Technology Transfer and Development -A Comparative Study of China, South Korea and Japan

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To my wife, Jie-Rong, and my daughter, Qian-Qian
-for their love, support and encouragement

Abstract

It is believed that the more backward a country, the great potential for her to catch up. The history of the modern economic growth, which started in the United Kingdom in 1780, seems to have indicated this. But why has only a tiny group of countries managed to achieve modern economic growth?

The neo-classical growth theory, based on the assumptions of constant return to scale, law of diminishing return and perfect competition, failed to explain the key causes of economic growth. The post-war experience of some countries, particularly Japan and South Korea, indicates that some things other than the increase in weighted labour and capital inputs, as claimed by the neo- classical growth theory, may have played a more important role in their rapid economic growth.

Technological progress is now regarded by many economists as the most important contributing factors to economic growth. Technological advance generates economic growth through its effect on total factor productivity. However, where the new technologies come from, raining down from heaven as many neo-classical economists suggest, or resulting from the intentional investment as the new growth theory shows, has been an important controversial issue over the past three decades. It is hoped by many that the new growth theory could help to open the 'balck box' in the near future.

This thesis is to examine what role technological advance has played in the economic growth of Japan and South Korea over the past three decades or so. A comparative analysis of China, Japan and South Korea in technology transfer, adaptation and diffusion will also be one of the main tasks of the study. Through this, the study tries to identify the key factors responsible for the successful assimilation and diffusion of new technologies in the Japanese and Korean economies.

The main aim of the thesis is not to test the new growth or new trade theories.

However, the key elements of the new theories have been analysed throughout the study. The present study goes further beyond the areas that have been raised in the new theories. The cultural factor, country's socio-economic background, role of government, role of industrial policies and the character of different institutions will also be examined.

The findings of the present study are: economies of scale and external economies have been the important factors for Japan and South Korea to have gained some comparative advantages in petrochemical and electronics industries. Rapid and efficient transfer and diffusion of new technologies have been the driving forces behind the fast economic growth both in Japan and South Korea during the post war period. A highly competent and efficient government, appropriate economic and industrial policies, a disciplined and well educated labour force and close co-operation between the government and the business community and between the management and employees have also played important role in the Japanese and Korean economic success.

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Chapter One

Introduction

Modern economic growth is characterised by increase in income and income per capita sustained over long periods of time. It started in the United Kingdom in 1780. Later, Germany and the United States began to catch up from the mid-nineteenth century. After one hundred and sixty years only a handful of the nations in the world joined the process. Japan was the only country outside the group of advanced Western nations to have started her modern economic growth from the late nineteenth century. Since early 1960s, a small group of developing countries has also achieved the economic 'take-off' and been catching up the advanced nations. Among them are Taiwan, Hongkong, South Korea and Singapore.

It is believed that the more backward a country, the great the potential for her to catch up. The history of the modern economic epoch seems to have indicated this. Two outstanding late comers, Japan since the 1880s and South Korea since the 1960s, have achieved a much higher rate of capita income growth than the United Kingdom, the United States and Germany at a similar early stage of industrialisation. However, until today only a tiny group of countries has managed to achieve modern economic growth, It is, therefore, very natural and interesting to ask the question: why has the whole world not developed?

Over the last three decades, many backward countries have managed to achieve only very moderate economic growth. The gap of per capita income between these countries and the developed ones has grown wider not only in absolute but also on comparative terms. Why have so many countries failed to realise their potential?

What has prevented these countries from achieving high economic growth comparable to Japan and South Korea? To find out the key contributing factors for the spectacular economic success both in Japan and South Korea certainly presents a formidable challenge; it is however very interesting and also very useful for most developing countries to learn. Japan, which had been devastated, mentally, physically and financially, by the war, has recovered and rebuilt herself into a great economic power. South Korea, one of the poorest countries in the world in the 1950s, had been described as a hopeless (both economically and politically) country even as late as 1960 by the international community. Three decades later, South Korea has become one of the most promising developing countries in the world and targeted to join the league of the most advanced nations by the end of the century. China, Japan and South Korea are all located in the east Asia and share many similarities in terms of social and cultural background, geographic location, climate and population density. In addition, China has got many advantages over her two neighbours, including her abundant natural resources and a huge home market. Why have Japan and South Korea but not China achieved such a high and sustained economic growth over the post war period?

What are the key contributing factors for the Japanese and Korean economic success? Modern economic growth is believed to be based on application of science and technology. Great potential for a backward country to catch up is mainly derived from the opportunity to acquire and apply existing technologies effectively and efficiently. If application of science and technology is the key to modern economic growth, one interesting question arises: can the 'economic miracle' achieved by Japan and South Korea over the past three decades be, to a great extent, attributed to the rapid technological advance (through technology transfer, innovations and diffusion) in these two countries? To answer such a question, three areas need to be explored. First, an effort will be made to examine the pace and pattern of technological progress in these two countries over the past four decades. Second, growth of total factor productivity (TFP) will be measured. The TFP is defined as the residual of growth rate of output over that of weighted inputs. Although many factors are believed to attribute to the growth in TFP, such as economies of scale, learning by doing, increases in knowledge and skill of labour force, technological advance is the key factor accounting for the TFP growth. Besides, both learning by doing and the increase in knowledge and skill can be also regarded as the technological advance. Therefore, a measured TFP growth over the past three decades in Japan and South Korea would mean that there has been rapid technological progress in these two countries. More importantly, it may be possible to single out (although in a qualitative way) the contribution of the technological advance to the economic growth in these two countries. Third, some details of technological advance in industrial level will be examined. It is hoped, through this, that the evidence of strong impact of technological progress on the performance of certain industries will be found. The effort will also be made to seek the relation between quick technological innovation and diffusion and growing competitiveness and market expansion in certain industrial sectors both in Japan and South Korea.

There is a huge international technology pool which contains a bulk of existing advanced technologies, from agriculture to industry, from mining to steel making, from petrochemicals to shipbuilding. The revolution and rapid expansion of information technology, including radio, TV, journals, newspapers and telecommunications, over the post-war period has made it much easier for a backward country to find out about useful technologies quickly. It is believed that a developing country could catch up with developed nations if it was able to transfer, modify, adapt and diffuse the existing technologies to its own economy effectively and efficiently. The truth is that though a backward country has great potential for catching up with the most advanced economies, it also has great difficulty in realising it. 'Technological backwardness', said Abramovitz (1986), 'is not usually a mere accident'. It is, rather, due to a weak social capability to introduce and manage more productive techniques than those in use. Another interesting question may therefore be asked here. Why have Japan and South Korea been able to realise the potential for catching up so successfully?

To answer such a question presents a formidable challenge. Surely many factors which have worked together have helped Korea and Japan to achieve this. Among the important factors which may have made considerable contribution to the rapid technological progress in Japan and South Korea are high levels of national education, commitment of government to technological progress and economic growth, competence of the bureaucrats, supply and quality of qualified professionals and skilled workers, consensus and aspiration of a nation and its people to economic growth and development, attitudes towards and effectiveness of co-operation between government, business community and labour force, attitudes of its people towards discipline and hard work, the way through which the government's policies, particularly economic policies, are formulated and implemented, the role and efficiency of its government, the rules and systems under which all institutions work, structure of domestic market, financing and management systems under which domestic firms are operated, saving and investment behaviour of both institutions and individuals, and some culture-related factors.

Education has been regarded as a key factor for technological progress and economic growth in a country. The high level of educational attainment achieved by these two countries may explain a considerable part of their success in realising the potential for catching up. Since technological advance is crucial to modern economic growth, the spread and content of education, which help to make the rapid and efficient application of existing technologies possible in a backward country, can be particularly important in this regard. There might be a strong correlation between the rapid expansion of engineering education and the impressive advance of certain industrial sectors in these two countries, in particular between the electrical/ electronic engineering and electronics industry in the case of Japan.

A government in a developing country may need to play a bigger role than its counterpart in the developed world. It should not only make the rules and systems for people to have a fair play, provide both human and physical infrastructure, create a favourable economic environment to reward invention, innovation and enterprise, but also be ready for active participation in the process of technological advance and economic growth. This may be particularly true for a developing country at its early stage of industrialisation. Development of modern industries increasingly depends on group action. In fact, expansion and competitiveness of modern industries in a country may be closely related to effective and efficient co-operation between its government, management and labour force. The genuine co-operation and co-ordination at national level in the areas of technology transfer and R&D may prove to be a big advantage particularly for a developing country.

Certain cultural factors may have played a positive, even important, role in Japanese and Korean economic success. This does not mean at all that some aspects of Japanese and Korean culture are better than those of other nations. However, different cultural background may lead to the establishment of institutions with different characteristics. For example, the American education system, which has put emphasis on individual development and creation (encourage new ideas and new thinking) and is very flexible, has long been praised for providing large number of world class scientists and Nobel Prize winners. However, the Japanese education system, which has given priority to teaching and learning, discipline, and groupness, is believed to have provided a large number of highly qualified professionals, such as engineers, managers, accountants, economists, who have helped Japan to transfer, adapt and diffuse foreign technologies and also developed new technologies domestically with a remarkable success.

In fact, behind technological progress lies the whole economic, social and political character of a nation. Moreover quick inspection of even limited detail in this regard confirms that the ultimate sources of economic growth are not easily discerned. Indeed it would not be difficult to defend the proposition that growth depends on the whole spectrum of social characteristics, where these are far from constant across successful countries.

As has been said earliei, once it has been established that technological progress has been the key for economic growth, some explanations are needed to analyse the factors behind it. To sharpen the focus and to make the analysis manageable, two industries, namely electronics and petrochemical, will be chosen for detailed study. Through comprehensive and also deep examination of these two industrial sectors, it is hoped that the impact of many factors listed above on technology transfer and development will be revealed. However, a pertinent question may be asked here: why have these two industries been chosen for detailed study? The electronics industry has been a leading force for economic expansion and growth over the past two decades not only in Japan and South Korea but also in many other countries. This industry has been advancing at a breathtaking speed. Numerous technological breakthroughs and major innovations can be seen in all its sub-sectors. Unlike many others, the electronics industry is characterised by capital-and also technology-intensity. Not only technology transfer and adaptation but also innovation and invention have played a very important role in the development of the electronics industry. While behind innovations and inventions lies firm commitment to R&D not only by individual firms themselves but also by a nation as a whole. It has been believed that Japan has done particularly well in electronics over the past thirty years or so. It is therefore very useful to have a thorough study of the Japanese electronics industry. Such a study should reveal some aspects of the dynamic relationship between technological progress and rapid industrial expansion. The effort will also be made to seek the relation between rapid technological innovations and inventions and growing competitiveness and market expansion of the Japanese electronics industry. Rapid application of new technologies can lead to reduction in cost and improvement in quality; this in turn would increase the competitiveness of Japanese electronic products both at home and abroad. The ratio and speed of substitution of foreign high-tech products at home and the dramatic intrusion and continuing expansion in the international market, especially American market, will be very useful for measuring the positive effect of the technological advance for the growth of the Japanese electronic sector and also Japanese economy as a whole.

Moreover, through the study of the industry, it is expected that the role of government will be revealed. What has the government of Japan done in the process of technology transfer, diffusion, innovation and inventions in the country's electronics industry? This can be seen through its economic policies, particularly the industrial policy, through its retaining the right of technology licensing, through its direct and indirect involvement of negotiation on the terms of licensing, through its education policy, through its financial and taxation policies, through its co-ordination of technology imports and R&D at the national level, and through its effort to facilitate competition between domestic firms both at home and abroad. In addition, the structure of Japanese electronic firms and their unique methods of financing and management will also be fully explored. The relation between rapid technological progress and fierce competition will also be examined. The latter may arise not only from firm's basic motivation-growth and market expansion but also from government's economic discipline, financial incentives and international trade.

