

Enhancing Productivity through Innovation: Korea's Response to Competitiveness Challenges

(Draft)

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1. Introduction

The production systems in the East Asia that have prevailed over the past years are dissolving rapidly. The factors underlying these changes seem to be different from those in the past. Multinational enterprises are apparently a driver of the change as in the past; but there are differences in today's changes. The world economic environment is changing rapidly. Hot debates on the architecture of the new international economic order are undergoing as well observed in WTO and DDA round tables. Globalization becomes a catchword or cliché nowadays, but there appear some countervailing movements against it; and there remain many issues to be resolved for a new international economic order to be settled. The rapid advances of information technology are enabling to overcome the limitations of physical distances and thereby to organize the production activities more effectively through the global supply chains. In line with the forces of globalization and IT revolution, the integration of low-cost economies to the world economy raises new challenges to national economies, in particular to Korea, forcing them to move towards knowledge-based innovative economies.

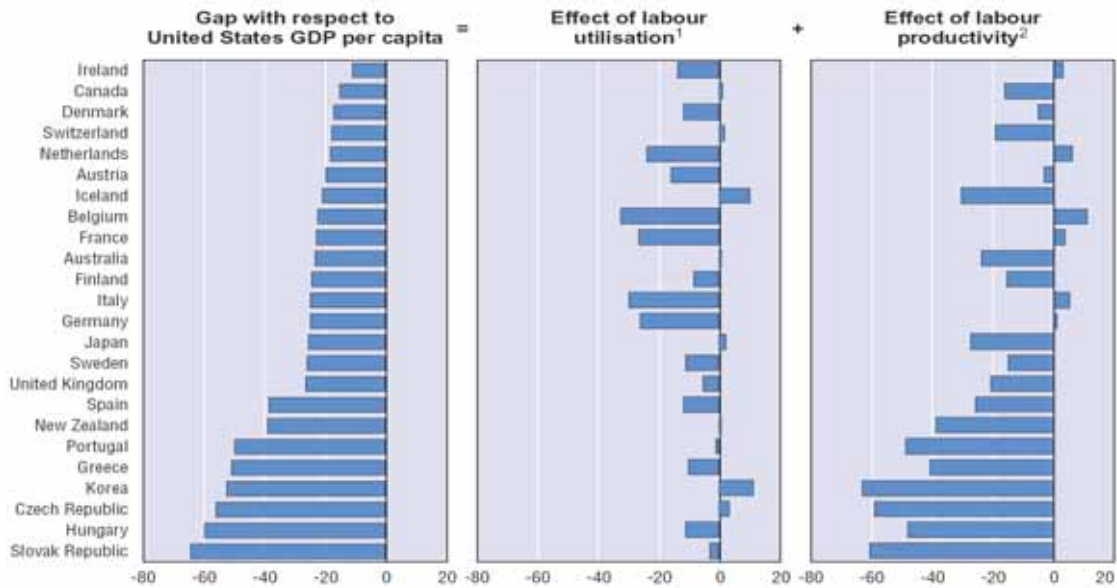
The changes describe above raise several questions. Theoretically, can the conventional theories of industrial development and international trade be maintained as the framework of explaining these changes? To what extent, and what aspect of the phenomenon? If not, quoting Gerschenkron, "how can we know if we knew what we would know"? From a policy point of view, is the rise of these low-cost economies a threat? Under what conditions is it an opportunity? Is "industrial hollowing-out" a revelation or result of structural adjustment responding to the changes in economic environment? Or, is there something more fundamental? Is "the China Fear" in Japan and Korea justified, or exaggerated reaction from the losing businesses? What are the policy framework and options to make these changes an opportunity for further growth?

It is not sure how long Korea can maintain international competitiveness in her flagship exporting products such as textile, automobile and IT products. What we have found from the first-year research, though preliminary to make a clear conclusion and definitive interpretations, is that the basis of international competitiveness of the Korean exporting products is not so strong and Korea needs to find out new engines of growth. The challenges faced by today's Korean economy would be termed as, in need of better words, the transition from the catch-up model to a knowledge-based economy. What are the requirements for a successful transition?

In terms of productivity of the economy as a whole, Korea is far behind other OECD economies. Against the existing productivity gap, we have seen a worrying sign in Korea's investment trend. It is worth reminding that Korea has shown very high machinery and equipment (M&E) investment ratio in the past years, but recent years we have seen rapid decreases. Compared two period between 1993-1997 and 1998-2002, OECD economies on the average has increased M&E investment from 9.4% to 10.8%, in terms of percentage average as of GDP. In contrast, Korea has shown decreases from 13.8% to 11.2%, yet still above the OECD average. It is noticeable to see that US and Japan has increased their M&E investment. Concerning business R&D investment, OECD countries have shown increasing trend, and Korea as well.

What does the trend imply? Is it the sign that Korea is transforming her economy from input-driven economy to one that is knowledge based? There are lots of issues to be investigated more rigorously and in-detail. We will do further research this year. For a moment, I will show some of the first-year research results of KDI project and focus on two issues – to make innovation system more effective and the current status of SME.

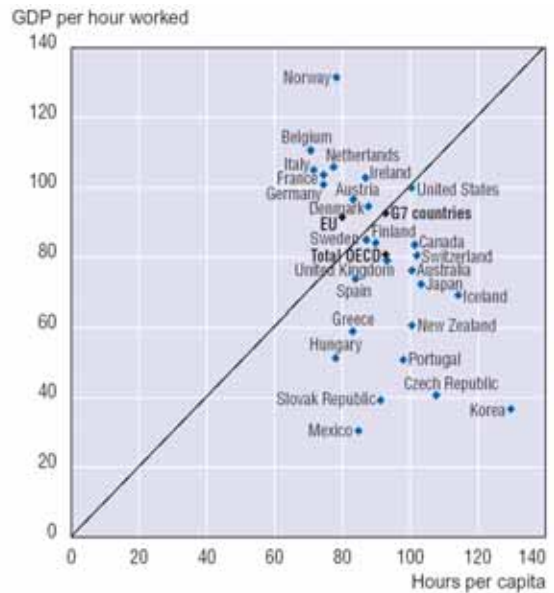
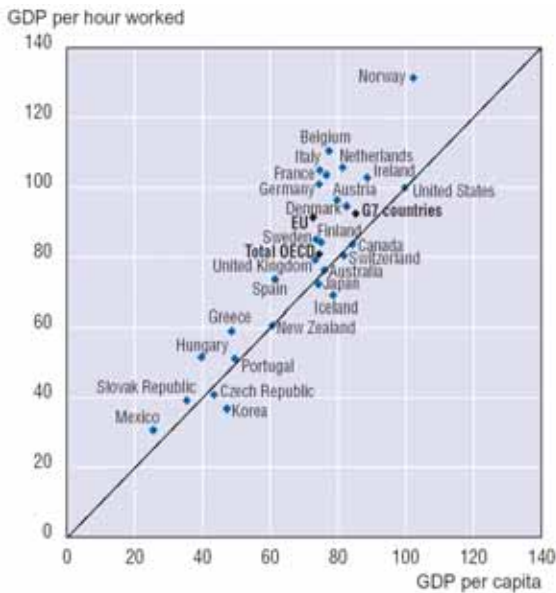
Figure 1: Income and productivity levels of OECD countries, 2002
 Percentage point differences with respect to the United States



Note: 1. Based on hours worked per capita. 2. GDP per hour worked.
 Source: OECD, *Science, Technology and Industry Scoreboard*, 2003.

Figure 2-1: GDP per capita and GDP per hour worked (US = 100)

Figure 2-2: GDP per hour worked and hours per capita (US = 100)



Note: Total OECD excludes Poland and Turkey.
 Source: OECD, *Science, Technology and Industry Scoreboard*, 2003.

Table 1: Investment Trend of OECD Countries

(Unit: period average, % as of GDP)

| | Machinery and equipment | | Business R&D | |
|--------------|-------------------------|-------------|--------------|-------------|
| | (1993-1997) | (1998-2002) | (1993-1997) | (1998-2002) |
| Korea | 13.8 | 11.2 | 1.81 | 1.94 |
| Sweden | 8.9 | 11.4 | 2.50 | 3.03 |
| Netherlands | 9.3 | 10.8 | 1.05 | 1.10 |
| Germany | 8.2 | 9.5 | 1.52 | 1.71 |
| Japan | 12.6 | 13.5 | 1.95 | 2.14 |
| USA | 9.3 | 12.3 | 1.81 | 2.02 |
| OECD average | 9.4 | 10.8 | 1.16 | 1.34 |

Source: OECD.

2. Structural Changes in Korean Industry¹

The Korean economy has experienced gradual changes in its industrial structure since the 1980s, where, as the industrialization process matured, the share of manufacturing became saturated while service sectors as a whole tended to take more portion in gross economic activities. The manufacturing sector has started to account for smaller shares in the late 1980s. However, its shares have recovered to the previous level after starting to increase in the second half of the 1990s: the manufacturing sector has shown the high growth rate since the mid-1990s. And productivity in the manufacturing sector has been greatly improved; particularly, high productivity increase is found in manufacturing firms that survived the financial crisis with successful restructuring.

Over the long-term period, the manufacturing sector maintained a stable level, whereas the service sector has been stagnant. Above all, productivity in the service industry is lower than that of manufacturing. In this regard, even though the service industry takes a larger share in terms of employment, its share is constant in terms of added value. This fact implies that enhancing productivity in the service sector is the crux of raising the overall economic growth rate.

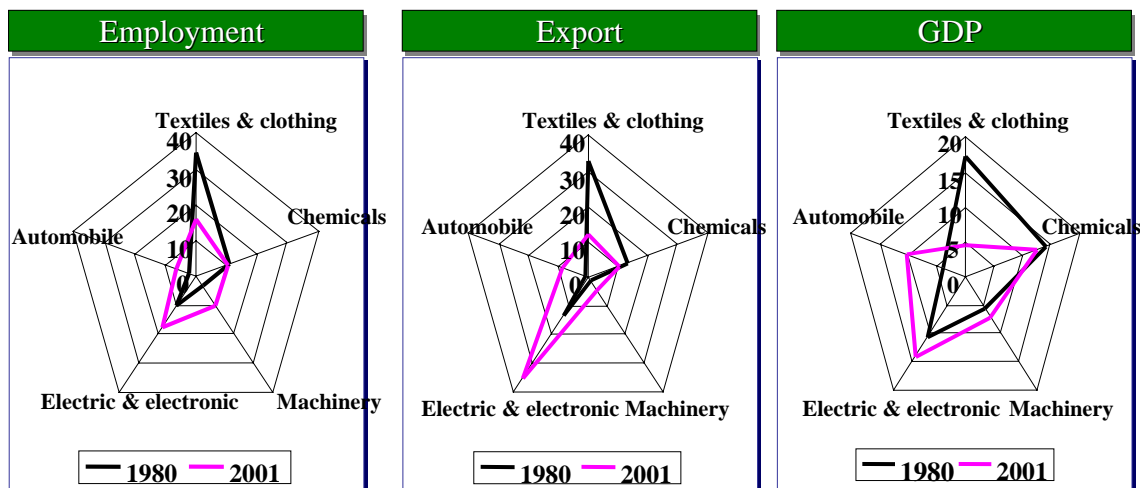
Within the manufacturing industry, intervals of business scales widen both in inter- and intra-sectors. Its expanding gaps in inter-sectors are the most evident in inter-sectoral differences in terms of growth rate and total factor productivity (TFP) growth. The electronics and automobile sectors lead a large part of the growth rate of the manufacturing industry and TFP growth. Especially, these growth rates are ascribable to the rapid productivity increase mainly by large conglomerates since the 1990s. Furthermore, according to findings of productivity analysis of manufacturing by sub-sectors and by five groups of firm-scale, the higher growth rates are found in electronics and automobiles, with the larger share led by conglomerates. And these conglomerate firms make a higher contribution to the growth rate of productivity and increasing productivity. These analysis results show that large conglomerates are expected to maintain the leading role in the growth of the manufacturing industry for the time being. In contrast, except for the smallest firm-cohort with less than 10 employees, smaller firms show poor records in productivity growth. The productivity improvement of smaller firms is an important task for sustainable growth and improvement of the competitiveness in manufacturing in general.

The phenomenon of widening gaps among inter-sectors and inter-firms which we call bifurcation or polarization is also identified in the analysis of financial structure. According to the results analyzing financial stability and profitability from 1990 to 2002, while both total assets and tangible asset investments have been on a downwards trend since the financial crisis, the gaps widen between large conglomerates and SMEs. In addition to this deepening polarization, signs of a decrease in increasing rate of tangible assets give rise to apprehension in light of an expansion of growth potential. However, as KDI study noted in the chapter reviewing R & D activities of firms, we have found a positive sign of the possibility that the Korean economy is in the process of transforming into an

¹ This section reports the findings of KDI project on Korea's industrial competitiveness. For more details, see KDI (2003).

innovation-driven economy as the number of technology-intensive SMEs dramatically increases after the financial crisis.

Figure 3: Changes in Shares of Five Major Manufacturing Sectors



Productivity

We used the plant-level manufacturing survey data for 1984-2001 compiled by the National Statistical Office. The data were re-compiled according to the 29-sector classification system of the KDI Multi-Sector Model, and, for five major industries, the data were rearranged into sub-industries according to the supply chain in each industry. The plants were classified into five categories according to the number of workers, and the analysis was performed for three sub-periods; 1985-89, 1989-97 and 1998-2001. We estimated both single-factor productivity, such as labor productivity and capital productivity, and total factor productivity (TFP), which was estimated by both the growth accounting method and multi-lateral method.

(1) Labor Productivity: Huge gaps of labor productivity were observed among industries and among size groups. The basic metals and electronics industries showed high labor productivity while textiles and garments, metal products, precision instruments industries showed a low level. We could also find that larger plants recorded higher labor productivity for the entire period, and that the gaps are widening. Analysis on the growth rate of labor productivity also showed a similar pattern. Specifically, the electronics industry showed an overwhelmingly high growth rate, and machinery and transportation equipment industries showed comparably high growth rates, while textiles and garments, paper products and publishing, and metal products industries recorded extremely low growth rates. Overall growth rate has persistently risen, with an exceptionally low growth rate right after the economic crisis. Analysis on the growth rate of labor productivity by plant size reveals an important result. We found that, over the entire period, larger plants recorded higher growth rates. However, we found, in addition, that smaller plants showed higher growth rates in the first sub-period (1985-89), that this trend reversed in the second sub-period (1989-97), and that the gaps widened in the third sub-period (1998-2001) when productivity growth was led mostly by large firms.

