had little effect on the industrial structure in South Korea, and the imbalance between the large and small sectors has mostly remained. As a result, end-product assembling *chaebols* rely heavily on Japan for technology-intensive parts and components, which constrains innovation at both large and small firms.

The Asian crisis appears to have catalyzed industrial restructuring in South Korea. Down-scoping and down-sizing in *chaebol*s and the recent promotion of venture businesses by the government prompted a major surge of high technology venture firms in South Korea. Their number increased from a mere 100 before the Asian crisis to 5,000 in two years by the end of 1999. In Spring 2000, more venture firms emerged at the rate of 500 per month, reaching more than 7,000 by June 2000, a significant change by any standard.

Global Networks

South Korean firms have developed extensive global networks with foreign firms that have provided capital goods, licensed technology, and OEM orders. These networks have been a major source of technological learning for South Korean firms. But South Korea has not relied heavily on foreign direct investment (FDI) for technological learning. The proportion of FDI to total external borrowing was only 6 percent in South Korea compared with 92 percent in Singapore, 45 percent in Taiwan, and 21 percent in Brazil (KEB, 1987). As a result, unlike other developing countries, the contribution of FDI to the growth of the South Korean GDP in 1972-1980 amounted to only 1.3 percent, while its contribution to total and manufacturing value-added was only 1.1 percent and 4.8 percent respectively in 1971 and 4.5 percent and 14.2 percent, respectively, in 1980 (Cha, 1983).

In contrast to the generally accepted wisdom, FDI in South Koreas does not contribute much to local capability formation. FDI definitely transfers production and management capabilities to ensure efficient production of foreign-designed products. It does not, however, transfer engineering and innovation capabilities. A comparative analysis of technological learning process and market performance between Hyundai Motor, an independent domestic firm, and Daewoo Motor, a joint venture with GM — the largest company with the largest R&D expenditures in the world — is illustrative. Hyundai licensed technologies from multiple sources and took the responsibility to integrate them into a workable mass production system, entailing a major risk. This approach forced and motivated Hyundai to assimilate foreign technologies as rapidly as possible throughout the process. In addition, Hyundai invested heavily in R&D in attempts to accumulate design and innovation capabilities. As a result, Hyundai developed its first indigenous model "Pony," with 90 percent local content in 1975, and it quickly improved its quality in subsequent years through serious R&D activities, making South Korea the second nation in Asia with its own automobile. As a result, Hyundai's local market share in passenger cars increased from 19.2 percent in 1970 to 73.9 percent in 1979. Hyundai exported 62,592 cars to Europe, the Middle East, and Asia, accounting for 67 percent of South Korea's total auto exports in 1976-1980 and 97 percent of total passenger car exports from South Korea in 1983-1986 (Kim, 1998).

In contrast, constrained by GM's global objectives, Daewoo had relied on GM for technology sourcing, having done relatively little in the way of developing its own technological capability and even less in designing its own products. Technology transfer in the form of joint venture is apt to lead to a passive attitude on the part of the recipient in the learning process, as the supplier guarantees the performance of the transferred technology. The investment in product and process improvement undertaken by Daewoo between 1976-1981 was only one fifth as great as those undertaken by Hyundai, although its production capacity, on average, was approximately 70 percent as large. As a result, though their products were comparable in engine size and price, Daewoo was operating at 19.5 percent of capacity compared with 67.3 percent for Hyundai in 1982. The differential in labor productivity was just as stark; only 2.61 cars per head at Daewoo compared with 8.55 cars per head at Hyundai. Conflicts between the two partners continued to plague the joint venture, giving the smaller Kia a chance to outpace Daewoo. The 1992 divorce from GM finally freed Daewoo to set its own global strategic direction and navigate at its own ambitious pace, recapturing the second position after Hyundai.