Compared with electronic and other high-tech industries, the petrochemical industry is rather mature. The low unit production cost and competitiveness of many petrochemical products may be achieved mainly by the quick and efficient adaptation and diffusion of the existing technologies. Therefore the study of the petrochemical industry will focus on the process of technology transfer and the major modifications of the imported foreign technologies aiming for energy and raw materials reduction. To become technologically competitive in electronics industry, some prerequisites, such as strong commitment to R&D, huge financial resource and a large number of brilliant scientists, engineers, managers and marketing experts, should be fulfilled. Without these, a country is unable to compete with others effectively in the areas of industrial electronics, office machine and telecommunication Even in mid- and up-market consumer electronics, strong R&D and technological capabilities are also very necessary. One needs to know not only how a technology works but also how it will be developed. On the other hand, most technologies in the petrochemical industry are standard ones. For a developing country with relatively weak financial resources and technologically backward, to become an international competitive petrochemical producer does not necessarily mean that the country should acquire a strong R&D capability and a large number of scientists and engineers in the industrial sector; however, a considerable R&D effort and ability are also needed for technology transfer, adaptation, modification and diffusion. Moreover, many petrochemical technologies have rather fixed technical coefficients. Competitive advantage may be gained from effective technology transfer rather than own R&D effort, and from minor but successive modifications rather than creation of new technology. This industry can be, therefore, taken for a full examination so that we may be able to show that a developing country has a chance to become a keen competitor in some industrial sectors even though relying on imported foreign technologies.

Experience of industrialisation over the past decades in the NIEs (Newly Industrialising Economies), particularly in four East Asian NIEs, namely South Korea, Taiwan, Singapore and Hongkong, demonstrates that a developing country can realise the potential for catching up with developed countries if certain conditions are matched. Two of the East Asian NIEs are almost entirely peopled by Chinese. And China shares many cultural and other attributes with South Korea and Japan. In so far as these characteristics were important to economic success in these countries, it may be asked why China has been a late starter in this group. And, related to this, is may also be asked whether China can learn from the experience of its two neighbours, namely Japan and South Korea. These questions seem particularly pertinent in the light of the fact that China has abundant natural resources and a big domestic market. To pursue these two questions systematically would require multidisciplinary study. Sociology, politics and economics and the interactions among them would all be relevant. Ambition has, however, to be tailored to what is manageable. In order to answer these questions, the practice and history of technology transfer, adaptation, diffusion and innovation in the Chinese economy over the past four decades have to be reviewed and examined first, including what they did, how they did, how well they did. Moreover, a special effort will be made to seek the key factors responsible for the slow process of technology transfer, adaptation, diffusion and innovation in China over the past decades. A full discussion of the Chinese economy and development, particularly the economic reform since the late 1970s, is also very useful for laying down a broad context for the analysis of Chinese experience in above areas. Given the special circumstances (political, economic, social and demographic) in China, cautions will be taken when relevant lessons are drawn from Japan and South Korea. To what extent China can learn from a specific Japanese or Korean approach, policy or strategy certainly presents another challenge. Moreover, how to learn, especially how to learn effectively and efficiently will be given special attention. The relevant Japanese and Korean lessons will be drawn first at a general level. Then the discussion will focus on petrochemical and electronics industries. And it is expected that implications for technology transfer, adaptation, diffusion and innovation in the Chinese petrochemical and electronics industries will be found.

However, to assert that China can learn many things from her two neighbours does not necessarily mean that these two countries are the only models for China to emulate. Moreover, it is extremely difficult, if not impossible, to find a 'perfect' model for other countries to copy. This is not, of course, the objective of the present study. The main purpose of the study is to make a comparison between these three countries in the area of technology transfer, adaptation, diffusion and innovation, and to shed some light on the questions raised above. Whenever possible, useful Japanese and Korean policies, approaches and strategies will be drawn for the attention of Chinese decison-makers.

The data for this study will be from: A. Government publications; B. U.N. publications; C. World Bank and IMF publications; D. Publications of the Associations of electronics and petrochemical industries in the three countries; E. Other published and unpublished studies of the subject; F. The survey in the petrochemical industry and to some extent also in the electronics industry in China.

Chapter Two

The Literature Review of Theories of Economic Growth, International Trade, Technology Transfer and Diffusion

2.1 Theories of Economic Growth

Neoclassical Growth Theory

Mainstream economic growth theory was devised by Robert Solow, of the Massachusetts Institute of Technology, in the 1950s, and has been much modified and improved since then. The heart of the neoclassical theory is an equation, called the production function, which says that the output of an economy depends on the amount of capital and labour employed. This so-called neoclassical theory is based on several assumptions. First, there is a constant returns to scale, which means that doubling the amount of both capital and labour will get twice as much output. Second, there is a law of diminishing return, which says that if more units of one input (such as labour) are added while all other inputs (such as capital) are held constant the marginal product of the variable input (labour) must eventually decline. Furthermore, the mainstream economists assume that there is perfect competition.

However, in the early years of the post war, many economists did not incorporate technological progress into their growth theories or models. Harrod-Domar model was just one of the examples. The model stands on two propositions. First, the national income of a country is proportional to its capital stock. Second, the increases in the capital stock come from savings which is assumed to represent a given proportion of the national income. According to the model, a country should raise its saving rate if it wants to increase its national output. Such a model is certainly too aggregative and fails to take into account other factors that constitute the real world. Moreover, in the Harrod-Domar model, the technology factor, represented by a constant capital coefficient, was taken as a datum. What mattered for growth is the saving ratio.

In fact, economists began, ever since the formulation of the model of vintage production in the late 1950's, to debate whether technical progress is due primarily to improvements in the design of new capital ("embodiment") or is mainly "disembodied" and thus independent of the rate of capital formulation. In an early and influential paper, Edward F. Denison (1964) argued that the embodiment hypothesis was largely "unimportant," because changes in the age distribution of the capital stock have only a small impact on output growth, even if all technical change is capital-embodied. However, the literature on quality change, on the other hand, implicitly assigns a significant role to embodied technical change as a determinant of the price of investment good (see Griliches, 1961; Robert E. Hall. 1971; Jack E. Triplett, 1983, 1987; Gorden 1990). Many studies suggest that technological improvement in the design of investment goods- embodied technical change-may be a significant source of total-factor-productivity change.

In October 1956 Simon Kuznets (1956) published his first of ten lengthy monographs under the title of 'Quantitative Aspects of the Economic Growth of Nations' (in the Economic Development and Cultural Change). According to Kuznets, total product growth accelerated as nations entered 'modern economic growth', starting with Great Britain in the late eighteenth century: the last one and one-half or two centuries represent a new economic epoch as compared to the longer past. He identified the economic growth of nations as a sustained increase in per capita or per worker product, often accompanied by an increase in population and usually by sweeping structural changes. Two very distinct characteristics of the growth process are: first, more and more labour force and material resources will be released from the agriculture to non-agricultural sectors. Second, the share of agriculture in total output steadily declines while that of non-agricultural sector increases. Kuznets divided the economy into three categories: agriculture, industry and service. He did a brilliant job in observing and measuring the pattern and pace of the structural change within many advanced economies. However, his work did not (and also was unable to) reveal the more basic determinants of the modern growth. He asserted that currently less developed countries have failed to enter the league of the advanced nations either because of the low initial levels of their per capita product or because of the low rates of growth in per capita product during the past century or so-- or for both reasons. Kuznets regarded technological advance as a important factor accounting for the modern economic growth. But his three sector classification was so broad that it could not be directly linked to the introduction and diffusion of major technologies. It is not surprising that, fifteen years after he had published his famous paper- Quantitative Aspects of the Economic Growth of Nations- he (Kuznets, 1971) had made this comment: 'Since the high and accelerated rate of technological change is a major source of the high rates of growth of per capita product and productivity in modern times and is also responsible for striking shifts in production structure, it is frustrating that the available sectorial classifications fail to separate new industries from old, and distinguish those affected by technological innovations'.

A growth theory which does not take into account technological factors will face extreme difficulty in explaining many facts of the real world. According to the neoclassical theory, the return to new investment in the developed countries should fall with time, because the stock of the capital in these countries grow faster than that of the labour force. On the other hand, investment in a developing country with little capital should spur output more powerfully than a proportionate amount of investment in an advanced country with rich capital endowment. However, the post war experience does not match the predictions. In fact, except in a small group of NIEs, icluding Singapore, Taiwan, Korea and Hongkong), the growth of per capita output in most developing countries have been lagging (in both absolute and comparative terms) behind that of developed countries.

To both these difficulties, the neoclassical theory has an answer: technological progress. Though returns diminish as more capital is added to the economy, that effect is offset by the flow of new technology. This could explain why rates of return have stayed high in the industrial countries and, arguably, why most poor countries have not grown faster than rich ones.

To face the challenge from the real world, most neoclassical economists began to explore new area, and reached consensus that technological progress is one of the most important contributing factors to economic growth. Where does technological progress come from and how does it take place? Neoclassical economists find it very difficult to answer these questions. The neoclassic growth theory, in effect, assumes that new technologies rain down from heaven as random scientific breakthroughs. In statistical terms, technological progress is simply "the residual"- the thing that accounts for any growth that cannot be accounted for in other ways.

'The residual' is also called TFP (Total Factor Productivity) growth. Technological advance generates economic growth through its effect on total factor productivity. Economic growth can be realised either by an increase in the quantities of productive inputs or by an increase in their productivity. From the long-term point of view, the second increase is more important, because it enables a society to produce more output with unchanged quantities of inputs. Gains in output beyond the increase in tangible inputs can be called the growth of total factor productivity (TFP). Putting it in another way, we can say the growth of TFP is the excess of total output increase over the weighted increase of inputs.

The increase in TFP can, in fact, be attributed to technological progress, economies of scale, changes in the skill and knowledge of the labour force and change in the efficiency of use of existing technology. Because the improvement in human capital (increase in skill and knowledge, which can be achieved through learning by doing) and the efficiency improvement can be classified as technological progress in a broad sense, then technological advance can be said to be the key factor in promoting TFP growth. Technological advance can increase output in two different ways. On the one hand, improvement in technical (including organisational) knowledge can allow given inputs to produce a larger output than what they are capable of yielding without the application of advances in technical knowledge in terms of the ways in which the inputs are combined. On the other hand, improvement in technical knowledge is most likely to require new investment both in materials and human capital. It may be necessary for new kinds of capital goods to be introduced, or for labour skills to be improved by education and training. The first of these two ways can be regarded as disembodied technological progress, and the second as embodied technological progress.

Many economists have made great effort to explain 'the residual'. Nobody, however, seems to have found the key to open the 'black box'. Many different approaches have been tried. Chenery (1986) and his associates had adopted a different approach and divided the economy into more diverse sectors. The 'intermediate production' had also been measured in the framework of his model. He tried very hard to draw a link between the structural analysis of average growth pattern and development policy. A number of other macro-economic studies have also shown the inadequacy of conventional explanations of economic growth and structural transformation. Many of them have tried to establish a statistical correlation between high growth rates in productivity and exports and technological effort, measured by some aggregate such as patenting activity or R&D expenditures as a share of GDP. However, they also fail to point out what have led to TFP growth.

Denison (1985) took a different approach- growth accounting. With great disaggregation, he identified many factors associated with the rapid economic growth in the United States and some other developed countries. Based on many assumptions, Denison produced some interesting results, including the proportional contribution of each factor to economic growth. Thus based on his studies, Denison notes: 'advance in knowledge'- covering both technological change and improvements in 'managerial and organisational knowledge'- was one of the key factors for economic growth in the USA from 1928-1982, accounted for 55 percent of the growth. Economies of scale accounted for 18 percent. It is however arguable whether his assumptions are realistic and his definitions, classifications and measurements robust.

Although the growth accounting method has been quite popular and widely used, some economists thought it is fundamentally wrong. According to Lauchlin (1986), the common approach which identifies the distributive shares with sector or marginal factor productivity in value terms and, after deflating these values by prices, with physical productivity as well, yields, an incorrect or misleading view on the true sources of, or contributions to, growth. Even more serious, the identification may lead to mistaken policies designed to faster or accelerate growth. In reality, distributive shares in the national accounts have little to do with physical productivity or the sources of growth.

Lauchlin claims that Denison's and any others' approaches of 'growth accounting' have produced the wrong sources of growth, because that 'productivity', in these models, is identical with and has been measured by the distributive shares in the national product or income. That is: if the share of 'labour' in the national accounts is 80 percent of the national income, growth accounting models would assume that labour "contributes" 80 percent of the national product.

It is true that Denison also proceeds to break down the concept of 'labour' into the number of workers, hours of work, age, sex and education of workers. He also attributes gains in growth to more formal education and equates more schooling with more work hours of labour. While he acknowledges that a correlation may also exist between better social economic conditions and higher earnings, he rejects this as an explanation, perhaps because it is even more difficult to measure in quantitative terms.

Probably no growth accounting model ever attributes 'sources of growth' to competition, institutional or socio-economic factors. The key reason for this is the extreme difficulty to measure them quantitatively. However, this is hardly a justification for attributing the gains to other factors that are easier to measure. It is obvious that the distributive shares of either labour or capital cannot be used as a good measure of sources of, or contributions to, growth.