(2) Capital Productivity: Capital productivity shows a relatively stable time-series, and the gaps among industries and among firm sizes are reducing, except for several industries. Capital productivity by plant size shows an “inverted U” shape, i.e., the plants with medium size show the highest capital productivity.

(3) Total Factor Productivity (TFP): Annual average growth rate of TFP for 1985-2001, computed by the growth accounting method, for the entire manufacturing sector was estimated to be 4.33 percent. It was estimated slightly higher than 4 percent until the late 1990s, but rose sharply up to 11.68 percent after the economic crisis. The food and beverage, textiles and garments, and precision instrument industries showed slow TFP growth for the entire period, while the electronics industry

showed an extremely high TFP growth rate, high enough to lead the TFP growth of entire manufacturing sector. The machinery and transportation equipment industries, in addition to electronics industry, also recorded high TFP growth rates, and these industries recorded remarkably high TFP growth in late 1990s. Growth pattern of TFP by plant size shows a trend highly similar to that of labor productivity. That is, smaller firms revealed higher TFP growth rates in the first sub-period, but the trend reversed in the second sub-period, and the gaps widened in the third sub-period. Estimation by multilateral index method showed almost the same results.

In conclusion, it can be said that the growth and technological progress of the manufacturing sector has been led by the electronics and automobile industries, and, in particular, by the fast productivity growth of large firms in the 1990s. This can be explained by the fact that the shares of large firms are relatively big in the industries with fast productivity growth.

It is expected that the growth of the manufacturing sector led mostly by large firms will persist for the time being. At the same time, however, it is necessary to pay special attention to the increasing share of smallest firms and to the slow productivity growth of medium-size firms (with 100 to 300 workers), since it would be impossible to sustain a high growth rate and improved competitiveness in the manufacturing sector without sufficient productivity growth of small- and medium-size firms.

Figure 4: Labor Productivity by Industry and Firm-size

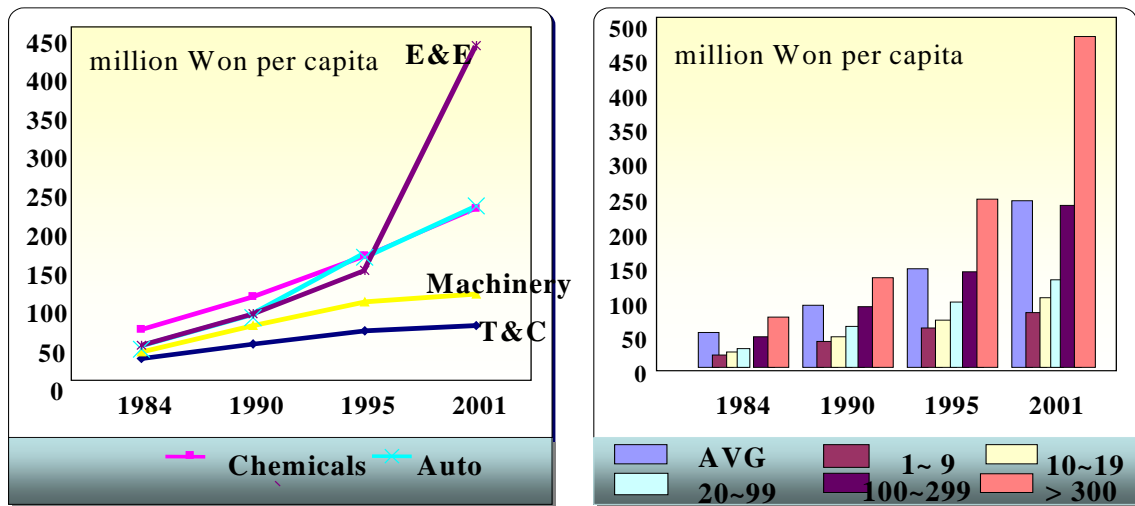
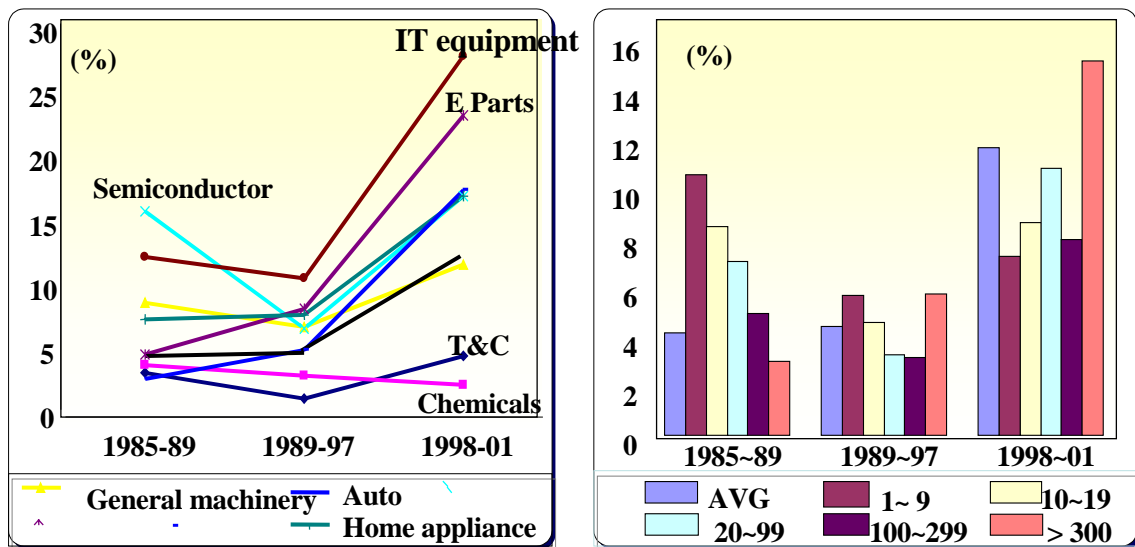


Figure 5: Total Factor Productivity Growth by Industry and Firm-size



Trade Performance

We analyzed the trade pattern of Korea through various indices such as market share, export similarity (ES) index, revealed comparative advantage (RCA) index, and trade specialization (TS) index at industry and sub-industry levels. The UN's trade data for the period 1992-2000 were used for this purpose, which, originally compiled by SITC, were re-compiled under the 29-sector classification system of the KDI Multi-Sector Model. The trade performance of Korea and the degree of competition among three countries - Korea, Japan and China - were evaluated by market shares and ES indices, while RCA and TS indices were used to analyze the current state of comparative advantage and the dynamics of trade pattern of the above three countries. In addition, we also analyzed intra-industry trade (IIT), i.e., the trade of "similar" goods, based on the UN's trade data for the period 1989-2002.

Estimation results clearly revealed the complementary and substitutive relations of the major industries among the above three countries. Korea recorded high export and market shares in IT equipment, semiconductors, textiles and apparel, and chemical products, while China in textiles and apparel and IT equipment's, and Japan in automobile, general machinery, IT equipment's and chemical products. In case of Korea and China, the shares of textiles and apparel were decreasing, while those of IT equipment's were increasing. Korea showed high and increasing export and market shares of semiconductors. On the other hand, Japan showed a relatively stable export structure, with high shares of automobiles, general machinery, electronics and chemical products. Japan's trade pattern revealed a comparative disadvantage in textiles and apparel, and electric appliances, while Korea in food products and beverages, precision and general machinery, and metal products, and China in automobiles, semiconductors, precision and general machinery, and chemical products.

All three countries showed high market shares and export similarity in the field of electronics, which seems to stem from the activities of the multinational companies that started establishing production bases in China since the 1990s and increasing exports. In recent years, China has overtaken Korea rapidly in the export of electronics (except semiconductors), and the competition between the two countries has also risen in the trade of precision instruments and metal products. Between Korea and Japan, export similarity in the field of automobiles was at the highest level, while competition between Japan and China was rising in shipbuilding as well as electronics.

Reviewing the TS indices, we could find that China was gaining competitiveness in almost every industry, that Japan was losing competitiveness in most industries except chemical products, and that Korea was enhancing competitiveness in more industries. China's competitiveness was improving in the trade of products with positive TSI such as electric appliances, miscellaneous manufactured products and metal products. In addition, IT equipment's, automobiles, and shipbuilding, previously net-imported (i.e., negative TSI), became net-exported, and the TSI's of chemical products, semiconductors, electronic components, general and precision machinery, and basic metals, though negative, have been improving recently. In case of Japan, on the other hand, only chemical products showed positive and improving TSI, while the TSI's of other products are falling. Korea's competitiveness was improving in the trade of metal products, electric appliances, automobiles and shipbuilding (goods with positive TSI) and of chemical products, petroleum and coal products, and electronic components (from negative to positive TSI). On the other hand, Korea was losing competitiveness in the trade of textiles and apparel, semiconductors, IT equipment's, and miscellaneous manufactured products (goods with positive but declining TSI) and of food and beverage, and basic metals (goods with declining negative TSI).

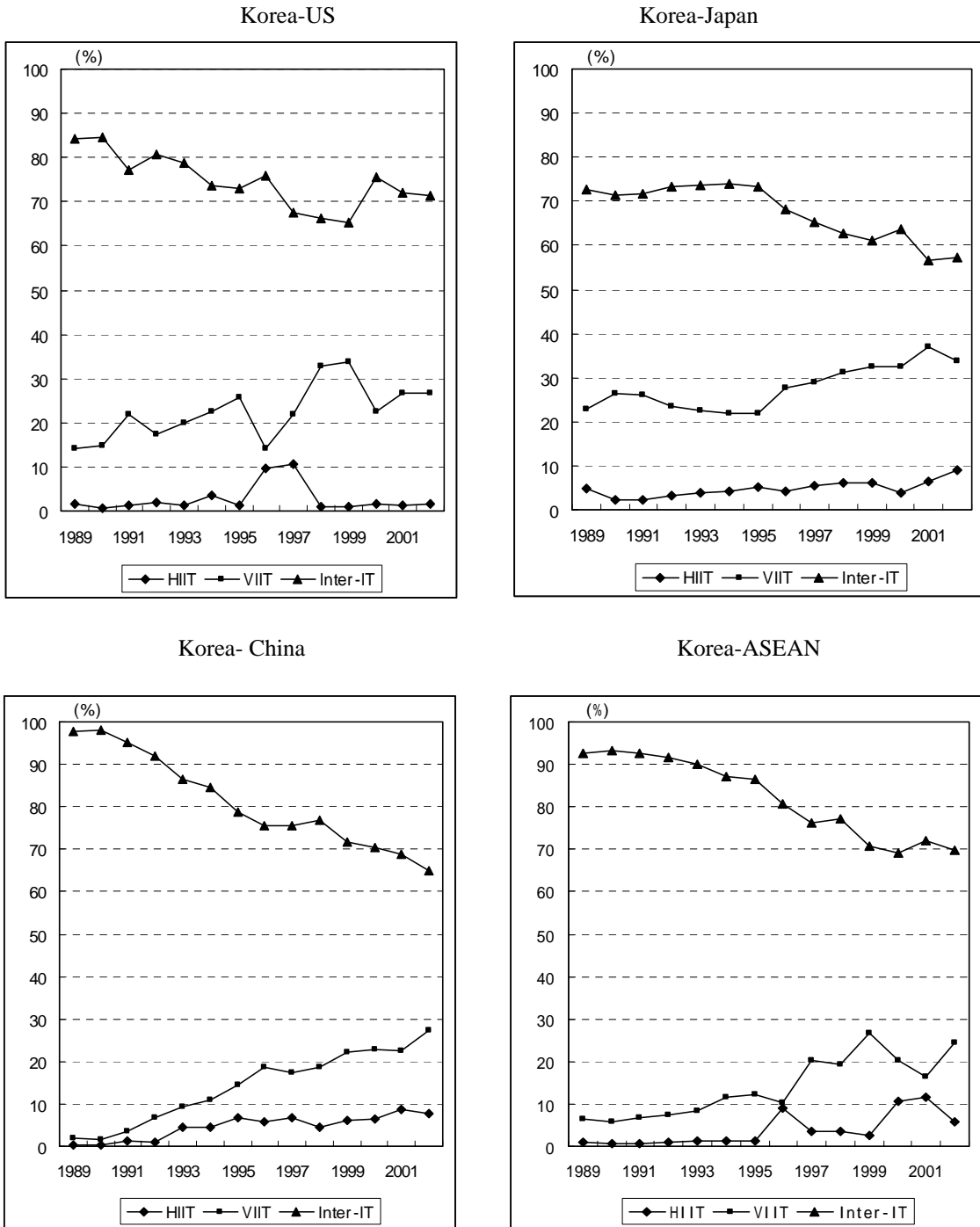
We performed the analysis of industrial competitiveness through IIT indices in addition to the study of inter-industry trade. Trade between Korea and Japan and between Korea and the US showed a pattern such that vertical IIT dominates horizontal IIT, which implied that Korea could produce and export "similar" products to the US or Japan, but with lower quality and price. We could not detect any evidence that the gaps were narrowing. On the other hand, we found increasing horizontal IIT between Korea and China, which implied that the quality and price of China's products were approaching those of Korea's. We also found that IIT with ASEAN, unlike IIT with China, was not increasing fast.