The semiconductor industry presents a similar story. MNCs transferred production capacity but not design or innovation capabilities. Signetics, Fairchild, Motorola, Control Data, AMI, and Toshiba began assembling discrete devices in South Korea in the 1960s and 1970s in order to take advantage of cheap local labor. Operations involved simple packaging processes; bonded assembly operations by wholly owned South Korean subsidiaries of foreign corporations with all parts and components imported from the parent companies and re-exported back to the consignors. The assembly operations required only about six months training of unskilled workers, transferring little design or engineering capability to South Korea. It was the largest domestic companies — Samsung, Hyundai, and LG — that

marshaled investment to enter very large scale integrated (VLSI) chip design and production on their own. Leading foreign producers refused to license VLSI technology to the South Korean *chaebols*. But the *chaebols* were able to find a number of distressed small semiconductor companies in the United States which were ready to sell what the *chaebols* needed most — chip designs and processes — in attempts to fuel cash for survival. To master the licensed technologies, Samsung set up an R&D outpost in Silicon Valley in 1983 and hired five South Korean-American PhDs in electronics engineering with semiconductor design experience at IBM, Honeywell, Zilog, Intel, and National Semiconductors. The outpost also provided opportunities for engineers in South Korea to participate in training and research in the U.S., enabling them to learn about VLSI technology (Kim, 1997b).

The Asian crisis has, however, forced South Korean firms to pursue FDI in an attempt to mitigate pressing short-term cash flow problems. In addition to peripheral businesses, core businesses went on the chopping block. Consequently, in contrast to China and the Southeast Asian countries, which have witnessed a sharp plunge in FDI after the Asian crisis (e.g., Singapore - 24.8 percent and Taiwan and Malaysia -19 percent), South Korea saw a dramatic increase in FDI. For example, FDI inflow in manufacturing drastically increased from $2.3 billion in 1997 to $8 billion in 1998 and to $15.5 billion in 1999. A lion's share of the new FDI is associated with merger and acquisition of South Korean firms by foreigners. Hewlett-Packard purchased a 45 percent stake in its South Korean subsidiary from its joint venture partner, Samsung Electronics, for $36 million. Dow Chemical took over Ulsan Pacific Chemical by purchasing a 20 percent stake. Phillips purchased a 50 percent stake in LG's highly profitable flat panel display business for $1.4 billion. Volvo purchased Samsung's construction machinery division for $730 million. In short, the South Korean economy will be far more linked with foreign multinationals than ever before, but recent FDIs do not necessarily transfer new technology, as they are mostly involved in acquisition of existing South Korean firms. They may however, transfer management know-how and improve transparency and accountability.

Some MNCs recently established local R&D centers in South Korea. Thirty-nine MNCs, or 1.4 percent of the total number of MNCs operating in South Korea in manufacturing, have so far established R&D centers in South Korea. Thirty-three, or 82 percent, of them were established in the 1990s when South Korea had developed a significant R&D base. The R&D centers of multinationals however, account for less than 1 percent of the total number of corporate R&D centers. Most of the R&D centers that multinationals operate in South Korea are involved in adapting their products to the local market, indicating that local R&D activities by mulitnationals are very insignificant compared to those by domestic firms in South Korea.

More recent foreign investors such as Motorola and Lucent Technologies came to South Korea to tap South Korea's leading edge technologies in semiconductor memory chips, flat panel displays, and code division multiple access (CDMA) mobile telecommunications — in which South Korea is ahead of Japan and the United States. Motorola acquired a South Korean venture firm, Appeal Technology, to gain access to sophisticated design and innovation capabilities and to source one of the most compact mobile telephone sets for

global marketing. Lucent Technologies is in the process of establishing its R&D center in South Korea to tap it's capability in telecommunications (Kim, 2000b).

Domestic Industrial R&D Activities

As South Korea underwent structural adjustments and entered progressively more technology-intensive industries, R&D investment became imperative to sustain its competitiveness in international markets. As a result, R&D investment has seen a quantum jump in the past decades. Table 1 (on page 19) shows that the total R&D investment increased from W. 10.6 billion (US$28.6 million) in 1971 to W. 3.349 trillion (US$ 4.7 billion) in 1990, and to W. 12.858 trillion (US$ 12.8 billion) by 1997. Though the South Korean economy recorded one of the world's fastest growth rates, R&D expenditure rose even faster than GDP. R&D as percentage of GDP (R&D/GDP) increased from 0.32 percent to 2.69 during the same period, surpassing that of many West European countries.

The government has launched various programs to induce the private sector to set up formal R&D laboratories. Spurred partly by these programs and partly by increasing competition in the international market, the number of corporate R&D laboratories increased from one in 1970 to 3,060 in 1997, reflecting the seriousness, with which South Korean firms have pursued high technology development. The *Chaebols* have dominated R&D activities, with the 20 largest domestic firms accounting for 71.8 percent of total corporate R&D in South Korea.