Hulten (1992) claims that the failure to adjust capital for quality change has the effect of suppressing the quality effects into the conventional total-factor productivity residual, and that approximately 20 percent of the residual growth of quality-adjusted output could be attributed to embodied technical change.

Scott (1993) also has a fundamentally different view towards the measurement of TFP. In his word, 'The change in "total factor productivity" (TFP), as the residual is sometimes called, has been and continues to be calculated again and again. Yet, if I am right, there should be no residual and no change in TFP.'

In fact, any theory of growth must be based on far more than correlation or a summation of sector value added. And a theory of growth must be based on observation and facts, but these must be of a different nature than those that break down national accounts by value added and indeed must help to explain the facts. A theory of growth must be logically consistent and offer what appears to be a reasonable explanation of a dynamic process.

The View of Development Strategists

Industrial Strategists have different views on how to pursue the goal of development. According to them, economic development requires an industrial strategy, which in turn needs some form of intervention by the state. The state's developmental role may thus be considered the principal element of an industrial strategy.

Neo-classical practitioners argue that the government's proper role is simply to establish an economic environment in which market forces will realise the efficient allocation of resources. The appropriate instruments to create this environment are prices and price-denominated polices (e.g. taxes and subsidies). The neoclassicals advocate a neutral policy regime, 'netural' meaning that policies should not selectively discriminate -that is, for tradeables, vis-a-vis world prices, and for non-tradeables, vis-a-vis relative scarcities. The neoclassicals believe that there are few inherent market failures and that existing market imperfections are by- and-large due to policy failures. These failures include errors of commission, licensing restrictions on production or interference in wage setting.

The core of the neo-classical prescription for a neutral policy regime is free trade. Correspondingly, under this regime the domestic prices of traded products equal their border prices- the border price policy being either the import price or the export price. Many neoclassicals think that the first-best means of infant industry encouragement needs to be an uniform and temporary subsidy to value added. But, as a practical matter, some neoclassicals (e.g. Balassa (1975)) prescribe a modest degree of uniform (and temporary) effective protection as the second-best means of generalised encouragement. Even so, all neoclassicals adamantly insist on the importance of uniform infant-industry incentives- that is, incentives that are granted equally, in overall effective terms, across industries and that are given automatically, without administrative direction.

For the industrial strategists, reliance on market forces operating in a neutral policy regime is but one of a number of possibly viable strategies. They actively pursue questions about how the government should identify strategically important industries and how it should promote them through selectively targeted price- denominated policies and more direct forms of intervention.

Several new elements have recently entered the debate. Some researches have demonstrated that the neoclassicals do not have all their facts straight: market forces alone are not responsible for the purported 'market successes' of economies like Japan or Korea. This implies that a neutral policy regime is not a necessary condition for successful industrialisation. The other new element is an evolving but distinct empirically based conceptualisation that puts indigenous dynamic phenomena involving technological change- not simply factor accumulation and allocation- at the centre of industrialisation. This conceptualisation implies that a neutral policy regime may not generally be a sufficient condition for rapid industrialisation.

According to industrial strategists, the Korean government has not practised neutrality in its incentive policies. Most significant, it had discriminated in its treatment between established, internationally competitive industries and new infant industries that were deemed worthy of promotion. There has been substantial industry- bias in favour of the promoted infant industries. These industries have benefited from protection, credit preferences, and various forms of tax inducements.

New Growth Theory

The mainstream economics seems to have failed to open the 'black box' over the past three decades. However, since the late 1980s, a new growth theory has begun to emerge. Many believe that such a new growth theory could become the foundation of the mainstream economics in the 1990s and beyond.

It is probably Paul Romer who first (in his University of Chicago doctoral thesis entitled "Dynamic Competitive Equilibria with Externalities, Increasing Returns and Unbounded Growth) made a very important contribution to the new growth theory in 1983 (also see Romer 1986, 1990). Many others, including Barro (1988), Becker and Murphy (1988), Grossman and Helpman (1988), Lucas (1988), Aghion and Howitt (1990) have also contributed to the development of the new theory.

New growth theory has revitalised the existing theory of long run growth by focusing on such determinants as investment in human capital, increasing returns to scale and the impact of openness in international trade.

Two major dimensions of this new growth theory emphasise the role of increasing returns to scale associated with the new technology and the dynamic externality effect of openness in trade, when openness is measured by export growth. In the presence of increasing returns to scale an investment process may generate a sustained growth in per capita income without causing a decline in the marginal productivity of capital to the level of the discount rate.

In the neoclassical theory technological progress just happens, in the new theory knowledge is a factor of production which, like capital, has to be paid for by foregoing current consumption. Economies have to invest in knowledge in the same way that they invest in machines. Third, since past investment in capital may make it more profitable to accumulate knowledge, the new theory admits the possibility of a virtuous circle in which investment spurs knowledge and knowledge spurs investment. This in turn implies that a sustained increase in investment can permanently raise a country's growth rate- an idea that the traditional theory denied.

The new growth theory has one most uncomfortable consequence. It is flatly inconsistent with the idea of perfect competition- the theoretical underpinning not just of the neoclassical theory of growth but of a good part of modern economics. Why is the new theory inconsistent with perfect competition? Because perfect competition means that firms are price-takers: they accept the price that rules in the market and cannot change it. Under constant returns to scale, as assumed by the old theory, it can be so. If firms cut their prices to win a bigger share of the market, they achieve no further economies of scale and therefore risk losing money.

With three (or more) factors, the assumption of constant returns to scale no longer stands up. Taking all the factors together, the production function shows increasing return: if you double the factors, output more than doubles. In this theoretical world, firms can cut prices, raise output and- thanks to lower costs- make a bigger profit than before: with increasing returns, therefore, competition is imperfect- another way of saying that firms are price- setters, not price takers. This change may seem insignificant. In fact, it turns economic theory inside out.

According to Romer (1990), technological change arises from intentional investment decisions made by profit- maximising agents. The distinguishing feature of the technology as an input is that it is neither a conventional good nor a public good, it is a non-rival, partially excludable good. The stock of human capital determines the rate of growth; and a large population is not sufficient to generate growth.

The argument presented by Romer is based on three premises: One, technological change- improvement in the instructions for mixing together raw materials- lies at the heart of economic growth. As a result, the model presented by Romer resembles the Solow (1956) model with technical change. Technological change provides the incentives for continued capital accumulation, and together, capital accumulation and technological change account for much of the increase in output per hour worked. Two, technological change arises in large part because of intentional actions taken by people who respond to market incentives. Thus the model is one of endogenous rather than exogenous technological change. The premise here is that market incentives nonetheless plays an essential role in the process. Three, the most fundamental premise is that instructions for working with raw materials are inherently different from other economic goods. Once the cost of creating a new set of instructions has been incurred, the instructions can be used over and over again at no additional cost.

Romer suggests that population is not the right measure of market size. The growth rate is increasing in the stock of human capital, but it does not depend on the total size of the labour force or the population. If the stock of human capital is too low, growth may not take place at all.

Conventional economic goods are both rivalrous and excludable. The interesting case for growth theory is the set of goods that are nonrival yet excludable. The third premise implies that technological change is a nonrival input. The second premise implies that technological change takes place because of the actions of self-interested individuals, so improvements in the technology must confer benefits that are at least partially excludable. The first premise therefore implies that growth is driven fundamentally by the accumulation of a partially excludable, nonrival input.

Nonrivalry has two important implications for the theory of growth. First, nonrival goods can be accumulated without bound on a per capita basis, whereas a piece of human capital such as the ability to add cannot. Second, treating knowledge as a nonrival good makes it possible to talk sensibly about knowledge spillovers, that is, incomplete excludability. These two features of knowledge-unbounded growth and incomplete appropribility- are features that are generally recognised as being relevant for the theory of growth.

If a nonrival input has productive value, then output cannot be a constant-returns-to-scale function of all its inputs taken together.

Contrary to Romer, Scott (1989) thinks that the neoclassical production function is no use and should be abandoned entirely. The core of his argument echoes an old debate in economics. He suggested that the measure of capital that appears in the production function is fundamentally incorrect. The production function is concerned with the change in the net stock of capital- i.e., with gross investment less depreciation. This implies that depreciation is a physical process that reduces the productivity of capital; as it were, a reduction in the number of machines in the economy. Wrong, says Scott. Machines that are properly maintained can run at their designed capacity for years- long after the production function regards them as having evaporated. That is why some economists prefer a different measure of change, gross investment less scrapping. Wrong again, says Scott. Machines are mostly scrapped when they become profitless. They may still be making things, but they are not adding to net output. So no productive capital is lost when they are scrapped.

This suggests that simple gross investment, without deductions, is the best measure of change in the capital stock. Yes- but there is a problem, says Scott. It does not follow, as you might think, that the sum of all past gross investment provides a good measure of the stock, because there is no way of knowing how much each bit of old capital is contributing to total output. Regrettably, the idea of a production function that links the level of output to the level of capital must be abandoned. The best one can do is use changes in capital- gross investment- to explain changes in output.

Like Romer, Scott regards technological progress as crucial for understanding growth. In his theory, though, technological growth does not appear as a separate influence: he treats gross investment and technological progress as one and the same thing.

Scott says that inventions are motivated and caused by similar factors to those which cause investment, that is, by their expected profitability. Innovation does not pour down from heaven, as in the neoclassical world. Nor is technological progress, or 'knowledge', a commodity distinct from new capital, one that has to be separately invested in, as in the Romer models. Knowledge and investment, Scott argues, are inextricably bundled up together. However, Romer, in contrast, insists that the analytical effort of separating the two is worthwhile.

Lucas (1988) assumes in effect that it is production of human capital rather than physical capital that generates this nonrival, nonexcludable good. However, unlike Romer, Lucas regards the production of such a nonrival, nonexcludable good an unintentional side effect of the production of a conventional good.

According to King (1990): countries' disparity in long- term growth rates lies in differences in national public policies. Appropriate and effective policies would provide incentives to encourage individuals to accumulate capital in both its physical and human forms. King claims that these incentive effects can induce large differences in long-run growth rates, and national taxation can substantially affect long-run growth rates. In particular, for small open economies with substantial capital mobility, national taxation can readily lead to "development traps" (in which countries stagnate or regress) or to "growth miracles" (in which countries shift from little growth to rapid expansion).

In King's model of economic growth, a comprehensive measure of "technical progress"- social investment in 'human capital'- is made endogenous along the lines suggested by Uzawa (1965), Rebelo (1987), and Lucas (1988).

Glomm and Ravikumar (1992) claim that human capital investment through formal schooling is the engine of growth. They think that although the recent models of economic growth, such as Romer (1986) and Lucas (1988), emphasise investment in human capital as an important factor contributing to growth, they do not single out the most significant component of human capital investment- formal schooling. Moreover, public investment is the major source for promoting formal school, these models do not, to some extent, account for the large involvement of the public sector in human capital investment.

Becker and Murphy (1990) claim that, based on strong evidence, there is a close link between investments in human capital and growth. Since human capital is embodied knowledge and skills, and economic development depends on advances in technological and scientific knowledge, development presumably depends on the accumulation of human capital.

Evidence for the twentieth-century United States supports this reasoning. Gross investment in schooling grew much more rapidly in the United States between 1910 and 1950 than gross investment in physical capital (Schultz 1960). Denison (1985) found that the growth in years of schooling between 1929 and 1982 "explained" about 25 percent of the growth in U.S. per capita income during the period. Moreover, the experiences of nearly one hundred countries since 1960 suggest that education investments in 1960 are an important variable explaining subsequent growth in per capita incomes (see Barro 1989).

In the Becker and Murphy model of growth, investment in human capital has played a central role. One crucial assumption in their model is that rates of return on investments in human capital rise rather than decline as the stock of human capital increases, at least until the stock becomes large.

On the contrary, neoclassical growth models assume the rate of return on human capital investments would fall as the per capita stock of physical capital increases. Such an assumption seems less plausible since human capital is knowledge embodied in people, while benefit from embodying additional knowledge in a person may depend positively rather than negatively on the knowledge he or she has already had.

Rebelo (1991) thinks that growth experiences can be the result of cross-country differences in government policy. He claims that his own growth model shares with Romer's (1986) model the property that growth is endogenous in the sense that it occurs in the absence of exogenous increases in productivity such as those attributed to technical progress in the neoclassical growth model. But, in contrast with Romer's emphasis on increasing returns to scale and accelerating growth, Rebelo's model displays constant returns to scale. Hence, his model does not resolve the issue of whether the type of increasing returns and externalities proposed by Romer (1986) is the key to understanding the growth process.