Table 2: Trade Specialization Pattern in East Asian Economies

| | Korea | China | Japan |
|-----------|---|--|---|
| Group I | Automobile and parts, Shipbuilding, IT home appliances, Metal products | Textile & clothing, IT home appliances, Other manufacturing | Chemicals |
| Group II | Textile & clothing, Semiconductors, IT equipment, Other manufacturing | Food & beverage, Non-metallic mineral products | Automobile and parts, Shipbuilding, IT equipment, Electronic parts, Semiconductors, Machinery, Metal products |
| Group III | Chemicals, Petroleum & coal products, Electronic parts | IT equipment, Automobile and parts, Shipbuilding | IT home appliances |
| Group IV | General machinery, Precision instruments | Semiconductors, Electronic parts, Primary metal products, General machinery, Chemicals, Petroleum & coal products, Precision instruments | Food & beverage, Textile and clothing, Petroleum & coal products |

Note: Group I = Highly competitive, TSI is positive and increasing,
Group II = Competitive, TSI is positive but decreasing,
Group III = New exporting industries, TSI changes from negative to positive,
Group IV = Weak industries, TSI has been negative.
Source: KDI, 2003.

Figure 6: Patterns of Intra-Industry Trade in Manufacturing Products



Note: HIIT denotes horizontal inter-industry trade and VIIT denotes vertical inter-industry trade.

Source: KDI, 2003.

Profitability and Financial Performance

We analyzed financial performance measures for each categorized firm-size of major manufacturing industries with the data of National Information & Credit Evaluation Inc. over a thirteen year period (1990-2002). In the analysis, we investigate empirically not only the various financial performance measures but also the value-based performance measures, EVA (economic value added).

Major empirical findings for the thirteen-year period are as follows; First, The profitability of domestic manufacturing companies in general displays an improving trend after the 1997 financial crisis even though there were significant differences between large enterprises and SMEs (small and medium-sized enterprises). For instance, ordinary income to sales of large enterprise and SME were 2.4% and 0.2%, respectively between 1990-1997, and these trends continued after the financial crisis as well as for ordinary income to total assets and interest expenses and ordinary income to total assets.

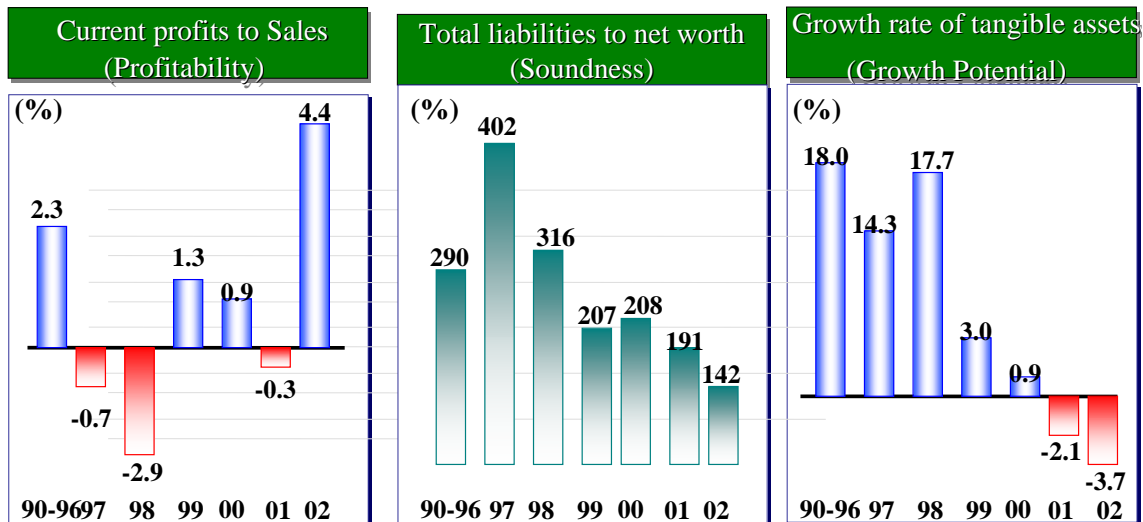
Second, the difference in the growth rate of sales between large enterprises and SMEs, one of the indicators concerning growth, became larger than those before the financial crisis. Especially, the growth rate of tangible assets of both of large enterprises and SMEs, which is the prior index of investment, has a declining trend after the financial crisis due to companies dormant facilities investment. Furthermore, the ratio of decline of SMEs is larger than that of large enterprises.

Third, the capital structure of companies was significantly improved. The debt-to-equity ratio fell to 213% during 1998-2002 compared to the 290% during 1990-1996. However, the average debt-to-equity ratio was 269% during the period of analysis. Meanwhile, their profitability gradually improved thanks to the decline in the cost of capital and results from the restructuring efforts.

EVA (economic value added) is a measure of a firm’s profit after subtracting the cost of all capital employed. It is defined as operating profits after taxes minus cost of capital. The average growth ratio of EVA was 22.3% for 1991-1996 but was 1.8 trillion in 1998 that is almost -40% of the preceding year. However, after recording a fall in 2001 there was a remarkable increase (79.8p%) in 2002. Major empirical results of EVA for each industry recorded almost positive values that means firms produced economic value. But SMEs experienced significant declines after the financial crisis.

The conclusion to be drawn from this analysis is that the results are mixed. In other words, we could not find the financial performance characteristic in the major industry, meaning that firm size is more important than each industrial characteristic in producing financial performance. Korean manufacturing companies have shifted their economic management goals from being a growth-based strategy to inward building for profit following the financial crisis in 1997. Therefore, the difference of financial performance between the Korean firms and the advanced countries is gradually reducing. While the average debt-to-equity ratio of the companies was reduced, it was not led by the efforts of companies but mainly by the government’s restructuring efforts and financial agents. Therefore, it is imperative that domestic companies sharpen their competitive edge so that they can produce stable profits regardless of outside situations with efficient and continuous investment and gradual reduction of the debt-to-equity ratio.

Figure 7: Financial Indicators



Foreign Direct Investment

Since 2000, Korea has experienced a sudden downturn in the amount of FDI (Foreign Direct Investment) inflow which has continued ever since. In addition, most of the FDI have been gravitated toward Seoul and Gyeonggi Province, and this gravitation has intensified even more since the crisis. The FDI into China, on the other hand, has reached a record high, making the gap between the growth rate of FDI amount into Korea and China bigger than ever.

According to the analysis performed to examine the effect of inbound FDI on productivity, the productivity of firms with FDI is higher than that of non FDI domestic firms with other things being equal. When the intra- and inter-industry productivity spillovers are examined, the coefficients of intra-industry and downstream industry FDI share are both found to be positive and significant. The backward productivity spillovers are especially bigger and more significant among all the variables, and are not affected by the model specification and share calculation method employed. The forward productivity spillover effect, on the contrary, appears to be unstable in terms of sign and significance. Depending on the model specification and share calculation method, it even appeared to be negative and significant in some cases. The existence of such effects, regardless of their direction, provide evidence on the public good aspects of FDI and thereby can be a rationale for governmental intervention in the course of attracting FDI.

In the case of outbound FDI, the size decreased drastically after the crisis, though lately it is showing some signs of recovery. While there has been sharp increase in the amount of outbound FDI into China, especially in the small and medium enterprise sector, it is uncertain whether this trend can last considering there is only a limited number of domestic firms that have capacity to penetrate Chinese market.

In general, FDI is known to raise productivity and to promote industrial restructuring through the transfer of advanced production and management technologies, not to mention increase in investment and employment. FDI would thereby raise the level of production and technological innovation in Korea.

While the world FDI market is also suffering from stagnation, there is a very high possibility that this market could revitalize in the near future. If it does, there will be a rapid expansion of M&A and strategic alliances among advanced countries and developing countries. Korea still possesses an advantage over China in terms of high value-added activities and industries. As long as we manage to innovate the strategy and propulsion system of attracting FDI, we can expect a turnaround that could take Korea out of recent stagnation in investment and the gravitation of FDI into China. This must be preceded by building a strategic FDI-attraction-system, improving the investment incentive system and M&A related laws and regulations, lifting the entry barrier of a national R&D system to FDI firms, etc.

Table 3: Korea's Foreign Direct Investment

| | (Unit: billion dollars) | | | | | |
|----------|-------------------------|--------|---------|--------|---------|---------|
| | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
| Inbound | 7.0 | 8.9 | 15.5 | 15.2 | 11.3 | 9.1 |
| | (117.6) | (27.0) | (75.6) | (1.0) | (-25.8) | (-19.4) |
| Outbound | 5.9 | 5.8 | 5.1 | 5.9 | 6.3 | 6.2 |
| | (-10.9) | (-2.0) | (-12.9) | (17.6) | (5.7) | (-1.4) |

Note: Registration basis; numbers in parenthesis are year-on-year growth rates.

Source: Inbound FDI = MOCIE, outbound FDI = MOFE.

2.2 Competitiveness of Major Industries

Electronics

The Korean electronics industry is characterized as a dual structure or an unbalanced structure. It is comprised of large conglomerates that play a leading role both in domestic and global markets and the remaining groups of companies that are weak in their technological competence. Considering the

electronics industry in general, competition with China is fierce in such sectors as computers and home appliances where price plays a key role in competitive advantage. The Chinese competition is relatively low in such sectors as memory chips particularly semiconductors and display units where non-price factors, for example technological leadership, are more important. Of particular interests is the dramatic increase of global market share by Chinese firms in communication equipment, rising as one of Korea's major competitors, presumably due to the roles of MNEs in China. The obstacles to further development of the electronics industry will be found in its dual structure, such as gaps between conglomerates and SMEs in both inter and intra-sectors. While leading conglomerates that have global business strategies can maintain their competitiveness through procurement of parts all over the world; the development of industries in general cannot be sustained without improving competitiveness of firms at a lower level. This conclusion implies that the government should make more efforts to rectify the dual structure, which indicates the importance of nurturing smaller technologically agile firms.

Automobile

The dual structure is found also in the automobile industry - the bifurcation of industry into the two groups of companies: final auto assemblers, led by conglomerates, and component suppliers made of SMEs at the lower level. While the final assembly sector is assessed to have a competitive advantage that enables them to penetrate into overseas markets, the persistent weaknesses of parts suppliers is expected to be a vulnerable element to the competitiveness of the automobile industry in general. Whilst modularization has become important in securing competitiveness in the parts industry, it is currently being implemented as a way of reducing costs for automobile components in order to compensate for wage differentials between final auto assemblers and parts suppliers. As R&D becomes the most critical strategic element in sharpening competitive edge, first-tier companies as well as many second and third-tier ones expand their R&D investment. Still, one of the biggest obstacles for the parts suppliers is the shortage of high-skilled labor in the production line due to their wage differentials compared to final assemblers. Owing to business restructuring after the financial crisis and the progress of market opening and the IT revolution, parent companies' global sourcing is strengthened. In this circumstance, conglomerates dealing with component suppliers have faced a turning point, changing from the previous vertical relationship. Competence of parts suppliers is weak in such areas as independent technological development, purchasing & sales, and capabilities of collecting information on global market trends, mostly relying on the parent companies. Whereas Chinese enterprises have higher price competitiveness, they lag behind Korea in terms of the level of technology, which delays the rise of Chinese firms as threatening competitors to Korean firms. However, building up firms' core competence requires accumulation of long-term experience. Taking into account that Korean parts makers do not have a considerably higher capability of developing technologies compared to Chinese firms, it is expected that Chinese firms would catch up to Korean firms in the near future. An upgrade in the quality of work force is needed to strengthen innovation capabilities and to expand the production capability of parts suppliers to the level where scale-economies is realized.

Machinery

The machinery industry faces a challenge to transform its current production system to one that is based on generic technologies, which enables to the production of differentiated products. In general Korea's machinery producers show dexterity in manufacturing and assembly, where company competitiveness originates. On the other hand, competitiveness is found to be low in the specialized machinery sector, which requires integration and application of new technology. This characteristic is largely due to the industrial structure of the machinery industry that is composed of, mostly, SMEs. The efficient and competitive production structure can be idealized as one where, when SMEs specialized in core parts and materials strongly support industrial base and conglomerates perform large-scale projects as well as lead the machinery industry. Ninety-eight percent of the Korean machinery industry is composed of SMEs based on the number of enterprises. As the majority of them are small scaled with the sales composition made mostly of single products, they lack sufficient competence to function as the bedrock of the machinery industry due to poor motivations for technology development. In contrast, big companies do not in general reach such stages as they can lead the development of the overall machinery

industry, even though they achieved business rationalization through restructuring processes after the financial crisis. Therefore, a pressing task is to consolidate the system-base of the industry, a system where specialized firms are closely linked through supply chains and innovation networks. It is also urgent to improve technological capability in machinery design and generic technologies, where Korea has big gaps compared to advanced countries. To accomplish this task, it is necessary to promote the inward investment of foreign companies, who are leading the global industry, as well as reinforce industry-academia linkages.

Chemicals

The chemical industry includes such diverse industries as petrochemicals, fine chemicals, and rubber and plastic. While it is linked with a series of production chains, obvious differences are found in each sub-sector in terms of production structure, required technologies and others. While there has been a slight decrease in value of production, the amount of export, and share of value-added just after the financial crisis, the chemical industry has recently experienced a recovery trend and some products meet global standards in light of production scale. There are contrasts between capital-intensive industries as petrochemicals and rubber and plastic and technology-intensive fine chemicals. Whereas the petrochemical sector, led by large conglomerates, has an export to production ratio of over 40%, with a high comparative advantage index, the fine chemical sector mostly remains oriented toward domestic demands with a lower competitiveness index in the global market. In terms of productivity, the petrochemical industry generally attains a high level of productivity due to the high capital intensity, while that of the fine chemical industry is low. However, a high level of competitiveness does not necessarily relate to a higher level of productivity in petrochemicals compared to fine chemicals. Without adjustment of the excess facilities and R&D efforts for new products, its current competitiveness cannot be maintained. In the chemical industry in general, prerequisites for sustained growth are, among others, development of new businesses and innovation of production process. Especially, the industry in general should re-orient its growth strategy to explore new markets through the development of differentiated products thus changing the current strategy of focusing on standardized products. More large companies are to be induced to enter into the fine chemical sector which is currently comprised of mostly small companies, and thus playing a leading role in the development of the industry as a whole. In tandem, the government should make more efforts to rationalize the industrial structure by inducing autonomous restructuring of over-capacity in petrochemicals and enhancing cooperation between large firms and smaller firms.