Over time, there has been significant change in the composition of R&D investment in South Korea. The government played a major role in R&D activities in early years, when the private sector faltered in R&D despite the government's encouragement. More recently, domestic firms have assumed an increasingly larger role in the country's R&D efforts in response partly to increasing international competition and partly to a policy environment supportive of private R&D activities. In 1963, the private sector accounted for only two percent of the nation's total R&D expenditure. This had risen to over 80 percent by 1994, which is one of the highest among both advanced and newly industrialized countries.

The R&D growth rate has also been one of the highest in the world. For instance, the average annual growth rate of R&D investment per gross domestic product (GDP) in 1981 through 1991 for South Korea was 24.2 percent compared to 22.3 percent for Singapore, 15.8 percent for Taiwan, 11.4 percent for Spain, and 7.4 percent for Japan. The average annual growth rate of business R&D per GDP is also the highest in South Korea (31.6 percent) compared to 23.8 percent in Singapore, 16.5 percent in Taiwan, 14.0 percent in Spain, and 8.8 percent in Japan (DIST, 1994).

In addition to intensified in-house R&D, South Korean firms began globalizing their R&D activities. For instance, LG Electronics has developed a network of R&D laboratories in Tokyo, Sunnyvale in California, Chicago, Germany, and Ireland. These outposts monitor technological change at the frontier, seek opportunities to develop strategic alliances with foreign firms, and develop the state-of-the-art products through advanced R&D. In Sunnyvale, LG Technology plays a pivotal role in designing the latest personal computers,

display terminals, and high resolution monitors, while the LG North American Laboratory in Chicago concentrates on HDTV, digital VCR, and telecommunications equipment. Samsung, Daewoo, and Hyundai Electronics have developed equally extensive R&D networks. Samsung has R&D facilties in San Jose, Maryland, Boston, Tokyo, Osaka, Sendai in Japan, London, Frankfurt, and Moscow. Daewoo has two in France, one in the U.K., and one in Russia. Hyundai has R&D facilities in San Jose, Frankfurt, Singapore, and Taipei.

Other important indicators of South Korea's rapid growth in industrial R&D are patent registrations in South Korea and abroad. Patent activities in South Korea have significantly jumped in the last two decades compared to the previous two, increasing a mere 48 percent in the first 14 years (1965-1978), but almost tripling in the next 11 years (1979-1989) and almost tripling again in the next four years (1989-1993). This reflects the increasing importance of intellectual property rights in the face of declining reverse engineering. The gap is still great when compared with advanced countries, but South Korea is catching up rapidly. Furthermore, the share of South Koreans in local patent registration also increased from 11.4 percent in 1980 to 58.9 percent by 1997, indicating rising technology activities.

U.S. Patent registration is often used as a surrogate measure of international competitiveness. The number of U.S. patents granted to South Koreans is far less than to Taiwanese, let alone that in the advanced countries. The cumulative number of U.S. patents granted to South Koreans between 1969 and 1992 is only 1,751, compared to 4,978 to Taiwanese. But South Korea jumped from 35th in terms of the number of patents in the U.S. with 5 patents in 1969 to 11th with 538 patents in 1992 with an average annual growth rate of 43.32 percent (NTIS, 1993). This growth rate is the highest among countries in the NTIS report.

The Asian crisis of 1997, however, appears to have exerted a significant influence over industrial R&D activities in South Korea. To improve short-term liquidity, large *chaebols* reduced their R&D activities by about 13 percent during the year following the crisis, but the government increased its R&D budget, raising its share in total R&D from 23 percent in 1997 to 27 percent in 1998. However, South Korea's total R&D decreased from W.12.185 trillion (US$12.8 billion) in 1997 down to W.11.336 trillion (US$9.5 billion) in 1998 (Kim, 2001). The disproportionate drop in terms of U.S. currency is caused by the devaluation of the South Korean currency after the crisis. The down-sizing of R&D activities by *chaebols*, together with the government's promotion of venture businesses, led to a major surge of technology-based small firms in South Korea. As a result, contrary to general expectations, the number of corporate R&D centers increased from 3,060 at the time of the crisis to 5,200 two years later. SMEs account for 95 percent of this increase.