However, Rebelo does give two reasons to reevaluate the role that increasing returns and externalities play in growth models. First, increasing returns and externalities are not necessary to generate endogenous growth. As long as there is a "core" of capital goods whose production does not involve nonreproducible factors, endogenous growth is compatible with production technologies that exhibit constant returns to scale. Second, the same type of phenomenon that motivated Lucas (1988) to introduce an externality in his model- the tendency for labour (but not capital) to migrate across countries in search for higher remuneration- arises despite the absence of externalities.

If the new growth theory has anything important to say about growth, it should be relevant for the growth experienced by the newly industrialising countries (NICs) of the Asian Pacific Rim. It is believed that the export growth rates have been very high and far above that of per capita income, and that the utilisation of scale economies in the manufacturing sector has been significant in the industrialisation process of these countries.

Sengupta (1993) suggests that in spite of great diversity in the pattern of growth in NICs in Asia, there exist some common factors which may be used to test some of the major tenets of the new growth theory. This new growth theory modifies the predictions of the neoclassical models of growth in several directions. The first is the role of non-rival inputs generating increasing returns in the export sector which has played a leading role in initiating new technological innovations. The second is the externality effect of human capital, which is a strong component of the overall increasing returns to scale that has characterised the growth phase of the Korean economy. Finally, the growth of the export sector has generated a dynamic resource reallocation process from the non-exports to the export sector, partly helped by an optimal outward-looking government policy and partly by the relaxing of the various controls and restrictions associated with the import-substituting policies.

Over the last decades economists have designed a variety of models to analyse economic growth and to measure the contribution of different factors to the growth process. However, none of these models can be claimed to be satisfactory. This is mainly because the process of the economic growth involves too many contributory factors of social, economic and political character operating in complex set of relationship with one another. Modelling these factors to simulate real world conditions is needless to say a formidable challenge. It is not strange at all that many well-designed and appropriate searches for cross-sectorial uniformities in subgroups of countries have so far only yielded unsatisfactory results. It is no exaggeration to say that no model can capture the great diversity of development experience in the NIEs, even within a small group of countries. The uniformities in social and political life that accompany development process and promote (or impede) economic growth are, at their core, a sequence of problems solved by each society in its own way. Averaging these solutions by some quantitative methods may not be the optimum way either to identify the sequence of problems or to explain the deviations from average behaviour. For example, under the military dictatorship of Park since early 1960s, economic growth in South Korea had accelerated. But dictatorship elsewhere brought economic disaster. The huge government subsidies to the private sector in South Korea over the last couple of decades had also proved very effective. However similar practices elsewhere had created widespread corruption and brought their economies into bankruptcy. Why have administrative measures and direct government intervention worked so well both in Japan and South Korea but not in some other countries? To analyse what factors have contributed to economic growth, making generalisations based on average indicators could be too superficial and hence not very useful. A better approach could be to analyse the different factors in the context of different countries. However, this dose not necessarily mean that the comparative statistical analysis of growth and development based on average indicators is not helpful; only that one should be very cautious when making the comparison and especially when interpreting the results.

Indeed, it is doubtful whether the most skilled handling of the tools of econometrics can yield a theory of growth or offer a basis for the formulation of policies to promote growth. Correlation alone cannot give the answer to the questions of whether a high percentage of saving- investment is the cause or the consequence of a high rate of growth; whether the contribution of generalised education lies in lessening immobility and promoting a better allocation of resources, or in increasing the physical productivity of labour; whether an increase in population and the work force adds to total gross production or simply dilutes distribution per capita; what is the role played by cultural aspects of a society (prudence, temperance, foresight, dedication to work, efficiency and widespread civil sense, versus contrary characteristics); what is the role of policy choices and the relative objectives of policy.

2.2 International Trade and Theory

Classical and Neo-classical Trade Theory

According to Kiljunen, there are important controversies within international trade theory over the explanation of structural changes in the international division of labour and the assumption that specialisation is beneficial to all participants. In recent years, some new explanations have emerged, aimed at qualifying the determination of comparative advantage. Furthermore, there are approaches that oppose altogether specialisation based on comparative advantage.

International trade occurs when people in different countries can make profits or take advantages by trading their products each other. Different production abilities, resources and tastes in different countries are the basis for international trade to start.

Which goods will be traded? Under what terms are they traded? Economists since long ago have shown their great interests in exploring the area. Adam Smith (1776) tried to seek the answers to the above questions. Smith made an important contribution by demonstrating that two countries would gain from a division of labour via specialisation and mutual trade when one is more efficient than another at producing one type of product, but less efficient than its partner at producing another product. Consequently, a country will specialise in those activities in which it has lower absolute unit costs than its trading partner.

David Ricardo (1817) developed the classic trade theory further. He had shown that there might be a gain through specialisation and mutual trade even when one country is better than its partner at producing both products, if its advantage is greater in one product than in the other. This turned out to be the most important finding and contribution to the classical trade theory. Since then, the principle of comparative cost advantage has been the the corner-stone of international trade theory.

The essence of the classical trade theory based on Ricardian comparative advantage means that a country would also be able to benefit from trade with another country although it is less efficient than its trading partner for all products in absolute term. The sufficient condition for trade to take place is the existence of the difference in the degree of inefficiency between trading partners in every branch of production.

In classical trade theory, comparative real cost is used to determine comparative advantage. However, the neo- classical trade theory adopts the concept of opportunity rather than real costs. With a given factor endowment, a country can produce various combinations of commodities. The optimum pattern of specialisation is determined through a comparison of the opportunity cost of producing a given commodity. A commodity will not be produced if it could be imported at a lower cost. And exports expansion will continue until marginal revenue equals marginal costs. Under the assumptions of full employment and perfect competition, the opportunity cost of a commodity is equal to its market value. Market prices of factors and commodities can therefore be used to determine comparative advantage under competitive conditions. The theory demonstrates that, where production possibilities and the consequent opportunity costs differ, countries will gain from trade.

Eli Heckscher (1919) and Bertil Ohlin (1935) came to a very important conclusion that differences in factor supplies (labour, capital, land, and natural resources) between countries are prerequisite for international specialisation and profitable trade. Relative factor prices differ between countries because factor endowments differ between them (e.g., labour will be relatively cheap in labour abundant countries) and so too will domestic commodity price ratios and factor combinations. Since different commodities require production factors in different proportions, a country with a relatively good labour supply, for example, has a comparative advantage in the production of commodities which make abundant use of labour. This country tends, therefore, to focus on exports of labour-intensive goods in return for imports of capital-intensive goods from a country with relatively ample supplies of capital. Hence, each country will benefit from international specialisation and trade by producing commodities that use more of its relatively abundant factors of production.

It is quite obvious that the Heckscher-Ohlin theorem has developed from the classical (Ricardian) theory of comparative advantage. However, there are some differences between the two approaches. The Heckscher- Ohlin approach puts emphasis on the differences in the relative quantities of factors rather than the differences in the relative qualities, which the Ricardian approach emphasises. Labour is regarded as the most important production factor in classical trade theory and differences in the productivity of labour is the main explanation for differences in trade patterns. However, the Heckscher-Ohlin theorem regards multiplicity of factors and the differences in factor endowments as the major determinants of trade pattern. Furthermore, the neo-classical trade theory, based on the Heckscher-Ohlin theorem, also makes some critical assumptions. Among them are: factors of production are compatible among countries; production function are identical, i.e., the same amount of factors is required to secure a given output in each country; and all countries have access to the same technological possibilities for all commodities, and therefore there are no inherent differences in relative labour productivity between countries.

One most important policy implication from classical and neo-classical trade theory is that free trade should prevail. Both theories claim that the world as a whole can greatly benefit from free trade. All participating countries will be able to share the gains from specialisation and trade. As a result, free trade tends to equalise factor prices among trading nations- e.g., by raising relative wages in labour-abundant countries and lowering them in labour scarce ones- so that international income inequalities decrease.

There are probably many shortcomings in neo-classical trade theory. This is mainly related to its assumptions, many of which are regarded as too hypothetical and unrealistic. Among them are perfect competition in product and factor markets, international immobility and national mobility of factors, identical production functions and qualitative similarity of production factors between countries, similar consumption pattern between countries and free availability of information and technology.

Some economists do not agree with the claim by neo- classical trade theory that free trade is beneficial to all. They have questioned the principle of specialisation along the lines of static comparative advantage. In their view, there is a very high possibility that an unequal international division of labour between developed and developing, or between 'core' and 'periphery' countries could emerge at a result of pursuing international free trade.

One trade theorem [see Singer (1964), Johnson (1954), Prebisch (1959), and Spraos (1983)] was derived as a condition for trade balance in the long run. According to the theorem, the terms of trade depend on the interrelation between the growth rates and the income elasticities of demand for imports. If the South produces relatively income-inelastic goods, it must face in the long run either slower growth or a deterioration in the terms of trade.

Singer and Prebisch argued that one-sided specialisation in primary products has made the peripheral economy very vulnerable to external cyclical fluctuations. The purchasing power of its exports is declining, it lacks the secondary and cumulative effects of manufacturing production and it has less scope for technical progress and productivity increases. As a consequence, the problems endemic to a peripheral economy arise: a chronic trade deficit, increasing external indebtedness, price instability, low relative wage levels, structural unemployment, and frequent emigration.

However, the most serious challenge comes from the neo- classical trade model itself.

Apart from the assumptions raised above, which were empirically very weak, neo-classical trade theory mistakenly regards that the technology and skills are stable and universally available. It also ignores technological change as well as differences in innovation and adaptation capabilities between countries.

The concept of 'technological superiority' may include not only product or production technology, but overall "skill endowment," such as entrepreneurial abilities, scientific capacities, the technical skills of the labour force, marketing skills, etc. In this respect, human capital may be treated as a separate factor of production, distinct from physical capital, in explaining trade patterns (Johnson 1968; Lary 1968).

Furthermore, high income countries are better endowed than low income countries with the factors which facilitate innovation: on the supply side, a developed technological infrastructure as well as an abundance of engineers and scientists; and on the demand side, potential markets for high quality goods which are large enough to justify the vast investment necessary to develop new products or technologies.

The rise of sizeable flows of manufacturing exports from LDCs to DCs and among LDCs over the past two decades has produced a substantial literature on the matter. However, the reasons or causes leading to the patterns and compositions of the manufacturing exports remain debatable and continuously controversial. Balassa (1981) has found that South-North manufacturing exports are considerably more labour (especially unskilled labour) intensive than similar flows in the opposition direction. Based on a multi-country study and using LDC data, Hrueger (1983) has reached a similar conclusion. Both findings seem to confirm factor-proportions analysis. However, as many other have claimed, the labour-intensive character of LDC exports to DCs is not uniquely predicted by factor-proportions analysis, and probably most importantly, many features of existing flows have hardly any association with typical HOS (Heckscher-Ohlin- Samuelson) analysis, while some findings do not fit the simple association which has been established by Balassa, Krueger and others.

Many economists regards the role of South trade as positive and important for economic development in the developing countries. For example, Lewis (1980) sees such trade as a mechanism to stabilise Third World growth in the face of a slowed down Northern engine. However some take a quite radical view. Fishlow (1984) regards intra- Third World trade as a mechanism to implement an efficient global import substitution policy in the South. Amsden (1980, 1984) has also given an important place for the South-South trade and emphasised the skill-intensive character of the trade.

According to Krugman (1982), labour productivity in the North increases steadily over time, while the South lags behind in the adoption of the best practice techniques. At any given time, the North-South wage differential is determined by technological disparities, labour supplies and the parameters of the commodity demand functions. The North specialises in the production of goods for which the rate of innovation is fastest or the imitation lag by LDCs longer.

New Trade Theory

The 1980s saw an extraordinary transformation in the way in which economists think about international trade. A vast literature has emerged which emphasise the role of market imperfections such as oligopoly, economy of scale, production differentiation and so on. Some have made great effort to incorporate either technology, e.g., measured by research and development activity (R&D) or human capital (skilled labour) as additional explanatory factors in models of comparative advantage.

Chenery and Keesing (1981) have presented a more complex view of the manufacturing export patterns of LDCs. They think that, aside from typical factor proportions features (labour and land abundance), product-cycle characteristics, historical inheritance (import substitution policies), marketing features, and static and dynamic economies of scale determine the manufacturing export patterns of LDCs.