Textiles and Garments

The textiles and garment industry has been gradually taking smaller shares since the 1980s. However, they still occupy a key position with 15% of total employment in the manufacturing sector as of 2001. They took larger shares in exports in spite of a slowdown in their exports with 13.9 billion dollars in the black in 2000. As domestic textiles and garment industries have tended to lose their competitive edge in general, the long-term trend of industrial decline is expected to continue. Considering the textiles and garment industries in general, recovering to the levels of their heydays is difficult to expect. Yet, the textiles and garments sectors still have potential for further development, with strategic specialization in the sectors of synthesis yarn and synthesis fabrics, where Korea has a high degree of competitiveness and strengthening design and brand marketing which enables to climb up a higher ladder of quality. For instance, developing super-functional textile materials and their commercialization is important for preventing a radical decline in the domestic textiles industries, as well as upgrading industrial structures. Reactivating the fiber and textiles sectors requires a creation of demand in the garment industry. It is also essential to create a demand of apparel with fashionability and marketability. Furthermore, innovation of a distribution system in the garment industry is critical for overcoming limitations of market size and creating further demand. Additionally, an initial generation of market environment is also required for domestic textiles businesses to convert into various kinds of small lots through formulating a distribution network of fashion clothes with low and medium price levels.

3. China Factor

China is becoming a major player in the world economy. It has shown astonishing performances in economic and export growth. For the period from 1985 to 2002, the Chinese economy grew at an average annual rate of 8.9% and China's share of the world economy increased from 1.2% to 3.8% (Table 4). Meanwhile, China's share of world exports has rapidly increased from 1.3% in 1985 to 5.2% in 2002, which is equivalent to 15.1% average annual growth rate. China's export growth rate surpasses its two neighboring countries; during the same period, average growth rates of exports from Korea and Japan were 11.0% and 6.0%, respectively. China has also successfully diversified its export markets. In particular, China's penetration into US, Japan and EU markets, the most advanced ones in the world, is remarkable. In 1985, China's exports claimed only 1.1% of those three markets; but, in 1999, had 4.9% of the total.

Table 4: China in the World Economy
(Unit: billion dollars)

| | 1985 | | | 2002 | | | 1985-2002 avg. annual growth % | |
|---------|-------|--------|-------------------|-------|--------|-------------------|-----------------------------------|-------|
| | China | World | China/ World % | China | World | China/ World % | China | World |
| GDP | 274 | 22,710 | 1.2 | 1,237 | 32,227 | 3.8 | 8.9 | 2.1 |
| Exports | 25 | 1,886 | 1.3 | 326 | 6,272 | 5.2 | 15.1 | 7.1 |

Note: GDP in constant terms; exports in current terms.

Source: UNCTAD, *World Investment Report*, 2003; WTO, *International Trade Statistics*, 2003.

Several factors explain China's rapid economic growth. Following Japan and other newly industrializing economies in East Asia, China adopted export-oriented development strategies. Backed by the country's large size, export markets enable China to realize economies of scale, one of the main sources of economic growth. In addition to these factors, which are frequently jointly referred to as the success factors of Asian economic growth, China's economic development process also has a unique aspect that is not all common to other Asian peers' earlier stages of economic development: that is its strong technological base. China's shift from technological nationalism to a more pragmatic strategy of developing national capabilities in conjunction with multinational corporations has also contributed to transform its economy.

China has transformed its economy on the foundation of a large science and technology base with technological capacities well beyond those of most developing countries (Kraemer and Dedrick, 2002). As part of its economic transition, China transformed its science and technology system to spur economic development. It did so partly by creating state-owned but market-oriented enterprises linked to commercializing the technologies developed in state-owned research institutions. For example, the four largest Chinese PC makers—Legend, Founder, Stone, and Great Wall—emerged from this background. The growth of indigenous firms with high technological competence even in earlier stages of economic development distinguishes China's economic development process from that of other Asian peers.

Conventionally, the process of economic development in developing or less developed countries is postulated on a linear model. Industrialization starts in technologically less demanding low-skilled industries; in the meantime, through experiences in low-skilled production, the economy and indigenous firms accumulate technological capabilities; and, then at the later stages of development, the economy and firms enter into technologically more demanding high-tech industries. The industrialization processes in Japan and in Asia's newly industrializing economies such as Korea and Taiwan were in most cases not exceptional to the linear stage model. But, in contrast, taking a cross-section of China's industrial composition, however, observers would find that almost every industrial sector exists in significant scale. Leapfrogging, particularly in high-tech industries, is taking place in China's economy. (See Box 1 for an example on China's communications equipment industry) China's computer industry and communications sector are good examples to show how a late-industrializing economy would take advantage of new technological opportunities through the interplay of the government and markets.

Box 1 The Growth of China's Communications Equipment Industry

While most countries, including Taiwan, presently are deciding to postpone the actual introduction of the 3G mobile telecommunications service, Mainland China is endeavoring to develop its own 3G system. The key to this daunting venture into new technology-based industry is the government's initiatives to promote the mobile Internet through a low tariff policy, to give opportunities for growth for indigenous companies, and to induce foreign investment. Three Chinese companies, DATANG Telecom, Huawei Technologies, and Chungxing, are concentrating on the development of relevant facilities such as base stations, and other mobile handset producers, including PTIC, Wavcom, Eastcom, and Chungxing, are working to upgrade their technologies in developing the 3G mobile handsets. MIC forecasts that by 2005, China will become the biggest market and production base for mobile communications, with the number of mobile telephony subscribers forecast to reach 245 million in 2005 from 117 million in 2001.

Source: <http://www.ntc.no:8080/files/ntc/rapporter/taiwaninternet.doc>.

Box 2: Huawei (華爲) Technologies Co. Ltd.

Established in 1988 by an army wireless communication engineer, Huawei Technologies is a high-tech enterprise that specializes in research and development, production and marketing of communications equipment. Taking 40% share in the Chinese market. Huawei's competitive strength is to produce high-tech products with lower costs, which enables it to compete with foreign suppliers both in domestic and overseas markets. It has succeeded in winning the competition in supplying communication equipment projects in Vietnam, Thailand, Indonesia, South Korea and Brazil. Sixty percent of its 16,000 workers hold MA degrees, and more than 2,000 are Ph.D.s. Huawei spends more than 10% of its sales in research and development – US\$342 million in 2001. With a headquarters in Shenzhen, Huawei has 11 R&D centers, among which are five overseas research institutes in Silicon Valley, Texas, Stockholm, Bangalore, and Moscow. It has numerous collaborative R&D projects with domestic and US universities. With its state-of-art design technologies, Huawei designs ASIC in-house and out-sources production to a US foundry company on an OEM basis.

Source: A. Kuroda, *Made in China*, tr. Park Jung Dong, 2002, p. 38 and <http://www.huawei.com>.

Impacts of China's development on East Asian trade structure

Overall, the rapid expansion of the Chinese economy creates a new growth opportunity for the East Asian countries and the world. As is shown in Table 4, the scale of China's economy has grown 4.5 times from 1985 to 2002; and China's entry into the WTO creates additional momentum for her trading partners for a bigger market with eased trade barriers. The question is, then, who will benefit relatively more from China's development. The answer is not straightforward, since the effect of increased trade depends on several factors.

The following figures show China's trade specialization pattern and the comparative advantages of China and her trading partners in Asia. Index for comparative advantages of international trade is calculated; and the manufacturing industry is disaggregated into 22 sub-sectors, and these sub-sectors are classified into four groups according to OECD standard of R&D intensities.² The KDI study of trade specialization patterns and comparative advantages of China and her trading partners in Asia, changes in China's trade specialization pattern are more apparent in bilateral trade with some Asian countries.

- With ASEAN:

In high-tech industries, China has comparative advantages in precision instruments, pharmaceuticals. In all mid-high tech industries, China has comparative advantages. China

² CTB in the figures represents for contributions to trade balances that are calculated by OECD method in percentage of manufacturing total. Positive CTB means structural surplus or comparative advantage; whereas negative CTB structural deficit or comparative disadvantage. For industry classification according to R&D intensity and the method to calculate comparative advantage, see OECD, Science, Technology and Industry Scoreboard, 2001.

has structural surplus in most of mid-low tech industries except petroleum refining and rubber and plastic. In low-tech industries, China has comparative advantages in paper and textile.

- With Korea:

Trade between China and Korea had begun in full scale in 1991 when two countries restored diplomatic relationships. It is very interesting to notice that in high-tech industries China has comparative advantages except communications equipment including semiconductor, though the margin is narrow. In mid-high tech industries, China has comparative advantage in electrical machinery including home electronics; and, Korea shows comparative advantages in the remaining mid-high tech industries. In mid-low tech industries, Korea has strong comparative advantages in rubber & plastic and petroleum-refining; and, except these two, China has comparative advantages. In low-tech industries, China has comparative advantages except food.

- With Japan:

China's trade with Japan shows very stable specialization patterns in high tech and mid-high tech industries, where Japan has mostly strong comparative advantages. In contrast, in mid-low tech industries China is gaining her comparative advantages; and, in low-tech industries, China has comparative advantages except food.

<<<Figure 8>>>

China's international trade shows an overall specialization pattern that is strong structural surplus in low-tech industries whereas structural deficits in the remaining manufacturing industries. But it is noteworthy that China's pattern of trade specialization is changing rapidly. For example, computer and office equipment in the high-tech sector and electrical machinery in the medium-high tech sector are rapidly changing from structural deficit to structural surplus.

China's changing pattern of trade specialization exemplifies how comparative advantages can be *created*. The rise of China's computer and communications equipment industries, as illustrated above, is a case in point. Coupled with the strategies of multinational corporations to capitalize on the growth potential of a country with a population of 1.2 billion, the Chinese government has introduced deliberate industrial policies to commercialize strong technological base. Indigenous firms are growing and accumulating technological capabilities that are comparable to those of foreign competitors. Technologically dynamic firms such as Huawei, (Box 2), are not prevalent in most developing countries; but, in fact, numerous Huawei's are growing in China. These factors interacting with others not mentioned here give positive feedback in the form of high economic growth and enhanced international comparative advantage.

China's trade relationships with other Asian economies show where its economy is moving. Currently, China's economy has strong comparative advantages in low-tech industries; but, at the same time, it is gaining comparative advantage in more technology-intensive sectors. Already, China has strong comparative advantages over ASEAN in some high-tech and most mid-high tech industries. China even shows comparative advantages over Korea in some high-tech industries, albeit with a small margin. But with Japan, there exists wide gap in high-tech and mid-high tech industries. Therefore, it is to be expected that competition between China and ASEAN and Korea will intensify in the near future; but China will not be an immediate threat to Japan in world markets for high- and mid-high tech products.

Prospects for the International Division of Labor between China and other Asian Economies

In discussing international division of labor in Asia, the flying geese model has gained wide audiences not only in academia but also in policy circles. The model was coined by Kaname Akamatsu in the 1930s and more rigorously developed by Kiyoshi Kojima later in the 1960s. Explaining the catching-up process of industrialization in latecomer economies, Kojima's model is based on two assumptions: (a) An economy's industrial structure is diversified and upgraded in a sequence from labor-intensive industries to capital-intensive industries and further to more capital- and knowledge-intensive industries. (b) The flying geese pattern of industrialization is transmitted through FDI from the lead country to follower countries

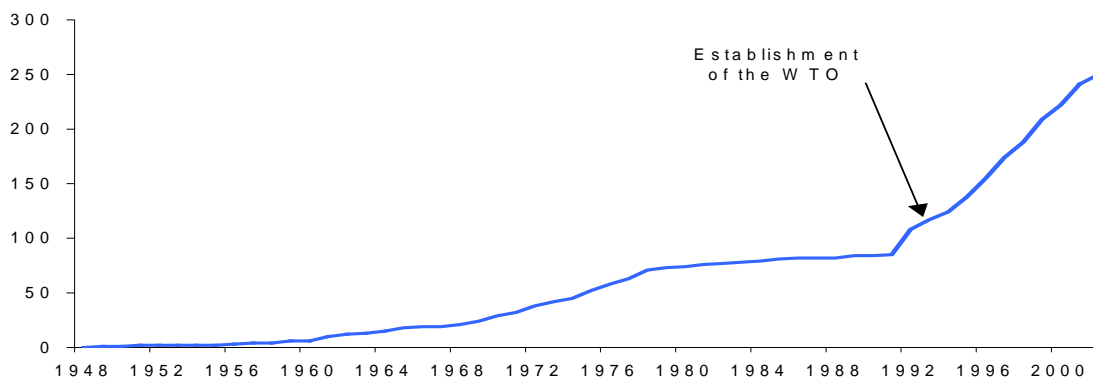
according to industrialization stage or per capita income level.

As Kojima (2002) acknowledged, the sequential process of industrialization characterized as the flying geese model does not fit the current status of the East Asian economies. First, Japan, as a lead country, has so far been unsuccessful in establishing a big new industrial sector needed to enlarge the scope of the regional division of labor. Second, in the 1980s, the Asian NIEs and some ASEAN countries (Thailand and Malaysia) graduated from the catching-up phase and became sub-leaders in exports and FDI to other Asian economies, and went ahead of Japan in certain other activities. The regional transmission of development in a manner consistent with the model has thus developed dual or triple paths. Third, since the 1990s, China became the largest Asian recipient of FDI and this contributed to the development of many technology-intensive industries. China's economic development does not fit well to the model in that its economy has leapfrogged in some technology-intensive sectors.

Accordingly, the international division of labor in the East Asia, and particularly that between China and other Asian economies, will be more diverse and different from the past. It will not be a sequential movement or a vertical division of labor as in the past; rather, the future shape of the international division of labor in East Asia will be more complicated, with multiple relationships between economies. Several factors will affect the shape of the international division of labor; some of significant importance will be briefly discussed in the following.