Despite decrease in R&D investment, R&D output in terms of patents increased significantly, indicating the improved quality of R&D activities. The number of patents granted more than tripled in two years after the Asian crisis from 24,579 in 1997 to 80,642 in 1999. The share granted to South Koreans also increased from 58.9 percent to 69.4 percent during the same period. South Korea is now fifth in the world in 1999 in terms of the number of industrial property applications, following Japan, the United States, China, and Germany. In terms of

industrial property applications by local residents per population, South Korea ranks second, with Japan taking first.

The number of U.S. patents granted to South Koreans almost doubled in two years from 1,891 in 1997 to 3,679 in 1999, ascending from 7th in the world to 6th, only after Japan, Germany, Taiwan, France, and United Kingdom. Samsung Electronics, one of the most R&D–intensive firms in South Korea, almost tripled its U.S. patents granted from 582 in 1997 to 1,545 in 1999, ascending from 17th to 4th, only after IBM, NEC, and Cannon. Such a rise is significant compared to 49 percent increase in the total number of U.S. patents granted to nonresidents during the same period, indicating that South Korea has been gaining rapidly in technological competitiveness after the crisis.

Education

South Korea is a land in which natural resources are comparatively scarce. Accordingly, the government and South Korean families have invested heavily in education, drastically expanding educational institutions in terms of quantity during the early decades, when the country was very poor. Unlike most developing countries, South Korea's expansion was well balanced at all levels prior to launching the industrialization drive. This produced a vast quantity of human resources with enough initial capacity to make sense of mature technologies transferred from abroad in the 1960s and 1970s. In more recent decades, however, the government did not focus on developing the quality of educational institutions, thus causing a major bottleneck in South Korea's technological learning. The problem of under-investment is most acute at the university level. All but a few universities have remained primarily undergraduate teaching-oriented rather than research-oriented. The government has belatedly recognized this problem and contemplated ideas of making a major educational reform, but little was implemented prior to the Asian financial crisis.

Nevertheless, university research did expand significantly in the 1990s. R&D expenditure by universities almost tripled in five years from W244.3 billion ($341.2 million) in 1990 to W.1.27 trillion (US$1.6 billion) in 1998. The number of university researchers also more than doubled from 21,332 to 51,162 during the same period. In addition, emulating the U.S. experience, the government also introduced in 1989 a scheme to establish Science Research Centers (SRCs) and Engineering Research Centers (ERCs) in the nation's leading universities. The number of SRCs and ERCs increased from 13 in 1990 to 45 by 1997. These centers receive research grants from the government for nine years.

As a result, the number of scientific publications per year by South Koreans as quoted in science citation index (SCI) increased steadily from 27 in 1973 to 171 in 1980, but rapidly to 1,227 in 1988 and 3,910 in 1994, and drastically to 10,918 by 1999, climbing from 37th in the world in 1988 to 24th in 1994 and to 16th in 1999.

The Asian crisis prompted the South Korean government to formulate an ambitious education reform program, called Brain Korea 21, to transform a dozen of leading universities into first-class research-oriented institutions. The government earmarked W.1.6 trillion (about $1.4 billion) to invest over seven years in order to implement the program. Despite strong

resistance from lower-tier universities, the government is determined to push forward the program. It is yet premature to estimate the outcome of the program, but once implemented properly, it is expected to upgrade significantly the quality of scientists and engineers graduating from South Korean universities in the future.

In addition, leading universities have established technology parks and venture incubating centers as a means to establish joint research with leading firms and to foster technology-based small businesses spinning off from university R&D laboratories. The implication is that universities will play an increasingly important role in South Korea's pursuit of high-technology industries in the future, a model that is familiar in the United States.

Domestic Support Infrastructure

In the absence of research in universities, the government took the initiative in establishing a Government Research Institute by recruiting overseas-trained South Korean scientists and engineers. GRIs accounted for 83.9 percent of the nation's total R&D expenditures and 43.7 percent of the nation's pool of researchers in 1970, reflecting their dominant role in R&D activities in early years.