And the latter may be crucial to explain the high concentration of those exports in a few countries. They suggest that there appears to be a strong element of learning by doing, which underlies the concentration of manufactured exports in a small number of countries. Once countries have acquired this ability, it seems to offset rising wages for a considerable period and make it possible to retain their shares of markets in which they would otherwise be losing their comparative advantage.

According to Krugman (1993), there has been a fundamental rethinking of the theory of international trade over the last two decades. Comparative advantage alone cannot explain the trade specialisation and pattern over the last two or three decades. Different resources endowments can certainly give some comparative advantage. However, It is becoming more and more clear that economies of scale and external economies can also play an important role in the international trade.

McCulloch (1993) claims that recent academic research has cast new doubt on the theoretical case for free trade, especially where high-tech industries are concerned. And much of both academic and public debate over appropriate trade policy now centres on the practical implications.

New trade theory and new growth theory are closely related to each other. They both accept several crucial assumptions, such as economies of scale, imperfect competition and external economies. Like new growth theory does to neo-classical growth theory, new trade theory also turns the neo-classical trade theory inside out. It is true that if you abandon the assumptions of constant returns and perfect competition, you has also abandoned the neo-classical trade world in which markets necessarily produce a Pareto optimum. Without such a precondition, free trade doctrine cannot be established. However, new theory does broaden the set of theoretical exceptions to the conventional wisdom, its emphasis on scale economies also serves to underscore the potential gains from open international markets.

Moreover, new theory also shows its strength in using new modelling techniques.

Drawing on tools recently developed by industrial organisation (IO) theorists, the new trade theory offers fresh insights into policy's impact in markets characterised by scale economics, oligopoly, and externalities. Although these conditions had been analysed earlier, traditional tools limited their theoretical depiction. For example, the extensive traditional literature on scale economies considered mainly external economies at the industry level, with individual firms assumed to experience constant returns.

New trade theory also emphasises the importance of product differentiation. Countries trade with each other not only because they want to buy totally different things from each other but also to buy many similar things with slightly different features. This can be demonstrated by the rapid expansion of the inter-country trade between the developed countries over the last three decades, where they have very similar factor endowments (capital, labour, etc.) It is also believed that product differentiation will play a positive role in trade between developing countries, especially between the NIEs.

If external economies are prevalent, it is very natural for the new trade theorists to provide an important policy implication-intervention and protection. The external economies tend to discourage the potential investors to invest in some industry, especially some new industries. These investors have fears of being unable to get a decent return on their investment in human and physical capital. For example, as the first mover, they should spend huge financial resources on training industry-specific labour. However, once the labour force is well trained, a new entrant could 'steal' them away from the first mover. As a result, the first movers bears all the costs of training the labour, but may reap none of the benefits. If this is a widespread perception among potential investors then it constitutes a case of systematic risk, and the infant industry may not emerge. Therefore, new trade theory claims that reliance only on market forces is very likely to lead to underprovision of the good or service in question. This kind of market imperfection requires governments to intervene.

Moreover, most of such new industries are human capital- intensive and knowledge-based, and are also potentially strategically important. These are also the industries where learning effects are crucially important, and where the benefits from the investment are spread widely in society. The experience of both Japan and Germany over the last three decades has shown the rapid technological advance in these new industries (electronics and petrochemical industries before late 1980s and semiconductor, information technology, artificial intelligence and biotechnology more recently) can give a country a strong competitive edge over its competitors in the international market. Moreover, it can also be argued that these industries are crucial in the development process in LDCs in general, and NICs in particular. Moreover, the success with which new technologies is absorbed has a crucial bearing on comparative advantage. The recent experience of some NICs has already shown this.

In the models of new trade theories, some very important factors, such as scale economies, product differentiation and external economies, have been systematically incorporated. This certainly makes the new trade theories more attractive and also more relevant to the current state of international trade. Most economists agree that these features are quite common in a real world. Some new models derived from the new trade theories can more comfortably explain the general trend and pattern of the international trade both now and in the past. In many new trade models, natural resource endowment is just one of the factors being taken into account. Moreover, economies of scale, external economies and product differentiation are the more important determinants for a country's comparative advantage. It was thought by many neo- classical trade theorists that factor endowments are the key source of comparative advantage. In the view of the neo-classical trade theorists, a technologically backward country with little capital and abundant labour can only compete in the agricultural-related production and export. However, the old trade theories failed to predict and explain why a country like Japan, with poor capital endowment even in the 1950s and with little or no natural resources in most industrial fields, could quickly become internationally very competitive first in steel making, shipbuilding and petrochemical industries and then in automobile, electronics and information technology industries. It is probably the same case for South Korea. Traditional neo-classical trade theories may never be able to solve the 'puzzles' of international trade. However, the new trade models, being incorporated with the above important factors, come near to offering a satisfactory explanation. Moreover, both theory and evidence suggest that these factors would become more important as industrialisation proceeds. The new trade theories do have an increasingly important part to play in explaining the direction and commodity composition of the trade of the newly industrialising countries, and will also have an increasingly important part to play in the future determination of the direction and commodity composition of those economies which are currently non- NIC developing countries.

As far as the new industries are concerned, the new trade theory appears to bolster the case for the interventionists. If the success in these high-tech industries is crucial, as it is widely believed, for a country's competitive edge in the international trade in the 1990s and beyond, some protective measures, instead of free trade, are certainly desirable. One thing seems clear now that research and development spending in these industries can create significant scale economies internal to an individual firm. Learning-by-doing and knowledge spillovers are very important not only for the domestic industry in question but also for a country's economy as a whole.

Over the last three decades, both Japanese and Korean governments have adopted a series of policies to promote their export industries. The continuous and also quick improvement in their production efficiency seems to have shown that these two countries have not only achieved big static gains by exchanging what they can produce more efficiently for what they cannot but also, probably more importantly, benefited greatly from the dynamic effect of dramatic expansion of trade, which led to rapid cost reduction and quality enhancement.

2.3 Technology Transfer and Diffusion

If technological advance has been the key for rapid economic growth, we should be able to trace its pace and pattern in the process of structural transformation and industrialisation in Japan and South Korea over the past decades. An pertinent question thus arises here: what have helped these two countries to achieve the rapid technological advance over the past three decades? Very broadly speaking, technological advance can be achieved mainly through two ways: technology transfer (importing technologies from abroad) and indigenous R&D activity (this may lead to inventions and innovations).

Technology denotes the sum of knowledge, experience, and skills necessary for manufacturing products and for establishing an enterprise. The term technology transfer in this study is defined as the importation, adaptation, and diffusion of these foreign knowledge, experience, skills and know-how to a host country.

It is believed that technology transfer is closely related to indigenous R&D. Speed and effectiveness of a transfer of certain technology by a firm, an industry or a country depends, to some extent, on their own R&D effort. A great degree of domestic R&D activities would not only help the receiving firm, industry or country to understand better and to select more appropriately but also enhance their bargaining power considerably.

It is useful to distinguish two types of R&D activities here: one is focusing on enhancing understanding and making modifications to imported foreign technologies; the other is aiming more ambitiously to make technological breakthroughs and to create some new technologies. It is generally perceived that a developing country, which is technologically backward and financially weak, should use its scarce financial resources on importing, modifying and diffusing appropriate existing foreign technologies. Big economic benefits could be gained from technology transfer rather than creating new technologies of its own. In a later stage, when the country narrows its technological gap with the advanced countries significantly and becomes a strong competitor to the technology leaders, it would be difficult for the country to achieve rapid technological advance by the means of technology transfer. And the domestic R&D at the time would be very much needed and should be promoted. There is, however, no clear cut opinion for the time when a developing country would reach the level that it should shift its priority from technology transfer to domestic R&D. This is not only because the pattern and pace of technological advance of individual industries vary greatly among certain group of countries with the similar level of industrialisation but also because different industrialising countries have very different factor endowments, such as level of education, industry and market structure, supply condition of highly qualified managerial and technical personnel, and the competence and experience of their R&D teams. It is very tentative to say that Japan since early 1970s and South Korea since the mid-1980s have reached the stage for accelerating and promoting domestic R&D activities. Japan became very competitive in most capital- and technology-intensive industries in early 1970s, when further expansion and technological advance can be achieved mainly through domestic R&D. However, to South Korea, deepening and intensifying domestic R&D became a necessity in just a handful of industries, including steel-making, shipbuilding, automobiles and some sectors of the electronics industries in mid-1980s.

Technology transfer can take different forms, depending on the kind of technological assistance needed. Technology can be transferred through: employment of individual foreign experts, arrangements for supply of machinery, technology licensing agreements, direct foreign investment, joint venture and turnkey contracts.

Licensing (Rhymes, 1971) covers the broad spectrum of permissions that are granted for the use of patents, technology, and trademarks, regardless of whether an equity relationship exists between the licensee and licenser.

Of the various systems of transmissions of technology, licensing is the most versatile as it offers flexibility in the choice and opportunity for the source firm and the receiving firm to accommodate their industrial needs through negotiation. According to Hawthorne (1970), licensing agreements may be divided into the following major categories:

1) Patent licenses: patent licenses are used for a specific process or method of manufacture, like a metal finishing process, or for a specific apparatus, product, or design coverage.

2) Know-how agreements: such agreements cover information that may be classified and thus difficult to obtain. They may cover various processes, formulas and industrial techniques.

3) Technical assistance agreements: These agreements involve supply of scientific assistance, engineering services, training, and management guidance to the licensee

4) Trademark/ or copyright licenses: These licenses cover certain registered and proprietary identification creation.

Licensing to an independent firm will be convenient when the licenser lacks some assets other than the intangible which are required for FDI, such as capital, an extensive sales and assistance network and so on. Also, licensing decreases the risks derived from changes in the foreign country where investment takes place and it has a shorter lead time than starting a subsidiary from scratch. On the other hand, intra-firm transfer avoids any leakage of technology to other firms and it is more convenient than licensing when arms length transactions are complex and difficult to enforce.

Enterprises often enter into turnkey arrangements in the early stages of their country's industrialisation, whereby one party is responsible for setting up a plant and putting it into operation. The turnkey contractor may be either the owner of the technology or the main supplier of machinery or even a consulting engineering organisation. Although it may be advantageous to deal with the party which is responsible for establishing a plant, the cost of a turnkey arrangement is often much higher than the cost of contracting separately for the various suppliers and technological services.

Technology transfer represents the single most important hope of alleviating the ever widening gap between the haves and have-nots in the world. It may provide an accelerated and long-lasting growth for the world's poor nations.

In the word of Emmanual (1983), technology transfer is a shortcut to Third World development. He points that regardless of whether the technology is transferred directly as it is purchased by the less developed countries or indirectly through perhaps a multinational company or foreign investments in the country, superior foreign technology is necessary for this shortcut.

Usher (1980), a specialist on growth accounting, concluded: '... economic growth depends predominantly on technical changes and cannot occur to any significant extent in its absence.'

Success in technology transfer is related to its appropriateness. If the transferred technology is not appropriate for the needs and conditions prevailing in the receiving country, no matter how superior or efficient that technology may be it cannot be adopted and diffused quickly and efficiently.

In order to identify the appropriate technology and transfer it effectively, the geographic, economic, cultural, and technical dimensions of technology transfer need to be examined carefully.

To achieve success in technology transfer programmes, wide-ranging actions are required for a co-operative program of action. At the national level, action is required on the part of governments, enterprises and research institutions.

Governments in the advanced economies have for many years been involved in stimulating scientific and technological progress within the scientific infrastructure, and in assisting technical developments in industry. The governments in the developing world certainly have the similar responsibilities. Possible policy tools can be generally grouped under three main headings. A). supply: provision of financial, manpower and technical assistance, including the establishment of a scientific and technological infrastructure. B). central and local governments purchases and contracts, notably for innovative products, processes and services. C). environmental: taxation policy, patent policy and regulations, that is those measures that establish the legal and fiscal framework in which industry operates.

Pack (1987) thinks that earlier debates on the choice of technology, perceived in terms of labour-intensive versus capital-intensive alternatives, ignored critical issues relating to productivity levels achieved with a technology once it has been installed, and the capacity to adapt and modify that technology over time.

Broadly speaking, innovations take two forms- product innovations and process innovations. The former involve changes in the specification of goods and services sold in the market, either as products for final, consumer demand or as products used as intermediate inputs in other parts of the economy. Process innovations involve changes in the nature of inputs or the way in which they are used in any given production process. However, the distinction between product and process innovation is blurred.