First, globalization with regionalism: The world economy is being rapidly integrated in various ways. Backed by the liberalization movements where GATT and WTO had made great efforts, international trade and foreign direct investment have rapidly increased. In addition to these traditional mediators of globalization, mergers and acquisitions are also proceeding internationally on an unprecedented scale. Literally, globalization is proceeding in full scale. Along with the globalization trend, however, there also happen international movements to integrate economies on a regional basis, particularly since the mid-1990s. According to Boonekamp (2002), the number of regional trade agreements (RTA) notified to the WTO has rapidly increased and accelerated during the 1990s. For example, the 125 regional free trade zones agreed since the WTO system was established in 1992, is the same as the total number of cases agreed during the entire life of the GATT system since 1948 (Figure 9). Regionalism alongside globalization is indeed becoming a new trend in the world economy; and, the new trend gives a hint to the future shape of the international division of labor in the East Asian region.

Figure 9: Cumulative Number of RTAs notified to the GATT/WTO , 1948-2002



Source: Boonekamp (2002).

Second, increasing importance of developing countries in the world economy and regional economic integration: As many developing countries adopted export-led development strategies since the 1980s, not only has the volume of world trade increased rapidly but also the share of developing countries in world manufacturing product trade has greatly expanded. For example, for the period between 1980 and 1998, those developing countries that pursued export-led growth strategies realized about 5% average annual economic growth rates, which is far higher than the 2% rates achieved by advanced countries. And, the share of manufacturing products in developing countries' trade increased from less than 25% in 1980 to more than 80% in 1998. The successful industrialization of developing countries and their increased

share in world trade imply that the role of developing countries in the world economy will be more important than in the past and that international trade relationships will be more diversified. As, in the East Asian region, China and the first and the second tier NIEs will play a more important role in trade and investment than before, while Japan's role as a lead country will be diminished.

Third, as economic activities of multinational corporations (MNC) are taking a larger share in the world economy (Table 5), the global strategies of MNCs in their choice of content and location of foreign investment are becoming more crucial in the economic development of host countries. UNCTAD reports that as of 2000 there are about 60,000 MNCs with 800,000 foreign affiliates and the number of MNCs coming from developing countries is increasing. In the freer trade and investment environment of today's world, countries are competing to attract more FDI and MNCs; and they are competing in creating more favorable conditions for this.

Table 5: Multinational Corporations' Activities in the World Economy

| | 1982 | | 1990 | | 2002 | |
|------------------------|---------------|-------------|---------------|-------------|---------------|-------------|
| | US\$ billions | % world GDP | US\$ billions | % world GDP | US\$ billions | % world GDP |
| MNC foreign affiliates | | | | | | |
| Sales | 2,737 | 25.3 | 5,675 | 26.2 | 17,685 | 54.8 |
| Value added | 640 | 5.9 | 1,458 | 6.7 | 3,437 | 10.6 |
| Exports | 722 | 6.7 | 1,197 | 5.5 | 2,613 | 8.1 |
| World GDP | 10,805 | 100.0 | 21,672 | 100.0 | 32,227 | 100.0 |

Source: UNCTAD, World Investment Report, 2003

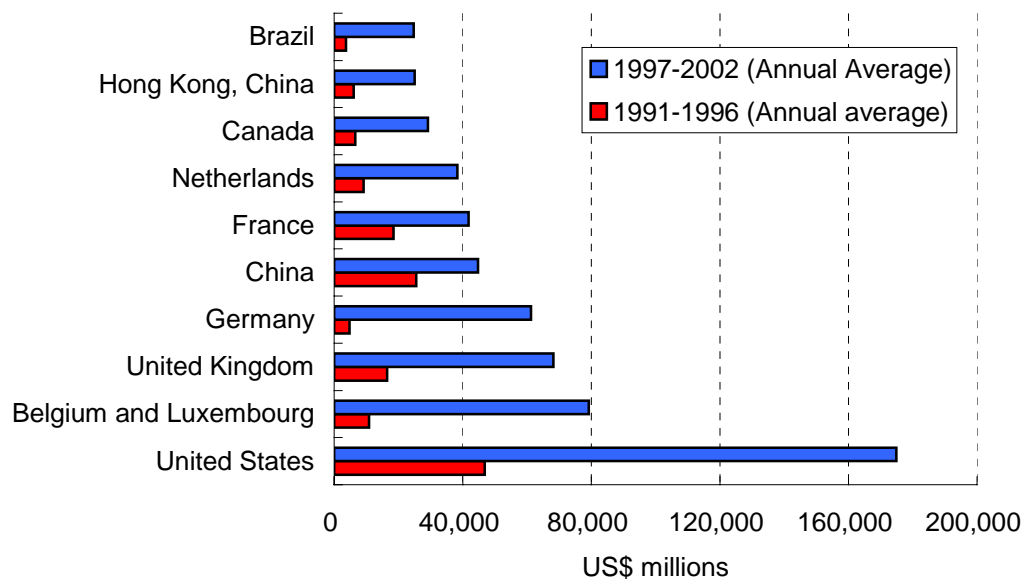
Despite the increasing role of developing countries in the world economy, the flows of FDI are concentrated on advanced countries and a handful of developing countries. During the period between 1990 and 2002, world FDI grew 9.5% on an annual average rate, which is far higher than the rates of world GDP growth (3.3 %) and world exports growth (5.0%) (Table 6). But the destinations of FDI are mostly confined to advanced countries (Figure 6): China is the only developing country among the top 10 recipient countries during the period between 1991 and 2002. According to the *World Investment Report*, 79% of US\$1,271 billion world FDI flows into advanced countries and 91% of FDI comes from advanced countries.

Table 6: Trade and Investment in the World Economy

| | Value (in current \$US billion) | | Average Annual Growth Rate (%) |
|-------------------|---------------------------------|--------|--------------------------------|
| | 1990 | 2002 | 1990-2002 |
| FDI inflows | 209 | 651 | 9.5 |
| FDI stock | 1,954 | 7,123 | 10.8 |
| International M&A | 151 | 370 | 7.5 |
| World GDP | 21,672 | 32,227 | 3.3 |
| World Exports | 3,442 | 6,272 | 5.0 |

Source: UNCTAD, *World Investment Report*, 2001; 2003; WTO, *International Trade Statistics*, 2003.

Figure 10: Top 10 FDI Recipient Countries



Source: UNCTAD, World Investment Report, 2003.

China is expected to become the manufacturing base of the world economy. China's industrialization will continue for the foreseeable future, and the pace of China's industrialization will be dependent upon, among other things, its success in reforming to a more market-oriented economic structure. China's rapid growth will in general give new growth opportunities for other countries; but there will be keen competition over the Chinese and world markets. In the process, the Asian economies will experience a structural adjustment much different from the past. In the past, as the flying geese model tells, upgrading of industrial structures of the Asian economies occurred sequentially and vertically. But as China is leapfrogging in its industrialization process, the industrial restructuring in the Asian economies will proceed across almost all industrial sectors. In sum, *intra-industrial restructuring* across the Asian economies will be prevalent.

The future shape of the international division of labor in the East Asian region will be more complicated than in the past. Any single country will not be able to dominate in an industry; rather, many firms of different nationalities will compete in the varied segments of a product market. Over the course, many more Asian firms will go multinational following their Japanese predecessors.³ Those MNCs will play a mediator role in promoting economic integration in the East Asian region. MNCs will relocate according to the strategic value of the host countries, so the challenge for national governments will be to create a more business-friendly, market-oriented socio-economic environment.

³ UNCTAD (2001) reports that among the largest 50 MNCs from developing economies 33 are from the East Asia—10 from Hong Kong, 9 from Korea, 7 from Singapore, 4 from Malaysia, 2 from Taiwan, and 1 from Philippines

4. Korea's Innovation System

4.1 The Evolutionary Process⁴

Although Korea, as a late-industrialising country, has depended heavily on foreign technologies, it has also made efforts to accumulate technological capabilities. At the initial launch of its economy-wide economic development plan, Korea was poorly endowed with factors necessary for industrialisation except for a plentiful labour force. Furthermore, the technological competence of Korean firms was far below world standards. Consequently, it was inevitable or natural to look toward foreign sources for technologies. After the industrialisation process launched in 1962, there was remarkable growth in imports of foreign. The process of technological capability building in Korea is characterised as a dynamic process of the interplay between imported technologies and indigenous R&D efforts.

Reviewing the process of industrialisation since the 1960s, there appears a general pattern of technological development across industries with some industry-specific variations. Table 7 presents the pattern in Korea's machinery industry. The table shows that technology transfer and in-house R&D are two principal modes of building technological capability in the machinery sector and other industries in general.

During the early stages of industrialisation, technologies are imported in packaged forms. Turn-key based plant imports were most common during those years, and assembling technologies were imported for the purpose of knock-down production and/or OEM. Then, afterwards, self-sufficiency in technology was enthusiastically pursued, although it was not achieved in a short period. Localisation of some technologies was one of the main goals both for government and private firms. In this period, imported technologies changed to un-packaged ones and the importation of operation technology increased in order to enhance productivity. After achieving, to some extent, the goal of promoting self-reliant technologies, the next step was to get Korean products into world markets. In order to do this, it was necessary to expand domestic markets. In this period, imported technologies were relatively more sophisticated and advanced, involving material-related technologies and control and design technologies. Throughout all periods, the ratio of OEM to own brand name (OBN) has steadily decreased.

Table 7: The technological capability building process in Korea's machinery sector

| | <i>The process of development</i> | <i>Technology imports</i> | <i>Production and R&D</i> |
|--------------------------|--|---|--|
| 1960s – 1970s | Policy goal: establishment of production base Characteristics: heavy dependence on imported technologies | Packaged technology: turn-key based plants Assembling technology | Knock-down type production system OEM-dominated Almost no in-house R&D |
| Early 1980s | Policy goal: promotion of self-reliance Characteristics: Import-substitution, Localisation of parts/components Production | Unpackaged technology: parts/components-related technology Operation technology | OEM/own brand: high ratio Product development In-house R&D begins |
| Late 1980s – 1990s | Policy goal: export-promotion by Means of expansion of Domestic market Characteristics: beginning of plant Exports, learning advanced and core technologies | Materials-related technology Control technology Design technology High-quality product tech. | OEM/own brand: low ratio Product innovation Process improvement |

⁴ For more detailed discussion on Korea's innovation system, see Suh (2000).

The pattern of technology transfer differs slightly across industries, particularly in the early years. Unit production industries, such as shipbuilding and machinery, relied mainly on formal transfer in the form of licensing and consultancy for the initial erection of production facilities and product design. Mass production industries, such as electronics and automobiles, also depended on formal transfer but to lesser extent. Instead, more emphasis was placed on engineering efforts for implementation. Continuous process industries, such as chemicals, cement, paper, and steel, were established on a turn-key basis.

Since the early stages and throughout the 1970s and 1980s, technology imports prevailed, and are still an important source of technological innovation. Recently, however, the outsourcing of foreign technologies has become more sophisticated, and the modes of technology transfer have become diversified and complex. Exchanges or alliances, for the mutual benefit of both parties, are beginning to take the place of unilateral technology imports. Furthermore, interest in foreign technologies is shifting towards more high-tech areas and/or design technologies, and the scope of foreign partners has widened considerably.

The growth of R&D activities in the private sector shows a similar pattern. During the earlier period of industrialisation, systematic in-house R&D efforts were hard to find out. It was not until the 1980s that Korean firms endeavoured to build in-house technological capability by institutionalising R&D activities. In the early 1980s, the R&D activities of private firms focused on the adaptation and assimilation of imported technologies. Product development was the main feature of R&D in those years. Since then, with a base of accumulated experiences and knowledge, a number of firms in some specific industries have been able to make some product innovations. Throughout these years, efforts to improve the production process have continued.

The pattern outlined above is clearly illustrated in Figure 11, which plots the trend of the relationship between technology imports noted as payment for foreign technology licensing fees and indigenous R&D efforts noted in terms of R&D expenditures over industrial production from 1976 to 2002. The trend changed substantially over the years. Indigenous R&D efforts remained at an insignificant level until the early 1980s, but since then R&D intensities have increased considerably. Consequently, the overall relationships between imported technologies and indigenous R&D efforts have changed from substitution to being complementary. Figure 5 shows that the trend of relationships changed around 1982. The turning is not accidental; this year marks the launch of NRDP, when private enterprises began to establish in-house R&D laboratories.

<<<Figure 11>>>

The changing relationship between royalty payments and R&D originated mainly from two sources: increased R&D efforts in the private sector, and governmental policy changes. Throughout the 1980s TI increased steadily and maintained its pace. At the same time, however, systematic in-house R&D efforts in the private sector have begun to prevail. Underlying this change, three driving forces, inter alia, have been influential. First, as the Korean economy moved to technology-intensive industries, foreign sourcing of technology could not meet the required technological standards. As foreign firms become more reluctant to release their technologies, it becomes harder to acquire advanced technologies by depending solely on the conventional means of technology imports. Second, the cost advantage of cheap skilled labor was exhausted after the early 1980s. Therefore, Korean firms felt the need to develop their own technological capabilities.

Underlying the changing relationships, both the private sector and the government have made concerted efforts to develop technological capabilities. First, there has been a fundamental shift in business strategy. In earlier years, international competitiveness relied mostly on such cost factors as low wages and scale economies based on mass production. And as imported technologies were of a kind that required simple assimilation and adaptation, there was no need to organise R&D activities. In later years, in contrast, as the cost advantage of cheap skilled labour was exhausted and the economic structure was transformed into more technology-intensive sectors, there was a pressing need for institutionalised R&D activities. The private sector met this need by establishing in-house R&D laboratories. Accordingly, the

pattern of international technology transfer has changed substantially, towards more sophisticated and complex forms.

In accordance with the stages of economic development, the Korean government has successively changed the orientation of S&T policy. In the earlier years, more emphasis was put on building the infrastructure for technological development, whereas in later years the emphasis shifted towards more specific targeted technological development. In the early years of launching full-scale economic development plans, the Korean government recognised very clearly that science and technology would play important roles in the coming years. In the 1960s, two noteworthy policy measures were initiated in this regard: the establishment of KIST (1966) and of MOST (1967). These two institutions, together with KAIS, which was established in 1971, have exerted powerful influences over the S&T community in Korea. MOST has been the main designer of Korea's overall S&T policy; KIST has played the role of technological functionary in responding to industrial demands for rapid economic growth; and, KAIS (later KAIST) first implemented the concept of the research-oriented university into the Korean higher education system. Subsequently, several important policies have been successively enacted; among others, the establishment of specialized GRIs since the 1970s, and, since the early 1980s, full-scale national R&D programmes.