To keep pace with increasing industrial sophistication and diversity, the government established several specialized GRIs (e.g., chemical, machinery, electronics, ocean, standardization, nuclear energy, biotechnology, system engineering, aerospace, etc.) to serve the growing needs of the private sector. GRIs began to play an important role in strengthening the bargaining power of local enterprises. This helped to acquire increasingly sophisticated foreign technology, and in drastically cutting the price of foreign imports by developing competing technologies locally. But most importantly, the GRIs generated experienced researchers for corporate R&D centers, and played a dominant role in undertaking various national R&D projects through the mid 1990s.

In the face of the rapid expansion of private R&D activities, however, and increasing intensity of university R&D, the role of GRIs has decreased vis-à-vis universities and corporate R&D centers over time for two reasons. First, GRIs are far less dynamic than corporate R&D centers. The former is under the bureaucratic control of the government, which stifles the vibrant life of creative individuals by rigid regulations. In contrast, the latter dynamically responds to market and technological changes for survival. Second, GRIs face difficulties in retaining competent researchers, as these researchers hop either to academic institutions for prestige and freedom or to corporate R&D laboratories for better economic incentives. Reform of GRIs to redefine their roles has been discussed for some time. But inertia and the labor union of GRI members have made it difficult to implement the reform.

The Asian economic crisis enabled the government to introduce a major restructuring of GRIs. As part of public sector reform, the government introduced three research councils, modeled on aspects of the German and British systems, and reorganized GRIs under the jurisdiction of these councils, eliminating direct control by government ministries. It might take some time before the new structure functions properly, but the restructuring is expected

to result in increased administrative freedom and major reorientation of GRIs to address new missions.

A critical problem remains unresolved. Government has largely been so preoccupied with mission-oriented projects that it has failed to develop effective infrastructure to support small and medium size enterprises. The technical extension networks developed in the 1980s have not proved adequate to help SMEs grow technologically. South Korea belatedly established a few industry-specific R&D institutes for SMEs in the 1990s, but their effectiveness remains to be seen.

Corporate Governance and Management

In addition to focus on core businesses and reduction in debt to equity ratio, *chaebol*s face serious problems in the area of corporate governance. In the environment where the state was the major source of constraints and contingencies, family owners of *chaebol*s developed a "conservation-of-power rationality" (Klein, 1977). They sought collusion with powerful politicians and technocrats in order to be able to enter lucrative businesses and to maximize the predictability of the environment. Few family businesses could have grown into a *chaebol* without such political patronage in South Korea. As family owners were more concerned with garnering outside influence than they were with generating internal capability in making their companies profitable, boards of directors and minority shareholders have had little power to curb the family owners' mismanagement. Moral hazards were prevalent.

In the wake of the Asian crisis, the government introduced measures to change corporate governance of *chaebol*s. Listed companies must appoint outside directors to strengthen the independence of the board of directors in supervising top management. Within the first year, 752 listed companies had assigned outside directors. But many companies hired their friends to the board. In the future, it will be difficult for the company to do so, as institutional investors and minority shareholders will have the right to recommend outside directors.

Another important arena is the improvement of management style in order to enhance effectiveness. With so much of the firm's success resting on the top manager's personal skills, South Korean firms naturally adopted a top-down management style. This management imperative, combined with the rule of military government over three decades, fostered a management style that resembled a military bureaucracy; hierarchical and centrally controlled but relatively less formalized. The notion of Confucian traditions and its familism fits comfortably with the hierarchical style of family-centered conglomerates. Unlike highly formalized bureaucratic organizations, South Korean firms were adaptable to changes once a decision was made at the top by the "commanding general." These organizations were quite compatible with and efficient in imitative reverse-engineering and production-oriented tasks of the 1960s and 1970s.

Many *chaebols* recognized the imperative of major changes to transform themselves into innovation-oriented organizations. This requires more decentralized, self-contained, strategic business units that can respond quickly to changing markets and technologies; an organizational climate that nurtures creative individuals and effective teamwork; effective

lateral communication and coordination across functions; and bottom-up communications to identify and respond quickly to market opportunities and threats. There has been a lot of rhetoric on these issues but little action.

The recent economic crisis has, however, forced *chaebol*s to reform their organizations and management to be compatible with new needs. Many *chaebol*s are making major efforts to transform their organizational structures and management styles. It will, however, take some time before results can be seen. The *chaebols* find that although the formal organizational structure and management system can be changed overnight, changing the behavior of managers and employees to be compatible with the new system is far more difficult and time consuming.