Innovation is a highly complex and high risk process involving many inputs-financial, economic, technical and social- and many factors. Technological innovation often requires organisational innovation for its successful implementation. In other words, industrial innovation involves not only technological change but sometimes also institutional, procedural and behaviour changes (Roberts, 1980).

Because of the very nature of the innovation process- its variability and technological, financial and marketing uncertainties- and of the actors involved, there are certainly limitations to what public policies can achieve. Furthermore, industrial innovation is a highly- risk undertaking and many projects inevitably will fail. Governments should be aware of, and be willing to accept, the possibility- indeed the probability- of failure in some of the companies taking up specific policy initiatives.

Because innovation is a dynamic process, the policy system should be sufficiently flexible and responsive to accommodate the possibility of rapid change. It should also be sufficiently flexible to accommodate different types of innovation in greatly differing contexts. Alternatively it should be tailored to suit specific situations, that is, different policies for different industries and /or different technologies.

A wide range of strategies has been applied in attempting to stimulate and/or direct innovation. The history of such policy is outlined in Ronayne (1984) and extensive discussion of policies and country experience can be found there, and in Pavitt and Walker (1976), Johnston and Gummet (1979) and Tisdell (1981). Policy tools which are available include direct government participation in research; attempts to stimulate private research by placing governments contracts for innovations; all manner of subsidies; tax reliefs, loans and investment allowances; centralised co-ordination of research activities; the patent system; attempts to reduce market imperfections; honours and awards; general economic management aimed at providing the most attractive climate for innovation; and educational and training schemes.

Direct government participation is perhaps most easily justified in relation to basic research. Pure research often has all the characteristics which will tend to lead the market to underinvest in it: large investments costs, uncertainty of outcome (with respect to the outcome itself, the date of solution and eventual value).

Which innovations, firms and industries are most deserving of support? It has been argued that governments are rather poor at 'picking winners'. However, such a claim also needs to be put into perspective with the fact that even professional R&D

managers are not good at picking winners either. It was once found in the USA that for every 100 projects begun, only 31 ever reached the market and of those only 12 were successful (Mansfield, 1971).

To be sure, public innovation policy can influence the rate and direction of technological advance to a degree. They can, however, only complement the activities of private companies; they cannot replace them. In short, public policies toward innovation can enhance the performance of competently managed companies and aid them in entering new fields; they can do little to help in the face of incompetent management.

It has already noted that the co-ordination of individual economic activities takes place through a variety of institutions, of which the firm, the market and the state are the most important. State is intimately involved in many aspects of technological change. The role and functions played by the state and by a number of non- state public institutions are due not only to economic motivations but to political motivations as well.

Firms which are able to make effective use of technological advances may increase their efficiency markedly. Those which fail to adjust to changing technology may find themselves outpaced and outclassed by their more innovative competitors. Failure to implement changes swiftly and efficiently may prove fatal.

According to Mansfield (1963), large firms have advantages for adopting an innovation early over small ones. This is because first, the costs and risks of early adoption are more easily borne by large firms; second, because of their size, there is a greater probability of large firms needing to replace old equipment at any point in time, thus, if the innovation is embodied in new equipment, large firms have greater opportunities to adopt early, on average; third, again purely because of their size, large firms are likely to encompass a wider range of operating conditions than smaller firms.

Many innovations are technically very sophisticated, they can only be operated efficiently and balanced with existing plant if managers, staff and workers understand the technical complexities involved. Thus inter-firm variance in the technical skills and educational attainments of managers, staff and labour force may lead to differences in the returns to be gained from adoption.

Many researches have been done to study the diffusion of the same innovation in a number of different countries and to explain the observed differentials in diffusion performance in terms of characteristics of the countries and industries concerned. For example, Swan (1973) examined the diffusion of synthetic rubber in 12 countries during the post-war period, and attributes the difference in diffusion to country-level explanatory variables such as the growth in output, the level of rubber imports and exports.

Nabseth and Ray (1974) in their final report on the study of the diffusion of ten major process innovations in six countries, summarised that: Inter-country difference tend to be explained in terms of three group of variables. First, the profitability of the innovation in different countries seems to be the most important one. They attributed differential diffusion rates with respect to numerically controlled machine tools to differences in labour costs, various factor prices (e. g. scrap metal, labour, capital) in the diffusion of basic oxygen steel- making and the compatibility of the country's upstream steel-making processes to the continuous casting techniques; second, and closely related, technological and institutional differences are also key factors; third, some more conventional economic industry characteristics, such as growth and size of the market, size of the firms, age of existing equipment, are also, to a great extent, responsible for the diffusion differentials in these six countries.

After having analysed 43 innovations, of which 22 were significant of 'breakthrough' instrument innovations and 21 were significant chemical innovations, and considered over 100 variables which previous literature considered of potential interest, the Science Policy Research Unit of Sessex University and Rothwell and his associates came to following conclusions. Successful innovators (relative to failed innovators) have a much better understanding of user needs, they pay more attention to marketing, perform their development work more efficiently, and make more effective use of outside technology and scientific advice, and the responsible individuals are usually more senior and have greater authority than their counterparts that fail; in instruments the 'constraints' of demand and marketing are of paramount importance relative to their importance for chemical innovations.

Maidique and Zirgen (1984), after examining the determinants of new-project success within a sample of 158 products of the United States electronic industry, found that in-depth understanding of the customer and the market place, well-coordinated design, production and marketing functions, drawing from existing technological and marketing strengths of the developing business units, proficiency in marketing and in research and development are very important in new product development.

In a classic paper, Rosenberg (1976) pointed to two opposing forces that determine how diffusion rates change with a change in the quality of new technologies. An increase in the relative superiority of currently available new technologies creates an incentive to switch to them. However, if substantially better technologies are expected to arrive in the future, firms have an incentive to wait for better technologies to arrive.

Similarly, in the Chair and Hopenhayn (1991) model, the diffusion rate depends on the current distribution of vintage capital, the relative superiority of the newest technology, and the quality of technologies expected to arrive in the future. The distribution of vintage capital in the future in turn depends on the rate of investment in current technologies.

It is sufficient to say that each of the factors above may have played a role in the complicated process of technology transfer, diffusion and innovations. It is extremely difficult, if not impossible, to set up any single mathematical model to represent this complexity. Therefore the best way is perhaps to analyse them individually. Whenever possible, effort would be made to explore the role played by individual factors and also the relationship between them.

The aim of this thesis is not to test the new growth and trade theories. However, all major features of these new theories should be kept in mind when the analyses and case studies in the following chapters are being considered. In fact, almost all key elements of the new theories, such as economies of scale, imperfect competition, external economies and human capital investment, would be examined in the analysis of the industrialisation process of the three countries, namely China, Japan and South Korea. Some major findings of the present research, whenever they are thought to be closely related to the new theories, would be highlighted. However, the present study prepares to go further beyond the areas that have been raised in the new theories. Therefore, many other factors, including cultural, socio-economic background, the role of government, industrial policies and strategies, and the role of institutions will also be examined.

Chapter Three

Review of the Chinese Economy and Development Trends

3.1 General characteristics

The Peoples' Republic of China covers an area of 9.6 million square kilometres, and so- following the Soviet Union and Canada- is the third largest country in the world. Its population is now around 1.1 billion. China is divided into 22 provinces, 5 autonomous regions and 3 municipalities (Beijing, Tianjin, and Shanghai).

China accounts for 22 percent of the world's population, a proportion that contrasts sharply with its 5 percent share of the world's arable land. Only 10 percent land in China is arable. Most of this arable land is in five plains, namely the North-East Plain, the Chengdu Plain, the North China Plain, the Middle and Lower Changjiang Plain and the South China Plain.

The North-East Plain comprises the 3 provinces of Heilongjiang, Jilin, and Liaoning, and has the Soviet Union lies to the north, and North Korea to the south- east. Spring wheat, soybean and sorghum are the major agricultural products. There are many large state-owned farms in this region.

The Chengdu Plain, in western Sichuan province, constitutes a large basin, 500 meters above sea level. It is surrounded by mountains and irrigated by several rivers. This is a very rich area. Its agriculture and complicated irrigation systems, which were well developed even 2,000 years ago, can guarantee a good harvest in all weathers. Transport links with other areas are, however, difficult to forge and maintain. The Changjiang (Yangtze) River used to be the key link between the Chengdu Basin and other parts of China. There are, however, now three railways. But the area is still remote. Rice is the major product in this heavily-populated area. The population is over 110 million, and so is twice as large as that of Britain.

The North China Plain, which is located in the area of Huanghe (Yellow) River, includes Hebei Province, Henan Province, Shandong Province, and the northern parts of Anhui Province and Jiangsu Province. Beijing and Tianjin, two of the three municipalities, are situated in this plain. Here is the cradle of Chinese civilisation, and this was also the first part of the country to be cultivated. Winter wheat, maize and cotton are the principal crops.

The Middle and Lower Changjiang Plain begins from the western part of Hubei Province in the east and ends at Shanghai, on the eastern coast of China. It stretches several thousands miles from west to east. Compared with North China Plain, especially North-East Plain, the climate here is warm and humid, and the soil is well irrigated. Major products are rice and cotton, but silk and wheat are also important.

The South China Plain is the area around the Pearl River. It is much smaller than the middle and lower Changjiang Plain and the North China Plain. It borders Hongkong in the South. Rice is the principal crop.

Except the Chengdu Plain, all the plains are located in the eastern part of China, and run from the extreme north to the extreme south. Ninety percent of China's population lives in only one-sixth of the total land area, and 75 percent of that population are to be found in these four plains. This gives the eastern part of China one of the highest population densities in the world.

Table 3-1 has shown us that between 1965 and 1988 real GNP of China rose at an average rate of 7.7 percent, and 5.4 percent per capita. In 1965 the level of real income per head was only 98 US dollars, and it reached to 330 US dollars in 1988,

Table 3-1 Some leading indicators for China and other economies, 1965-1988

Level and rates of growth of GNP per head

	GNP Per Head (US $-- 1988)		Real Rates of Growth (Average annual-- %)		
	1965	**1988**	**65-88**	**65-80**	**80-88**
China	98	330	5.4	4.2	9
Korea	790	3,600	6.8	7.6	8.7
India	226	340	1.8	1.3	3
Japan	7,981	21,020	4.3	5.3	3.3
Low-Income @	199	280	1.5	2.9	-0.8
Lower-Middle	765	1,380	2.6	4.0	0.3
Upper-Middle	1,920	3,240	2.3	3.6	1.5
High-Income	10,123	17,080	2.3	2.8	2.1

Sectoral (Real) Rates of Growth and Sources of Growth

	Rates of Growth, 1965-88 (Annual average- %)			Contributions to Growth, 1965-1988, (% share)		
	A	I(M)	S	A	I(M)	S
China	4.17	10.8 (10.0)	10.6	11.4	63 (41)	26
Korea	3.2	15.0 (15.1)	9.4	5	67 (65)	29
India	2.4	5.4 (5.8)	5.0	20.8	33 (28)	46
Japan	0.8	7.2 (8.5)	4.5	0.7	69 (67)	33
Low-Income	3.2	8.4 (8.7)	6.0	24	48	28
Lower-Middle	3.1	5.9 (6.0)	5.4	10	35	54
Upper-Middle	3.0	4.3 (...)	6.2	2	35	57
High-Income	1.3	2.7 (3.5)	5.0	1	23	76

Changes in Economic Structure-Sectoral Shares (%)

	1965			1988		
	A	I(M)	S	A	I(M)	S
China	44	39 (31)	17	32	46 (33)	21
Korea	38	25 (18)	37	11	43 (32)	46
India	44	22 (16)	34	32	30 (19)	38
Japan	9	43 (32)	48	3	41 (29)	57
Low-Income	44	28 (21)	28	33	36 (...)	32
Lower-Middle	22	28 (19)	50	14	38 (25)	50
Upper-Middle	18	39 (...)	42	...	...	...
High-Income	5	41 (30)	55	...	...	...

Source: World Bank, World Development Report, 1990,
Statistical Annex, Table 1, 2, 3, and 26.

Notes:@ excluding China and India

which was higher than the average of other low-income countries (excluding China and India), where the average income per capita was 199 and 280 US dollars for 1965 and 1988, respectively. Industrial expansion has contributed 62.5 percent of total economic growth in China over the last twenty-three years. And the manufacturing sector has been responsible for 41.2 percent of the overall increase. The unusually small share of the service sector of the Chinese economy makes a sharp contrast with all other economies in the world. Moreover, its big industrial sector more resembles that of South Korea than that of other low-income countries. However, its GNP per head is still very low, and its agricultural sector is also quite large.