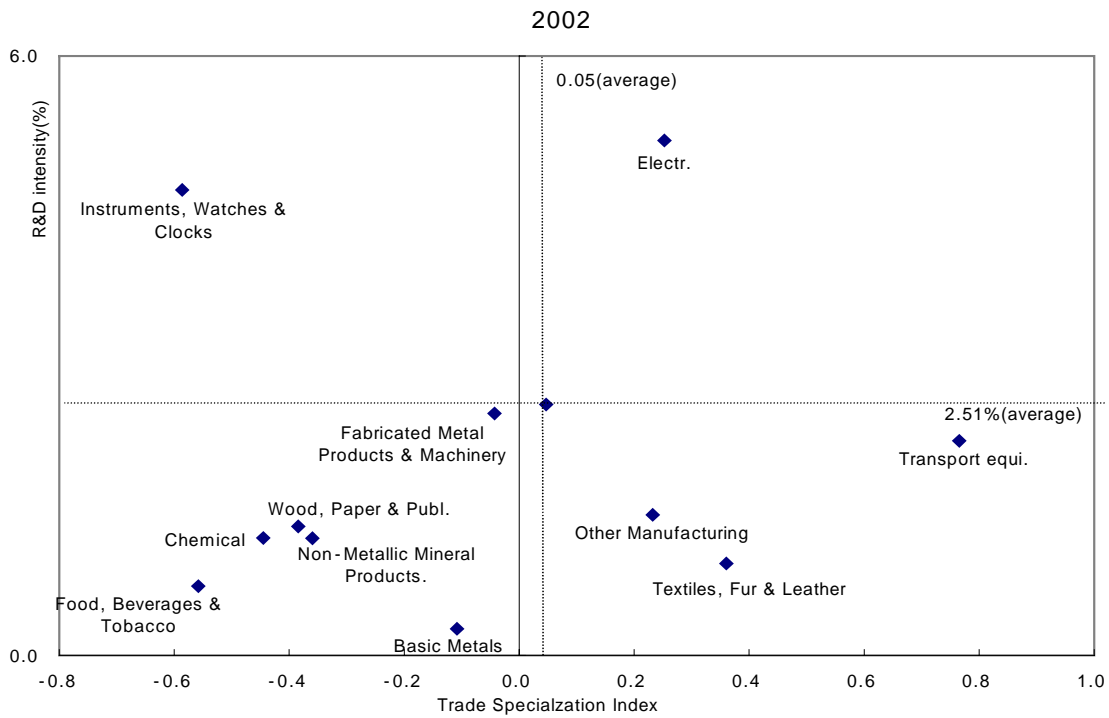
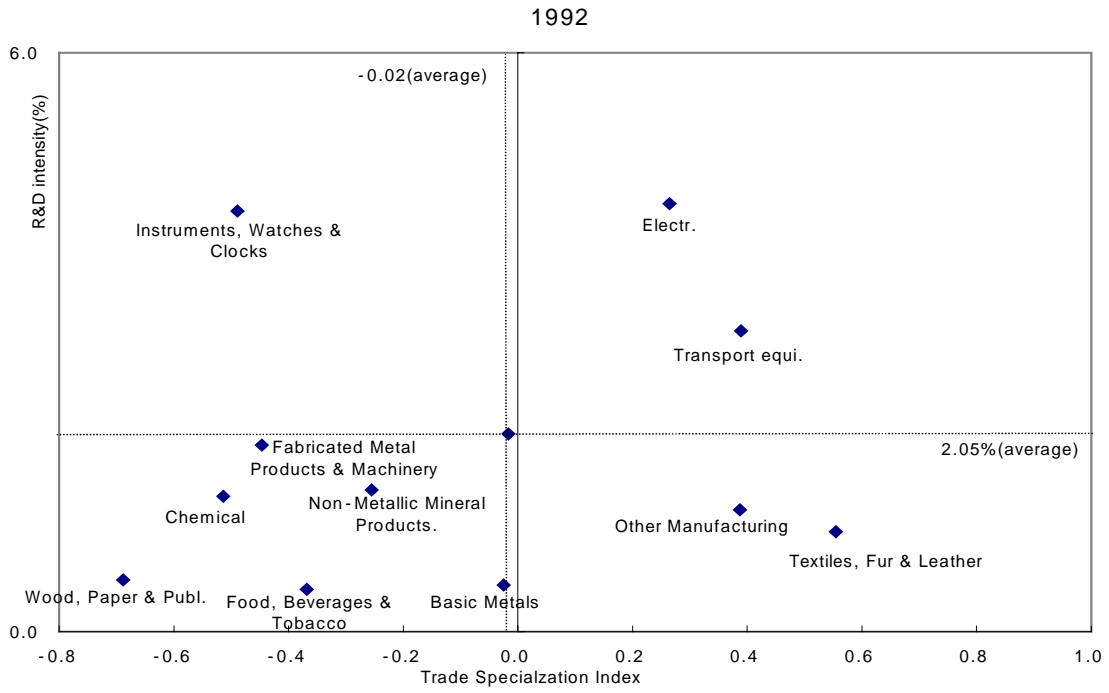
The process of building technological capability is best considered from the aspect of the choice of technology. The fact that most imported technologies are in a mature stage of development shows that products are already standardized in the world market. Moreover, in order to compete with foreign firms in world markets, i.e. produce standardized products without having technological superiority, cost advantage has to be achieved by economies of scale. Consequently, technologies that render economies of scale in production have been preferred. Large plants in petro-chemicals, semi-conductors, shipbuilding, steel, and the automotive industry exemplify the choice of technologies of this kind. Most of these industries demonstrate economies of scale in production as well as large plant size. In looking at industrial linkages, Korean industries in general show vulnerable backward and forward linkages when starting a new venture. For instance, when the semi-conductor industry was launched, there were neither adequate backward linkages to the equipment and raw materials sector nor forward linkages to the computer sector. The strategy of development for both government and private firms has been to assume that such lacked elements as components and raw materials will come from foreign sources. Combining imported technologies with cheap labor in the earlier period and fully exploiting human factors in the later period has enabled Korean firms to compete in foreign markets. In general, Korean firms have shown adroit movement in the operation of imported plants and the absorption of imported technologies. The choice for big technology is also closely related to the government's aggressive export-promotion policy and to large firm oriented industrial policy.

R&D Activities and Industrial Competitiveness

Korea's industrial R&D spending is highly concentrated within a small number of industries. ICT sectors (communications equipment, semiconductors, computers, and electrical and electronic products) account for 57.6% of the total manufacturing R&D expenditure, followed by the automotive sector (19.6%), chemicals (9.8%), machinery (3.9%), and iron and steel (3.8%). All of these industries, except for chemicals and machinery, make a positive contribution to the trade balance. Furthermore, Korea is one of the major exporters of high-tech products, although the value content of Korea's exports, including high-tech products, is still low. For instance, Korea's up-market share in EU-15 countries is below the OECD average, while its down-market share is one of the highest, exceeded only by that of Turkey, the Czech Republic, and Poland.⁵ Korean industries, despite their high R&D intensity, have not yet been successful in harnessing R&D potential to added value in their products.

⁵ For more information, see OECD *STI Scoreboard* 1999.

Figure 12: R&D intensity and TSI in Korean Manufacturing Sectors



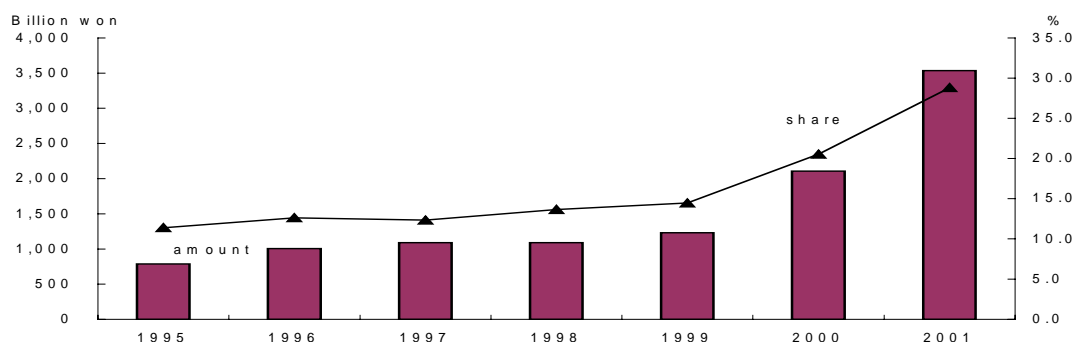
4.2 Changes since the Financial Crisis⁶

Business R&D Activities

In the past years, large firms played a leading role in industrial R&D activities. Since the early 1980s, private enterprises began to establish in-house R&D centers, and large firms established most of them at that time. For example, the *Directory of Korean Technology Centers* published by Korea Industrial Research Institutes in 1985 listed 141 industrial R&D centers, out of which only 15 centers belonged to SMEs. Another characteristic of industrial R&D activities in past years is their mostly adaptive nature. This was mainly because R&D activities were to assist the production of mature products. Technologies invented elsewhere were transferred by licensing contracts or other means of technology transfer, and adapting those transferred technologies to the requirements of the production process was the major goal of industrial R&D activities.

The trend has changed, particularly since the financial crisis in 1997. As shown in Figure 13 although SMEs are still responsible than less than one third of total R&D expenditures, their spending is increasing more rapidly than that of large enterprises (LEs), which results in an increase in SMEs' share. During the period 1995 and 2000, SMEs' share of total industrial R&D expenditures has doubled. Do the increased R&D spending by SMEs and their increased R&D share imply that SMEs' role in industrial innovation activities is also increasing.

Figure 13: R&D Expenditure by SMEs and its Share of Total R&D Expenditure



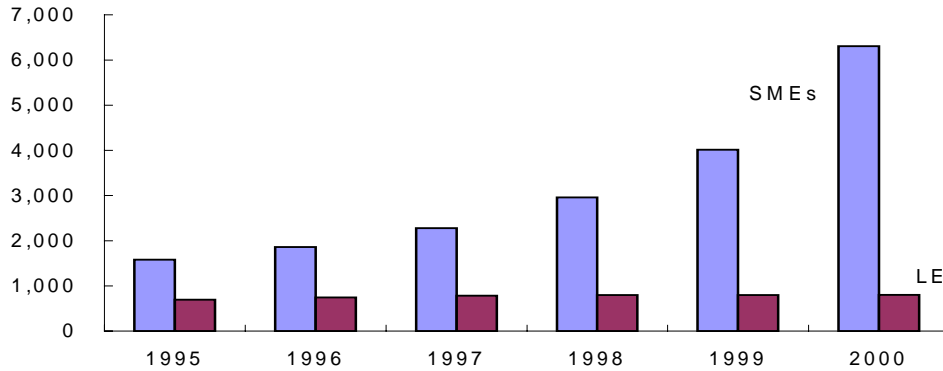
Source: Ministry of Science & Technology, *Report on the Survey of Research and Development in Science and Technology*, each year.

The financial crisis in 1997 and the restructuring efforts afterwards had an unexpected effect on Korean business. Profitability came to be recognized as more important than market expansion. Firms' spending for technological development is no exception. Companies, particularly large firms, have endeavored to downsize and streamline their R&D laboratories in line with business restructuring. Downsizing s forced many R&D personnel to leave large firms; and many of these displaced professionals have established small-scale, specialized R&D laboratories or technology-based small firms. As shown in Figure 14, the number of corporate R&D centers increased very rapidly since the financial crisis, and most of the newly established corporate R&D centers are small in size.⁷

⁶ This section is based on Suh (2003).

⁷ In addition to the restructuring of large firms, other factors contribute to the increase in small-sized corporate R&D centers. The government's drive to create "venture" companies and changed capital market conditions for start-up companies are among them.

Figure 14: Number of Corporate R&D Centers



Source: Korea Industrial Technology Association

The increasing number of small-scale, specialized R&D centers or technology-based small firms will change the industry's landscape. First, a direct effect is the increases in R&D expenditure and intensity by SMEs. Second, the existence of technologically agile small firms will lead to changes in business relationships, particularly between large and small firms. Supporting statistics are following.

Total R&D expenditures by SMEs doubled between 1997 and 2000, whereas expenditures by large enterprises increased by only 5.1%. The increases in total R&D expenditures by SMEs is partly due to the sharp increase in the number of SMEs that spend on R&D activities, as manifest by the sharp rise in the number of SME R&D centers. But the R&D intensity of SMEs, defined as the ratio of R&D expenditures over sales, also increased, from 2.8% in 1997 to 3.1% in 2000. In contrast, the R&D intensity of large enterprises decreased from 2.1% in 1997 to 1.8% in 2000. In sum, not only is the number of SMEs that spend on R&D increasing, but also SMEs are intensifying their R&D activities since the financial crisis. The same observation and conclusion apply to the case of researchers. From 1997 to 2000, SMEs strengthened their R&D activities by sharply increasing the number of researchers they employed, whereas the number of researchers at large enterprises remained almost during this period.

The effects of the financial crisis on the R&D activities of SMEs vary across industrial sectors. R&D expenditures have increased in almost all of sectors, except ships and boats, railroad equipment, and communication services. In terms of R&D intensity, chemicals, including medicine and pharmaceuticals, electrical products, transportation equipment, including automobiles and parts, ships and boats, railroad equipment and aerospace, and services in electricity, gas and water and communication show decreases. Note that R&D intensities of SMEs in Korea's 'flagship industries,' such as chemicals and transportation equipment, have all decreased by a big magnitude. In contrast, IT related sectors such as computer & office equipment, semiconductor & electronic parts, and communication & media equipment have all showed big increases in R&D expenditures or intensities. The different pattern in R&D expenditures across industrial sectors is also to be found in the pattern of changes in the number of researchers in different industrial sectors. Particularly striking are the semiconductors and electronic parts, communication and media equipment, and the business services sectors, where the number of researchers including Ph.D.s and R&D expenditures increased more than three times. These are sectors in which specialized, small R&D centers are burgeoning; and therefore, networking and collaboration could be expected to be more prevalent than other sectors.