Labor Movement and Sociocultural Factors

Another important element that influences the dynamics of technology development is the labor market and sociocultural environment, which set the stage for individual behaviors and social interactions in South Korea. Although the formal ban on unions was lifted in the early 1960s, the legal framework in which unions were permitted to function was so restrictive that it virtually eliminated the possibility of organizing any genuine independent unions through 1987. In addition, the government used various means to suppress the labor movement in order to maintain industrial peace for rapid economic development. As a result, workers became exceedingly docile.

Then, following the democratization decree in 1987, the labor movement suddenly exploded in disorderly, violent, and in many cases unlawful ways. But due to deteriorating social and economic climates, the once militant unions became relatively more matured and evolved into more responsible forces in the 1990s. Nevertheless, a series of labor strikes have resulted in significant changes in the social and organizational climate. There have been shifts in the power structure and workers have become far less submissive than previously. One survey shows, for example, that those who agreed to obey to superiors' directions dropped from 90.6 percent in 1979 to 65.3 percent in 1991 (Shin and Kim, 1994).

Many cultural and situational factors have affected South Korea's work ethic (see Kim, 1997). After a decade of labor unrest, work ethic and discipline have deteriorated significantly. Constant demands for higher wages have also pushed South Korea's real wage to over 91 percent in terms of U.S. dollars, which was 2.8 times that of productivity, eroding South Korea's competitiveness in international markets. In addition, the new generation brought up in affluence appear less willing to work hard compared to the older generation.

The Asian crisis has, however, exerted a major impact on labor in South Korea. Facing the bankruptcy of banks and *chaebol*s, the drastic downsizing of surviving companies, consequent high unemployment, and the reduction of the purchasing power of the average surviving worker by 30-40 percent, labor unions had to shift from a militant strategy to one that involves more bargaining and compromise, and workers have become more willing to work harder than they were before the crisis.

Conclusion and Discussions

South Korea's phenomenal economic growth in the first two decades of its industrialization may be attributed to its strong system for national innovation. But major strengths in the early decades have become liabilities in more recent times, as South Korea has failed to adjust to rapidly changing political and economic circumstances. This failure, together with mismanagement of the financial sector and foreign investor panic, led to a major economic crisis in 1997. It is yet premature to assess the full impact of the crisis, as it is still unfolding and national economic performance appeared to take another downturn in 2001, in tandem with the slowing U.S. and global economies.

The Asian crisis has undoubtedly affected painfully the economic and social life of South Koreans, yet, despite the negative effects of the crisis as widely reported in the news media, the crisis could also turn out to be a "blessing in disguise," if policy makers and managers can use it as an open to transform South Korea's outmoded economic and innovation systems, and to bring them more in line with requirements of the new millennium.

South Korea has made significant strides in reengineering various critical elements in its innovation system. The government, financial, domestic support, and corporate sectors have undergone a high doze of restructuring programs with noteworthy results. Research and development activities at corporations and universities also produced significant results after the crisis, and worker attitude has improved noticeably. But South Korea still has a long way to go, as experiences in such countries as New Zealand, Sweden, and the United Kingdom show that even with consistent efforts it takes a decade or more to see the substantial results of major reforms.

This paper also poses several critical questions. The first set of interrelated questions includes: Is South Korea making major changes to accommodate globalization after the Asian crisis? Is it possible for a small country like South Korea to sustain its technolonationalism in the face of increasing domination of innovation by larger, more technologically advanced countries? Is South Korea giving way its technolonationalism after the Asian crisis and moving toward technoglobalism?

South Korea is evidently making major changes to *accommodate* to globalization. Both the government and large firms are actively seeking foreign investment to attract new capital, new technology, and new management know-how, and to develop broader links with advanced industrialized countries. The Asian crisis resulted in a major increase in FDI in South Korea, as mentioned earlier. But do these changes signal a move toward technoglobalism? The answer is definitely "no." South Korea is willing to work more closely with multinationals to accommodate increasing globalization, but it will try to use every means to retain its own system of technological innovation and industrial production. The government, for example, intends to increase public R&D funding from 3.47 percent of the total government budget in 1999 to 5.0 percent within a few years, indicating its determination to reinforce basic and mission-oriented applied research. After the Asian crisis, the government launched a new initiative called the 21st Century Frontier Technology R&D