China has performed much better in the 1980s than the past. This may be mainly attributed to the following key factors: First, nation-wide agricultural reform boosted the morale of millions of peasants in the countryside, and increased their production efficiency very considerably. This led to an impressive increase in the production of grain, oil-bearing seed, cotton, and other economic crops, such as tobacco. Second, rapid increase in foreign trade helped to improve economic efficiency and transform the industrial structure. And, third, technology imports both through foreign trade and foreign investment greatly enhanced economic growth.

China's export and import expanded very quickly during the 1980s. Thus foreign trade was less than 8 percent of GDP before the mid-1970s, but accounts for a third of national income today. The total value (in current prices) of the foreign trade was US$ 22,630 millions in 1978, and reached to US$ 102,800 millions in 1988, an increase of 354.3 percent over 10 years. This was in sharp contrast with most of the other big developing countries in 1980s. For example, Indonesia had a total of 9

Table 3-2 Some other major social and economic indicators, China

1. Total foreign trade (US$ Mn)
   1988 102,900 (47,600-export, 55,300-import)
   1987 82,934 (39,542-export, 43,392-import)
2. Geographic size ('000 sq. kilometres) 9,600
3. Population Mn 1,034.75 (mid-1984)
4. Population growth rate 1.5%
5. Total fertility rate 2.3% (1983)
6. Life expectancy 67 years (1983)
7. Population per physician, 1740 (1980)
8. Students enrolment by level of education institution (million)

primary	105.3 (1970)	146.3 (1980)	133.70 (1985)
secondary	26.3 (1970)	56.3 (1980)	48.63 (1985)
tertiary	--	1.1 (1980)	1.7 (1985)

9. Share of the accumulation in GDP
   21.4%-1952 39.6%-1960 32.9%-1970 31.6%-1980 31%-1984
10. Consumer durable owned by worker families and peasant families (per 100 families)

bicycles	worker	127 (1980)	163 (1984)
	peasant	37 (1980)	74 (1984)
wristwatches	worker	224 (1980)	283 (1984)
	peasant	69 (1980)	152 (1984)
radios	worker	85 (1980)	103 (1984)
	peasant	34 (1980)	61 (1984)
sewing machines	worker	66 (1980)	78 (1984)
	peasant	23 (1980)	43 (1984)
black & colour	worker	32 (1980)	80 (1984)
TVs	peasant	-- (1980)	7 (1984)
washing machines	worker	-- (1980)	40 (1984)
cassette tape-recorders	worker	5 (1980)	34 (1984)

11. Per capita consumption of major agricultural products (kilograms)

	grain	cotton	oil bearing crops
1960	215	1.6	2.9
1970	293	2.8	4.6
1980	327	2.8	7.85
1984	390.5	6.05	11.55

Sources:
1. For 1988: State statistical Bureau, China.
   For 1987: World Development Report 1989, P.190, Table 14.
3. For 1983 & 1984: A World Bank Country Study -- China Socialist Economic Development, Volume I. For 1985.

4., 5., 6., & 7. : World Development Report 1985.
8. Ministry of Education, China; For 1985: Beijing Review, August 27, 1985.
9. China Economic Handbook, First Edition 1986.
10. Ibid.
11. State Statistical Bureau, China.

percent decrease of foreign trade between 1980 and 1987. Nigeria had a even further decline with a fall of 63 percent. In 1980, the total value of Nigeria's foreign trade was 8.4 percent bigger than that of China. By 1987, however, the total value of China's foreign trade was 444.8 percent greater than that of Nigeria. Again, in 1980, the total value of Brazil's foreign trade was 14 percent bigger than that of China; seven years later, the total foreign trade of Brazil was 93.2 percent smaller than that of China.

The successful development of China's foreign trade can be partly attributed to the exploitation of trade opportunities and markets in Hongkong, Japan and the United States. The direct and indirect trade with South Korea, Taiwan, Singapore and Malaysia also produced strong positive effects on the rapid expansion of Chinese foreign trade over the last decade. Compared to the four Asian small dragons, the current size and recent growth rate of China's foreign trade are moderate. In 1987, the total value of China's foreign trade was 6.5 percent smaller than that of South Korea, and 17.2 percent smaller than that of Hongkong.

As mentioned above, only 10 percent of China's land is arable. This, together with the large population, means that cultivated land per capita in China is quite small in comparison with the world average. China's population rose very quickly between 1949 and 1979, from 541.67 million in 1949 to 970.92 million in 1979, a total increase of 79.2 percent. The number has kept rising, breaking the 1,000 million mark in 1981. It is estimated that the total population is now between 1,050 million and 1,100 million. Between 1949 and 1970, the annual rate of natural increase was well above 20 per thousand, except in 1950, 1960 and 1961-- when natural and manmade disasters curtailed population growth. Since the 1970s, the Chinese government has had a serious family planning policy, and in the late 1970s, the 'One Child per Family' programme began to be implemented effectively and compulsorily. Since 1975, the natural increase has been brought down to a quite low level, and it had fallen to 12.05/1000 and 11.7/1000 in 1978 and 1979 respectively. The current annual rate of population growth is 1.5 percent, lower than in many developing countries, and is very close to that of South Korea (1.6 percent), but higher than that of Japan (0.9 percent) and other developed countries. In 1988 life expectancy at birth in China was 70 years, much higher than that of other low- income countries (except Sri Lanka, where it was also 70). This feature of Chinese life reflects the wide reach of the public health service and the numbers of trained medical personnel. Thus in 1984, there was one physician per thousand population in China. The comparable average for all low-income countries was 5,580 when China and India are included. This average was 13,910 when the two large countries are left out.

In 1949, there were 347,000 primary schools in China, and this number increased to 924,000 in 1979. The secondary schools had expanded dramatically from 5,200 in 1949 to 147,300 in 1979. The total number of the universities and colleges in 1979 was 633, many of which were located in the large cities. The total number of students enrolled in the universities and colleges in China in 1985 was 1.7 million. The percentage of age group enrolled in primary school in China was 89 and 129 percent in 1965 and 1986 respectively. The corresponding figures for the secondary school was 24 and 42 percent respectively. The weakest area in China's education is tertiary, where only 2 percent of age group was enrolled in 1985. This makes a sharp contrast with that of South Korea, where the percentage of age group in higher education rose from 6 percent in 1965 to 33 percent in 1986.

Investment rate as a percentage of GDP has been impressively high in China over the last four decades For most years, the figures have been over 30 percent, and even reached to 39.6 percent in 1960. It is very reasonable to assume that if all these resources invested in China over the last forty years had been used efficiently, both

Table 3-3 Output of major industrial products, China

Items	1983	1984	1988
chemical fibres '000 tons	541	735	
yarn	3,270	3,219	
cloth (100 Mn meters)	149	137	176
sewing machines '000	10,872	9,349	
bicycles '000	27,582	28,614	41,200
wrist watches '000	34,690	37,982	
domestic washing machines '000	3,695	5,781	10,500
refrigerators '000			7,400
electric fans '000	10,457	17,710	
radio sets '000	19,989	22,203	
television sets '000	6,840	10,038	24,900
colour TVs '000			10,300
cameras '000	926	1,261	
coal mn tonnes	715	789	970
crude oil mn tonnes	106	114.6	137
electricity bn kwh	351.4	377	469(1987)
steel mn tonnes	40	43.4	59.2
cement mn tonnes	108.2	123	180(1987)
chemical fertilisers for agricultural use mn tonnes	13.8	14.6	17.7
synthetic ammonia mn tonnes		18.4	
ethylene '000 tonnes	654	648	
plastics '000 tonnes	1,121	1,180	
out tyres mn	12.7	15.7	
tractors '000	37	40	
walking tractors '000	498	689	
internal combustion engines mn hp	29	40.7	

Sources: For 1983 & 1984: China Economic Handbook
For 1988: State Statistical Bureau, China

the economic growth rate and the level of living standard would have been considerably higher than it is today. However, the living standard of Chinese people has improved, especially since 1980. This can be seen both from per capita consumption of major agricultural products and consumer durable owned by per family. The per capita consumption of grain increased from 215 kilograms in 1960 to 390.5 kilograms in 1984, the corresponding figures for cotton were 1.6 kilograms in 1960 and 6.05 kilograms in 1984, and for oil bearing crops were 2.9 kilograms in 1960 and 11.85 in 1984, but we should keep in mind that these figures are still very low when compared with all developed countries and many other developing countries. In the consumer durable sector, big improvement has also been made over the last 15 years.

China's total grain production was 407.3 million tonnes in 1984, including 178.26 million tonnes of rice. The productivity of land covered by major farm crops has improved considerably over the last decades. This can be seen from the table 3-5. From 1949 to 1983, the yield of rice per hectare increased 169.6 percent, from 1,890 kilogram/hectare in 1949 to 5,096 kilogram/hectare in 1983. The corresponding figures were 334.4 percent for wheat (from 645 kilogram/hectare in 1949 to 2,802 kilogram/hectare in 1983), 140 percent for corn (from 1,508 kilogram/hectare in 1965 to 3,623 kilogram/hectare in 1983), and 383 percent for cotton (from 158 kilogram/hectare in 1949 to 763 kilogram/hectare in 1983). Labour productivity has, however, been very low.

Table 3-4 Output of major agricultural products, China

Items	1949	1984	1987
'000 tons			
grain	113,180	407,310	
of which			
rice	48,650	178,260	
wheat	13,810	87,820	
corn	---	73,410	
soybeans	5,090	9,700	
tubers	9,850	28,480	
cotton	444	6,253	
oil-bearing crops	2,564	11,910	15,250

Source: China Economic Handbook

Table 3-5 Increase in the yield of major farm crops, China (Kg/hectare)

	1949	1965	1980	1983
rice	1,890	2,940	4,133	5,096
wheat	645	1,020	1,890	2,802
corn	---	1,508	3,075	3,623
soybeans	615	713	1,095	1,290
tubers	1,403	1,778	2,828	3,111
cotton	158	420	548	763

Source: China Economic Handbook.

The Chinese economy can be categorised into three sets according to ownership status: the state-owned sector; the co-operative sector; and the private sector. Immediately following the establishment of the communist government in 1949, the state took over all enterprises which were owned by the former Nationalist authority. At the beginning, this sector was not very big, but it expanded very fast. During the early years of the PRC, the state-capitalist sector and the private sector together dominated the industry and commerce, but they began to lose weight to the former two sectors. Especially, the state-capitalist sector had almost phased out within the first decade of the founding of the PRC. The state-owned sector mainly controlled the heavy industry; the state-capitalist sector dominated the light industry, and the private sector took the bulk of commerce and handicraft industry. The co-operative sector used to be very small. But it later took control of agriculture in a wave of rural collectivisation. Moreover, the collective economy also spread very quickly in the urban areas. Privately-run commerce and individual handicrafts were gradually pushed into a corner, and finally forced to give up. Technically speaking, the state-capitalist sector was only a temporary phenomenon in the economic history of the PRC. It disappeared (was bound to disappear sooner or later) very quickly during the communisation period. The private sector luckily survived during the last decades, but it also suffered heavily and was near to being wiped out.

The principles on which the Chinese economy should be reconstructed were outlined by Mao Ze-Dong several years before 1 October 1949 (the founding date of the PRC). These principles were later embodied in the 'Common Programme', which served as the national constitution in the early years of the republic. According to the Common Programme, all enterprises and industries vital to the economic life of the country and to the people's livelihood were to come under unified operation by the state, and the co-operative economy was to be promoted and given preferential treatment. It was then predicted that these two sectors would come to dominate the economy. In its early years, however, the new government did not harm the private sector. On the contrary, private producers and traders were given some encouragement and support on the conditions that such support did not run contrary to the state-owned sector. Given this caveat, state policy toward the private sector was always ambiguous, and private agents were not normally given the benefit of the doubt.

3.2 Agricultural Development and Reforms

3.2.1 Land Reform

From the summer of 1950 to the spring of 1953 nation-wide land reform took place. In many respects, this was very moderate, and so contrasted sharply with the land reform in the early years of the Soviet Union. The land reform boosted the morale of the majority of the rural population, the poor peasants, and encouraged the key and dynamic forces of agriculture, the middle peasants, and did not hurt the rich peasants too much. It also deliberately avoided the radical change aiming to reach complete economic equality and to eliminate poverty in the rural areas. As a result, agriculture progressed very quickly. The official statistics announced that the gross value of agriculture output (at 1952 prices) increased by almost 50 percent between 1949 and 1952 (The State Statistical Bureau, 1960.). Even the more careful Western estimate also put the average annual growth rate at 7.4 percent for these years (Wiens, 1978).