The Emergence of Innovation Networks

Based on cross-shareholding, subsidiary companies in a Chaebol are mostly vertically integrated. Vertical integration can be seen in that subsidiary companies in a Chaebol take part in various stages of a supply chain. Diversified business structures of Chaebols might allow to developing horizontal division of labor among subsidiary companies of a Chaebol; but, horizontal relationships between Chaebols or subsidiary companies of different Chaebols are less prevalent. The expansion strategy of Chaebols, which aims to widen business areas as possible, results in more diversified business structures for Chaebols; but, it

obstructs the development of horizontal relationships between companies, in particular those between Chaebols and SMEs.

The business relationships that were prevalent in the past years have been changing after the financial crisis. Chaebols could no more pursue as aggressively as in the past the expansion strategy based on debt financing and cross-shareholding. Instead, they had to substantially lower their debt-ratios and to rationalize their diversified business structures. The new strategy was to concentrate on core businesses and to sell out or spin off unprofitable businesses. As is shown in the TABLE 8, 442 business branches that had employed 67,863 people had been spun off to independent companies. *Samsung* has rendered 161 spin-off companies, followed by *Hyundai* with 98 companies, *LG* with 94 companies and *SK* with 45 companies. Spin-off companies from these four Chaebols account for 398 companies, more than 90 % out of total. The number of spin-off companies peaked at the year of 1998, when the repercussions of the financial crisis on the corporate restructuring were also at its highest.

Table 8: Spin-offs from Chaebols

| | No. of mother co. | No. of spin-off companies | | | | | | No. of employees |
|---------------|-------------------|---------------------------|---------------|---------------|--------------|-------------|----------------|------------------|
| | | 1997 | 1998 | 1999 | 2000 | 2001 | Total | |
| Samsung | 16 | 0 | 115 | 29 | 5 | 12 | 161 | 17,235 |
| Hyundai | 12 | 36 | 27 | 18 | 8 | 9 | 98 | 16,937 |
| LG | 15 | 5 | 18 | 51 | 14 | 6 | 94 | 21,443 |
| SK | 11 | 3 | 11 | 11 | 13 | 7 | 45 | 3,650 |
| Hanjin | 5 | 0 | 0 | 4 | 1 | 0 | 5 | 2,866 |
| POSCO | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 40 |
| Hanwha | 2 | 0 | 0 | 4 | 0 | 0 | 4 | 2,636 |
| Doosan | 1 | 0 | 0 | 0 | 3 | 1 | 4 | 103 |
| Ssangyong | 1 | 0 | 0 | 0 | 2 | 0 | 2 | 880 |
| Dongbu | 1 | 2 | 5 | 1 | 1 | 0 | 9 | 144 |
| Dongyang | 2 | 0 | 0 | 2 | 1 | 0 | 3 | 227 |
| Hyosung | 1 | 0 | 2 | 0 | 0 | 0 | 2 | 52 |
| CJ | 3 | 1 | 0 | 0 | 1 | 4 | 6 | 643 |
| Kolon | 3 | 0 | 0 | 0 | 3 | 0 | 3 | 289 |
| Hyundai Dept. | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 658 |
| Daewoo E. | 1 | 0 | 0 | 4 | 0 | 0 | 4 | 60 |
| Total | 76 | 47 (10.6) | 178 (40.3) | 124 (28.1) | 53 (12.0) | 40 (9.0) | 442 (100.0) | 67,863 |

Note: Spin-off is confined to the cases of MBO (management buy-out) and EBO (employee buy-out).

Source: Federation of Korean Industry, 2001.

The increasing tendency of large enterprises to make strategic alliances with venture companies is another new trend that has occurred since the financial crisis. Strategic alliances had been more prevalent between large enterprises; but it was hard to find those between large enterprises and SMEs before the financial crisis. Two factors, among others, are worth to note. First, backed by the expansion strategy, large enterprises, particularly Chaebols, usually set up their own business branches or subsidiaries when new opportunities arose or found. In other words, large enterprises preferred to internalize new business opportunities rather than to externalize them. The second factor was that since the number of technologically advanced SMEs had been few, the number of partners for alliances with LEs was also few. Under these circumstances, strategic alliances between firms, particularly between LEs and SMEs, will not be well developed.

The situations described above have also been changed since the financial crisis. Because of the more stringent financial constraint, LEs should concentrate on core businesses. Spinning-off, as is explained above, is other side of the concentration. And there come a large number of technologically agile smaller companies. These changes have rendered a new trend of increasing strategic alliances between LEs and SMEs.

TABLE 9 shows some examples of strategic alliances between LEs and new technology based firms,

or venture companies in the Korean parlance. *Samsung Electronics*' strategic alliances with about 100 venture companies focus on non-memory chips where it has the strong necessity to enter into and needs business partners. *LG Electronics* runs what they call LG Venture Club composed of venture companies founded by retirees from *LG Electronics* or other *LG* companies. (See below for details on LG Venture Club.) *LG Chemical* has made strategic alliance with four venture companies and plans to increase the number of partners. *SK* and *CJ* are collaborating with venture companies for R&D projects for entering into new businesses where they do not have competence.

Table 9: Strategic Alliances between LE and Venture Company

| | |
|----------------------------|---|
| <i>Samsung Electronics</i> | Strategic alliance with about 100 venture companies. Focusing on non-memory chips |
| <i>LG Electronics</i> | LG Venture Club |
| <i>LG Chemical</i> | Made alliances with 2 domestic and 2 overseas venture companies |
| <i>SK</i> | Project for developing pharmaceutical products with 11 venture companies |
| <i>CJ</i> | Project for developing pharmaceutical products with 2 venture companies. Plan to make alliances with 20 venture companies |

Source: Dong-A Ilbo, March 27, 2002.

Although there is no complete information on the new business relationships between LEs and SMEs such as in TABLE 4, we can further assume that strategic alliances and other kinds of business relationships between LEs and SMEs are rapidly increasing. There are, at least, two grounds for the assumption. First, the necessity of strategic alliances is stronger than before the financial crisis. When LEs need to enter into new businesses, partnership with NTBF(new technology-based firms) will be less costly and risky than total internalization. Second, smaller NTBF will have an incentive to make alliances with LEs that have advantages of scale economies. Partnership with LEs will allow NTBF to safeguard their growth by utilizing LEs', for example, capital and marketing advantages.

The financial crisis of 1997 has brought many, some fundamental, changes to the Korean economy. As North (1990) notes, institutions structure incentives in economic action. Apparently, the financial crisis has rendered an institutional change that will give different incentives to economic agent and, consequently, result in different modes of inter-firm relations. Structural changes after the financial crisis have rendered new constraints and incentives. The government and the bank will no long offer Chaebols preferential policy loans. Chaebols will face tougher financial constraints, so they will not be able to pursue the aggressive expansion strategy as before. Diversified business structures are already undergoing streamlining that focuses on more competent areas. On the other hand, the number of technologically agile small firms is rapidly growing. These new technology based firms will have much more eased business environment in that they will have more chances to get financial resources than before. Majority of those SMEs that are trying to enhance their technological capabilities and to move up to higher ladder of value chain will also face a different business environment where they will no longer have safe umbrellas from the contractors. Those relationships are fading away. Instead, they have to compete with other suppliers globally. This new environment will act as either a new opportunity or a new threat. It depends on how these SMEs in transition would prepare for it. The increasing number of foreign owned companies is a new phenomenon to the Korean economy. Still small in numbers, but they will make a difference to the Korean economy in any ways. There are some positive signs that these firms are strengthening their technological activities in Korea, but the linkage of these firms with the other Korean firms and Korea's innovation system are still in the stage of early development.

5. Discussion

The Korean economy is facing a new environment. There are new technologies in such fields as ICT, biotechnology and new materials. As economic activities will be more knowledge-intensive, so the transition to the knowledge-based economy requires significant changes in work and production organizations, industrial relations and in the structures of governance. The world economy is becoming more integrated in both trade and investment; this fosters (and is caused by) freer movement of capital and production activities across national borders. The trend toward globalization emphasizes the importance of the global integration of national economic activities. That the Korean economy has matured and developed at a level comparable to advanced economies implies that the available stock of technologies drawn on through conventional technology transfer is exhausted. How well are Korean firms responding to these changes? Can the Korean economy achieve sustainable economic growth in the future?

Making Innovation System more effective

Under the new economic setting, both domestically and internationally, the conventional ways of technological development will not be as effective as they have been in the past. Standing at the crossroads, faced with new challenges, private firms need a new strategy. The task for Korean private enterprises is to make the transition from borrower to innovator. This presents several issues for discussion.

First, the industrial structure shows the weakness of upstream sectors, particularly in the capital goods industry. This weakness is closely related to the predominance of large firms, notably Chaebols, and the government's industrial policy. In accordance with the aggressive export-promotion policy that complements the tiny domestic market, the imported technologies are both mature in life cycle, and able to render economies of scale in production. Consequently, a few large firms have made large-scale investment, with the aid of favourable government support. The production structure has centred on end products, and ignoring support firms and industries has resulted in heavy dependence on the foreign sourcing of materials, parts, and components. This chronic phenomenon renders the Korean economy vulnerable to external changes in the foreign market. Accordingly, strengthening upstream industrial linkages is one of the most urgent tasks for the Korean economy.

Second, related to the first issue, a small number of Chaebols and research institutions are dominating innovation activities. The dominance of Chaebols, per se, is not an evil. The problem lies in the diffusion of innovation. The internal diffusion of technological innovation is not so active in Korea. The lack of domestic diffusion among firms is well demonstrated by the fact that repetitive importation of foreign technologies is common. Furthermore, the diffusion from research institutions to private firms is not as effective as expected. More organic co-operation between domestic firms, particularly between large firms and SMEs, and more active collaboration between research institutions and private firms are imminent. In this regard, we have observed a positive sign of change, for example, the emergence of innovation networks between conglomerates and SME. It is needed to sustain this trend.

Third, technological co-operation between domestic firms and foreign firms should be promoted. In the past, the Korean economy has benefited from the inflow of advanced foreign technologies. Now, new modes of co-operation such as cross-licensing and strategic alliances need to be utilised more. Facing rapid changes in technological opportunities and the expansion of globalisation, private enterprises need to strengthen the development of human resources and international R&D networks.

SMEs in transition

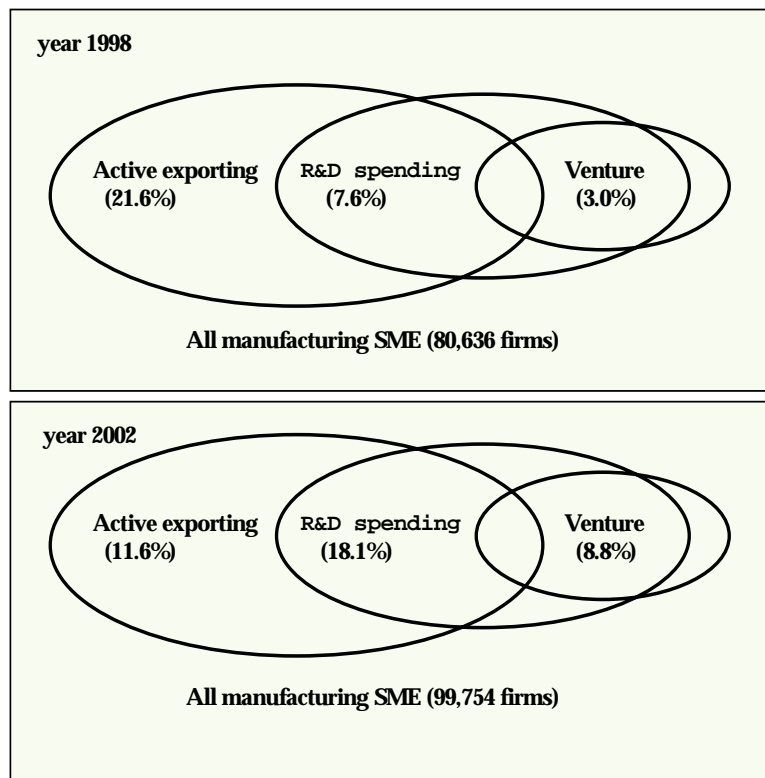
Today's SME in Korea face a challenge to strengthen their technological capabilities and thereby to move up to higher ladder of value chains. Unlike the new technology-based firms (NTBF) or those small numbers of firms that can make partnership relations with chaebols or other firms, however, the prospect for the rest of SME is not necessarily positive.

Figure 9 below⁸ gives a snapshot on the current status of manufacturing SME in Korea. The figure

⁸ The data are from Korea Federation of Small and Medium Business, and as of 1998. "Active exporting"

classifies manufacturing SME into three: those that are actively exporting, those that are spending money for R&D, and those are certified as “venture”. Exporting can be interpreted a measure to indicate firm’s overall competitiveness; R&D spending as a measure of firm’s technological capability; and venture certification as an entrepreneurial capability to enter into a new business. Intuitive conclusions can be drawn from the figure. Most of Korean SME are home market-oriented that only about 12% manufacturing SME are actively engaged in exporting, which might imply that they are vulnerable to market opening. Notice that the share of those active SMEs in exporting decreased by 10 percentage-point from 1998 to 2002. In terms of technological capability, about 18% SME have ever spent money for R&D purpose – an increase by 10 percentage point from 1998. This implies that majorities of SMEs are weak in their technological capabilities; but there is a positive sign of increase. In contrast, the fact that 9 % of manufacturing SME get the certification of “venture”- a significant increase from 3% in 1998 - might be a promising indicator for the prospect of Korea’s SME in the future⁹.

Figure 15: Classification of SME by Activities



Source: Korea Federation of Small and Medium Business

firms are those that exporting more than 30% of total sales.

⁹ Despite the debate on the nature of “venture” in Korea, it is evident that venture activities in Korea are very active. An indicator is the investment in venture capital as a percentage of GDP. OECD (2003) shows that Korea is one of countries above OECD average.