Program, indicating South Korea's efforts to crack cutting-edge technologies on its own. The industrial sector also has similar goals. Although the Asian crisis caused a major setback (13 percent cut) of industrial R&D in South Korea and uncovered many problems in several sectors, they are only temporary phenomena. It might take many more years before the financially troubled *chaebols* can again take up their R&D activities, but other firms have drastically intensified R&D activities after the Asian crisis to strengthen their international competitiveness. Samsung Electronics, for instance, ascended from 17th in 1997 to 4th in 1999 in terms of US patent registration, which is often used as a surrogate of international competitiveness. South Korea may be the only country among newly industrialized economies (NIEs), in which many firms market their products under their own brands, a sign of its determination to survive on its own. In short, increasing globalism in South Korea is a means toward a nationalist end.

The second set of interrelated questions includes: Why does South Korea cling to technonationalism? Is it possible for a small and weaker country like South Korea to survive to retain its technonationalism in a globalizing economy? South Korea is not a small country like Scandinavian or Benelux countries. Its population size approaches that of France and U.K. If North and South Korea united, its population would increase to well over 70 million, approaching that of Germany. It is the perception of policy makers and managers that such a large country cannot prosper only as a production locale of and at the whim of multinational companies and that South Korea should have its own global strategy to determine its own destiny. Japan could not have advanced as much, if it had followed Singapore's strategy.

Can South Korea succeed in the race of innovation and production increasingly dominated by larger technologically advanced countries? The answer is "it remains to be seen." Like Japan, the South Korean government is determined to revamp its educational systems and strengthen its basic research capability. Leading universities will be transformed from undergraduate-oriented teaching schools into graduate-oriented research institutions. It might take a decade or longer to bring them up to the level of advanced OECD countries, but changes will definitely be accelerated in the future. Large firms will undoubtedly strengthen their R&D activities, as they approach closer to the world frontier. In this process, South Korea will become a fully modern advanced industrial country.

These efforts, however, may not be sufficient to sustain South Korean technonationalism. The worst case scenario is that South Korea might excel in a few sectors and become a smart follower in many others. History tells that smart followers often outperform pioneers in the long run (Schnaars, 1994). Even in technoglobalistic participation in innovation and production systems dominated by industrially advanced countries, smart partners can engage in more sophisticated technological activities and enjoy a greater degree of control and autonomy than otherwise. And given local absorptive capacity, the diffusion of learning in such participation to local firms will accordingly take place effectively.

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Table 1: Research and Development Expenditures, 1965-1998

	1965	1970	1975	1980	1985	1990	1995	1998
R&D expenditure	2.1	10.5	42.7	282.5	1,237.1	3,349.9	9,440.6	11,336.6
Government	1.9	9.2	30.3	180.0	306.8	651.0	1,780.9	3,051.8
Private Sector	0.2	1.3	12.3	102.5	930.3	2,698.9	7,659.7	8,276.4
Government vs. Private	61:39	97:03	71:29	64:36	25:75	19:81	19:81	27:73
R&D/GNP	0.26	0.38	0.42	0.77	1.58	1.95	2.51	2.52
Manufacturing Sector								
R&D expenditure	NA	NA	16.7[a]	76.0	688.6	2,134.7	5,809.9	6,439.2
Percent of Sales	NA	NA	0.36[a]	0.50	1.51	1.96	2.72	2.64
Number of Researchers (total)[b]	2,135	5,628	10,275	18,434	41,473	70,503	128,315	129,767
Govt Research Inst.	1,671	2,458	3,086	4,598	7,542	10,434	15,007	12,587
Universities	352	2,011	4,534	8,695	14,935	21,332	44,683	51,162
Private Sector	112	1,159	2,655	5,141	18,996	38,737	68,625	66,018
R&D expenditure per researcher (W 1000)	967	1,874	4,152	15,325	27,853	47,514	73,574	87,361
Researcher per 10,000 Population	0.7	1.7	2.9	4.8	10.1	16.4	28.6	27.9
Number of Corporate R&D Centers	0	1[c]	12	54	183	966	2,270	3,760

NOTES:
a: for 1976.
b: The figures does not include research assistants, technicians, and other supporting personnel.
c: for 1971.
Source: Ministry of Science and Technology