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Figure A1: Gross Output and GDP by Sector (current price, percentage share)

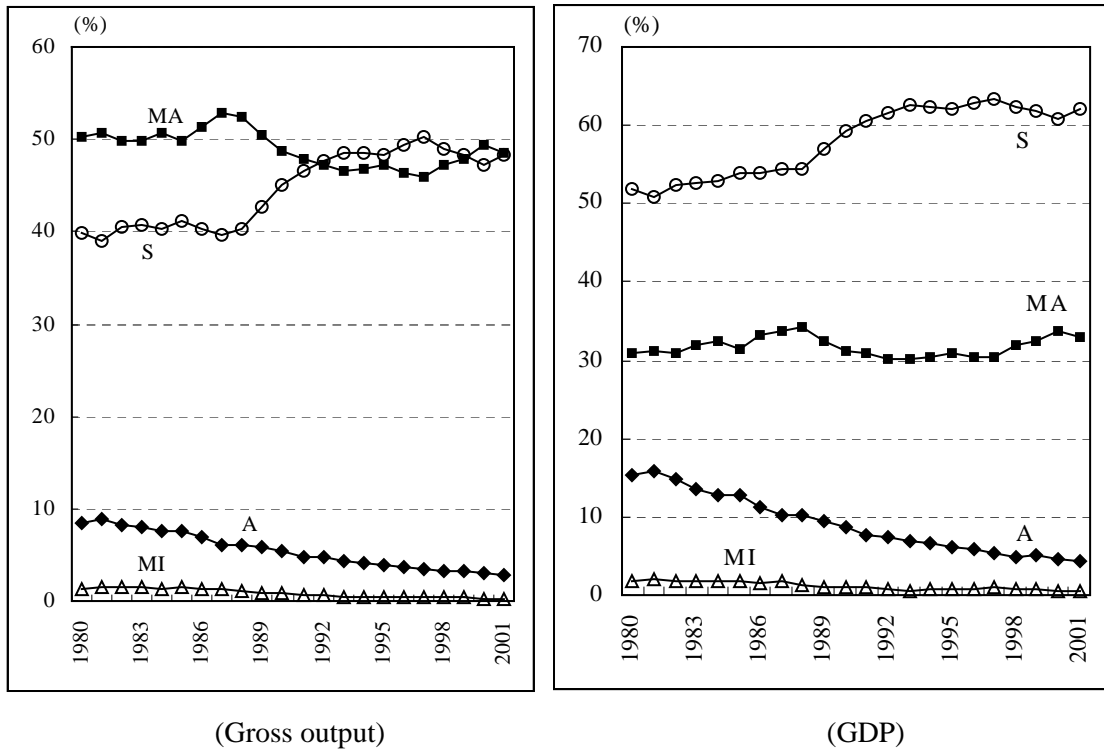
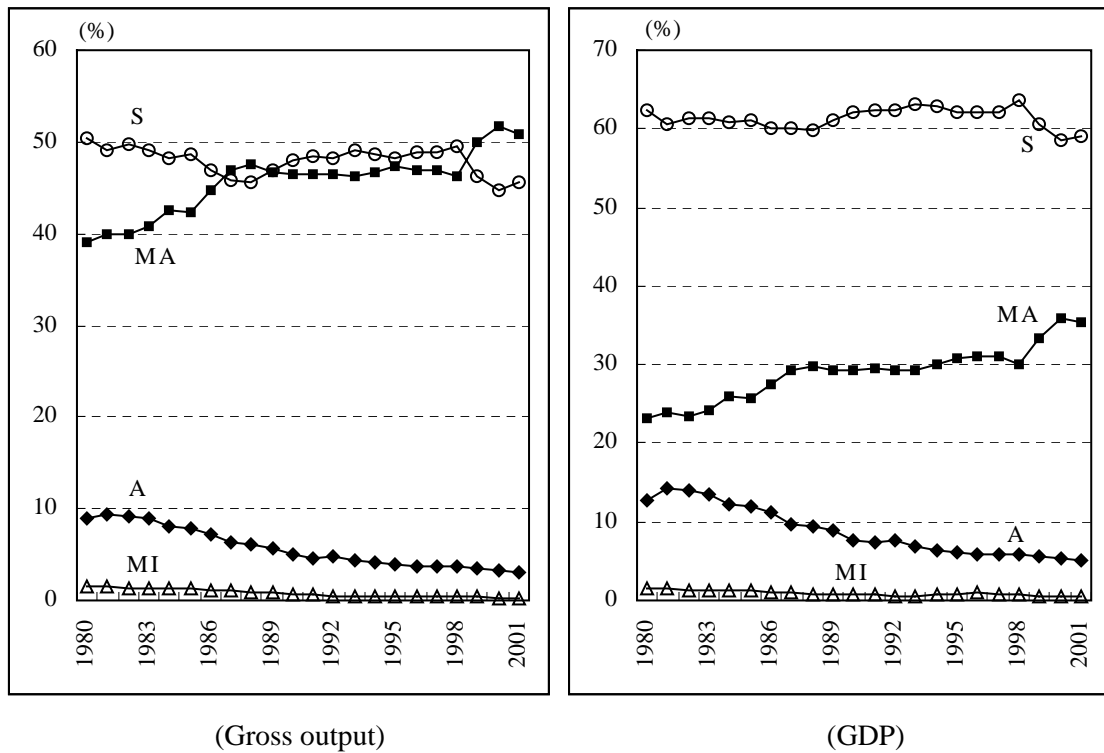


Figure A2: Gross Output and GDP by Sector (1995 price, percentage share)



A = Agriculture, Forestry and Fishing, MI = Mining and Quarrying, MA = Manufacturing, S = Service
 E = Electric and Electronic Products, A = Vehicles and Parts, T = Textile and Apparel

Figure 11: Changing Relationship between Royalty Payment and R&D (1976-2002)

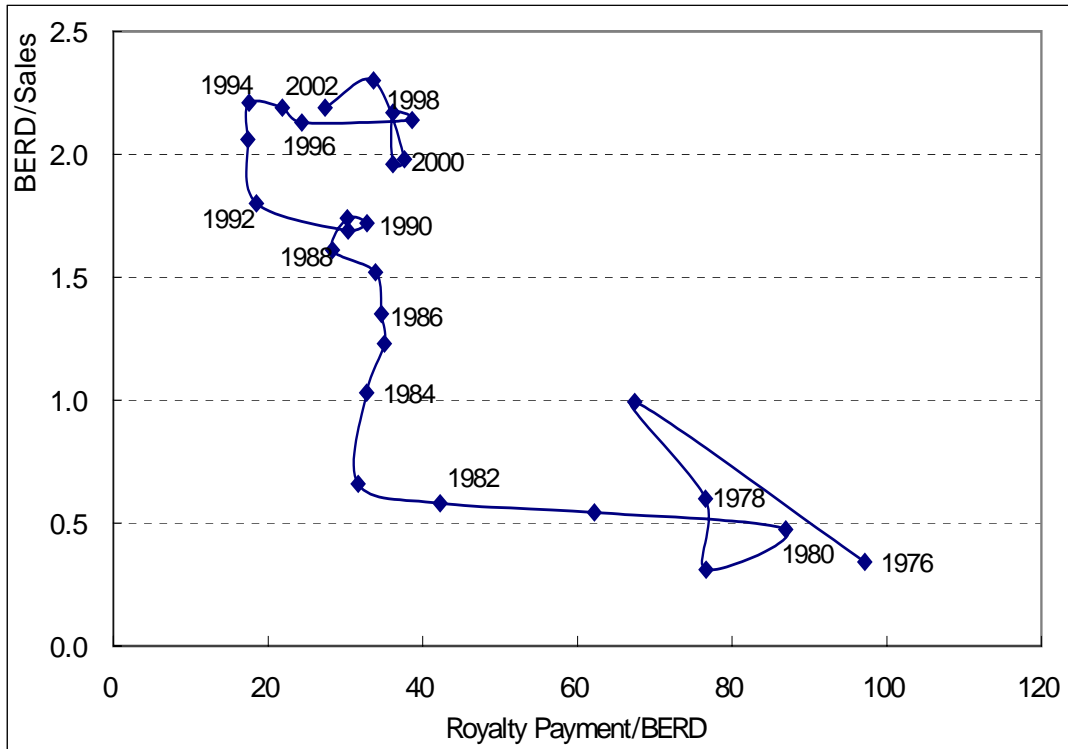
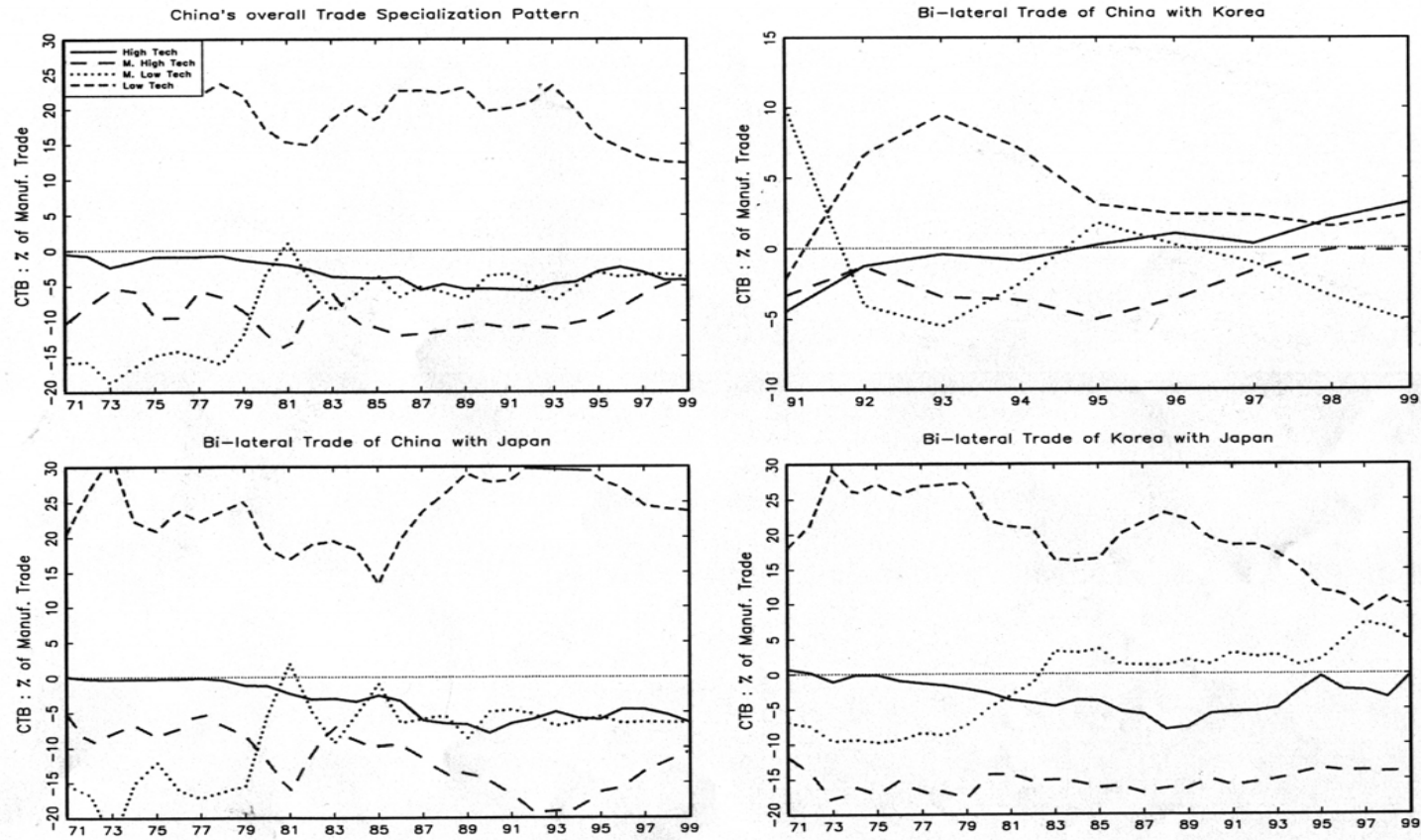


Figure 8: Trade Specialization Patterns



[APPENDIX] EMERGING PATTERNS OF INNOVATION NETWORKS AND CLUSTERS

| | <i>NTBF</i> | <i>Large Manufacturers</i> | <i>SMEs in transition</i> | <i>Foreign-owned companies</i> |
|---------------------------------------|---|--|---|---|
| Main Challenges | As a new entrant, needs growth strategy. | Feel the necessity to enter into new businesses | Face more competition, and feel strong necessity to upgrade tech. capability. | Need to secure market positions; restructuring from MNE's strategic viewpoints |
| Industrial Characteristics | Emerging high-tech sectors such as ICT and bio-tech | Scale-intensive industries where chaebols, Korean conglomerates, have dominated. | i) Traditional sectors where Korea is trying to move to higher-valued areas; ii) Specialized-suppliers where Korea is still behind world frontier. | i) Science-based sectors where MNEs have been dominating; ii) Firms that have yielded ownership to foreigners. |
| Examples of Regional Agglomeration | Daeduck valley, Pohang Techno-park Seoul Teheran valley | Kumi electronics complex, Woolsan Automobile & Shipbuilding industries. | i) Taegu textile, Pusan footwear industries; ii) Chonan semiconductor equipment, Changwon machinery industries. | i) Pharmaceutical industry in southern Kyoung-ki ii) Regional agglomeration not yet found |
| Innovative Capabilities | Highly-specialized; have core competence. | Strong in-house R&D capability; have wider spectrum | Mostly weak; but some have strong competitive advantages | i) Mostly weak; but mother companies are very strong ii) Diverse |
| Engines of growth | New ideas and innovation from in-house R&D. | Scale economies, in-house R&D | Skill-intensive, cost-efficient production | Proprietary assets from mother companies; some have technological competence |
| Inter-firm networking | Horizontal relationships. | Vertical integration prevailed, but cooperative relations are developing. | Diverse. Trying to strengthen ties with other actors, but faces bottlenecks – internal competence is weak. | Strong ties with mother company. Linkages with domestic actors have been weak, but tend to be increasing. |
| Linkages with other innovation actors | Good | Moderate | Weak | Not yet well developed |

Source: Suh(2003).