So it is very reasonable to say that the first four years of the PRC were marked by a very good agricultural performance.

3.2.2 Collectivisation of Agriculture

Some problems began to emerge soon after the land reform. For example, in some large areas, especially in north- western provinces, poor peasants could not even produce enough food grain for themselves, and certainly could not produce a surplus for reinvestment. Another, related, serious problem was that some peasants were going into debt again and having to sell their land (redistributed to them few years earlier) and so became landless labourers. The moderate land reform had already resulted in the problem of land ownership. For example, after the land reform, the average farm size of 'rich peasants' was 5.2 acres, which was almost three times that of 'poor peasants' and 75 percent larger than that of middle peasants. When other factors are taken into account, the gap becomes much wider. To solve the above problems, the Party and the government opted for the co-operative mode of agricultural organisation. It was believed that this would permit a more rational use of land, equipment and animals; lead to greater self-financed investment; and improve incentive. More important, in the view of the leaders, was that cooperatives would lead the whole rural population on the way to collectivisation.

The main instruments of co-operative organisation were the Mutual Aid Team (MAT), Elementary or Lower Stage Agricultural Producer Cooperatives (LAPCs), Advanced Agricultural Producer Cooperatives (AAPCs) and Communes.

3.2.3 Policy Shifting

It was commonly believed that the mid-1950s was the most crucial moment for the Chinese policy-makers. They needed to ask themselvs very carefully: why did agricultural growth slow down? What were the major reasons accounting for this? What were the appropriate policies to deal with these problems? What was the alternative if a chosen policy did not work?

The Chinese leaders at the highest level did not reach a consensus about how to deal with the agriculture problem. However, for ideological reasons above, collectivisation was chosen as a strategy of agricultural development.

During the process of collectivisation, two principles- voluntariness and mutual benefit- had been severely violated in most places.

It was supposed that the giant cooperatives could solve many problems which private farming and MATs could not, such as building new and more complicated irrigation systems; accumulating public funds for further investment, purchasing new machinery and other modern inputs; and specialising planting. These potential advantages were truly attractive. But the most important issue was whether co-operative farming could deliver these promises and achieve efficient agricultural production. If not, productivity could not be raised, public funds could not be accumulated, and the living standard of whole Chinese population could not be improved.

During the 'Great Leap Forward', the cooperatives were replaced by new institutions-People's Communes. These then existed for twenty years, until they were dismantled in 1979. The rural people's communes initially were the institutional counterparts of GLF's labour-intensive technology policy. Emerging spontaneously as amalgamations of cooperatives trying to mobilise enough labour for the unprecedented mass irrigation campaign of the winter 1957-1958, they were quickly seized on and popularised by the Party. Then the communes were deeply involved in 'backyard iron casting', which brought catastrophe to the whole economy. Although the GLF failed disgracefully, the communes continued to exist.

From 1955 to 1958, grain production did rise marginally from 183.9 to 200 million tones. However, it began to decline sharply after 1958, and dropped to an all time low in 1960, when the official output of grain was 143.5 million tones. Grain output did not reach the 1958 level until 1965.

The total output of grain increased from 194 million tones in 1965 to 284 million tones in 1975. This represented an average annual growth rate 3.7 percent. Given the increase in population from 725.4 to 919.7 millions during the same period, the average annual growth rate of grain output per capita was only 1.1 percent. This increase was far too low to cope with the growth of people's needs.

3.2.4 Rural Reforms in 1980s

In December 1978, the third plenum of the Eleventh Central Committee of Chinese Communist Party decided to carry out economic reform in the rural area. The first decision was to whether raise the price of agricultural products. In the summer of 1979, big price increases were put into effect: 20% increase for grain quota purchase, 50% increase for above quota sales and 22% increase for all agricultural purchases (including grain, cotton, oil- bearing crop, sugar and other sideline products). In addition, the price of all agricultural products were increased in subsequent years: by 7.1 percent in 1980; 5.9 percent in 1981; 2.2 percent in 1982; 4.4 percent in 1983 and 4.0 percent in 1984.

Between 1979 and 1984, the agricultural sector underwent a rapid change. The communes had been dismantled and the private farming had been restored. This process was accomplished in three steps.

First, 'Baochan daozu', a system of contracting output to the groups of individuals was introduced. This was soon followed by a system of contracting output to the household called 'Baochan Daohu'. The only difference between the two systems was the number of people who made the contract- 'Baochan Daozu' had ten or twenty (even more) people, but 'Baochan Daohu' had one household. The two contracting systems however shared many similarities. First, an agreement would be made with their teams such that failure to fulfil the contract would be penalised and success in exceeding the contract receive bonus or permission to retain the surplus output. Second, their teams had the power to make plans for planting, allocate irrigation and control the use of draught animals and machinery. Third, in return for handing in contracted outputs to the teams, in return, they received the agreed work points. Thus both 'Baochan daozu' and 'Baochan daohu' did not break with the spirit and methods of collectivisation, although they did take a big step away from past practice.

The third system of contracting everything to the household was called 'Baogan Daohu'. Under this system everything was divided and redistributed to the households, including light machinery, draught animals and farming tools. The individual household did not need to give the output to the team in exchange for work points. Contrary to this, the individual household should fulfil the quota sales, meet the agricultural tax, and pay a little contribution to the team to maintain some necessary public services. All surplus either agricultural or/and sideline products were kept by the household. It was up to the household to decide whether to sell to the state at the above-quota price or negotiated price, or to sell on the free market. The work points accounting system was eliminated. The 'Baogan daohu' system actually went back to the early 1950s when the state acted as the landlord and peasants as the tenants. But the production teams still retained the power to set sales quotas and tax obligations for the individual household.

As a result of the reform, Chinese agriculture had recovered and grew very quickly between 1978 and 1984. The word 'very impressive' and 'dramatic' were often used by both Chinese and foreigners to describe Chinese agricultural performance during this period. According to official figures, the GVAO grew by no less than 9 percent per year between 1978 and 1984, an unprecedented achievement in China. Per capita food grain output grew by 3.8 percent per year between 1978 and 1983. This growth rate was far exceeded by those of edible oils (14 percent), and of meat (9 percent). Moreover, cotton production had an average annual increase of 17.5 percent between 1978 and 1984.

3.3 Reform and Development in Industry and Trade

3.3.1 Nationalisation

Hyper-inflation plagued the Chinese economy for several years before the communists took power in mainland China. The prices of major consumer products had risen several thousand times. This problem can be attributed partly to successive wars, especially the eight year Anti-Japanese War (1937- 1945) and the four year Third Civil War (1945-1949) and partly to the incompetence and widespread corruption of the Nationalist government. In addition to inflation, there were also many other serious problems, such as widespread starvation, powerful and organised crime, and high unemployment.

From 1950 onwards, the new government dominated by the communists adopted many tough measures to try to solve these problems. One of the most effective means used was the ban on the circulation of gold, silver and foreign currencies. Later, new Chinese currency- Reminbi (RMB or Yuan) was introduced. Unlike the Nationalist authority, the new government deprived private banks of the right to service deposits. All government offices, military units and enterprises were required to deposit their money in the branches of People's Bank of China, which was then China's Central Bank. The private bank operation had thus been brought to a halt.

The heavy industries, particular the capital producer industries, which were under the control of the Nationalist government, had been confiscated by the new government. This formed the backbone of the state-owned sector. The railway system, which was the corner-stone of the whole Chinese transportation network, had been severely disrupted during the war time. In October 1949, less than half of the country's rail lines were in operation. Two years later, the entire railway system was functioning, but at far greater intensity than in the past.

With total and effective control of the railway, the government easily took over the wholesale trade in the urban areas. The supply of food grain, cotton and other key raw materials were also monopolised by the state. This monopoly power forced many privately-owned textile and food processing industries to give up. As a result, the numbers of industries directly or indirectly controlled by the state accounted for about 45 to 63 percent of total industrial output.

By 1952, the gross value of industrial output had grown two and half times that of 1949, and exceeded pre-war levels by almost a quarter. Output of almost all important products had reached or exceeded past peak levels.

According to the Chinese version of socialism, state- and collective-owned sectors should dominate the national economy. The whole process of changing private ownership into state and collective ownership in industry and trade, which was called 'socialist transformation', took place in the 1950s. The unique character of the transformation movement was that: the PRC adopted a rather moderate method-forming joint venture enterprises. Under the programme, the former owners handed their enterprises and properties to the state, in return they would receive the interest payments based on their assets (which were assessed jointly by the state and owners themselves). These former owners and managers, who were highly experienced and skilful both in production and management, were publicly welcomed to stay in their former enterprises, not as the owners but as the state employees. They could work as a director, a new manager, or as a deputy manager or deputy director. By 1953, there were a thousand joint enterprises, employing 270,000 people and producing about Y 2 billion annually. But the number had more than doubled during the 1954. Furthermore, at the end of 1955, private industry accounted only 16.2 percent of gross industrial output. By the end of 1956, private industry and trade were virtually eliminated all over China.

Under the agreement between the state and private owners, the latter would receive fixed interest payments at 5 percent of assessed value of their shares (5 percent was relatively favourable under noninflation Chinese economy). The period for receiving interest payments by private owners was first agreed to seven years (from January 1956 to December 1962), then extended to the September 1966.

3.3.2 Centralisation and Decentralisation

The central planning infrastructure began to be set up in China in the early 1950s. The method of organising the central planning economy in China was based on the concept of material balance. Under the guidance of SPC, every ministry was obliged to prepare a detailed proposal for the following year. In their proposals, the total amount of output would be projected, and the destination of their output would be described as well. Consequently, the total amount of capital, labour, raw material and energy and transportation would be put in the acquisition list to the government. The State Council, with the effective assistance from the SPC would make the final judgement and balance the plans proposed by every individual ministry. The national economic development plan would thus be a constitution of intersectoral balance. A detailed input-output table could be used to describe the plan.

At the early years of the PRC, the central government seemed to be able to make plans and choose priority investment areas. As both the number of commodities and the number of enterprises for which the central government assumed responsibility grew rapidly in the course of 1950s, the maintenance of such a high degree of centralisation became increasingly cumbersome. Before 1952, only 28 of the most important producer goods and raw materials, such as steel, coal, power, were directly balanced by the central government. But this number grew rapidly, reaching 235 by 1956.

Given the huge size of the country, large numbers of enterprises, millions of products type, lack of transportation and communication facilities, and severe shortage of competent statistical personnel, central planning organs were certainly unable to function effectively and efficiently.

There are, in principle, two ways of dealing with the problem. The first one is to entirely abandon the principle of the central planning, to restore the reputation and power of the market, and give back all rights of planning, production, management and marketing to the individual enterprises. This approach would inevitably make the central government and also local authorities lose their power, especially the party's privileges of intervening in economic affairs. The second approach is to decentralise some power to localities, leave the provincial governments to deal with many economic matters, but the central government still has the final say on major economic issues. All major decisions made by the provincial governments must be submitted to the top hierarchy in Beijing, any contradiction with national plan should not be allowed. Before the economic reform of the 1980s, Chinese leadership under Mao had carried out several times economic experiments using the second approach, and all of them had failed. Centralisation imposed order and greater balance but resulted in a rigid, lifeless economy. Decentralisation, on the other hand, stimulated economic activities but resulted in chaos and disproportion.

3.3.3 Economic Reform Since the Late 1970s

Some rather radical reforms took place in Sichuan province in October 1978. These were initiated by the former Premier, Zhao zi-yang, then the party secretary of the province. At the beginning, only six state-owned enterprises in the province were included in the reform experiment. In July 1979 the State Council decided to enlarge the experimentation to 4,000 enterprises throughout the country. This number rose to over 6,000 in 1980, comprising 16 percent of the nation's state-owned enterprises. Their output values and profits accounted for 60 and 70 percent respectively of the total from state-owned enterprises.

There were eight special rights granted to the enterprises taking part in the experiment in Sichuan, which later became the base for further experiments.

First, the right to retain part of the profit made (about 3-5 percent), according to the state plan and up to 25 percent of the profit made outside the state plan.

Second, the right to keep two years profit from the production expansion which resulted from the reinvestment of their own funds accumulated in the past.

Third, to keep 60 percent of the depreciation fund.

Fourth, after having met the state plan, they could produce according to the need of the market.

Fifth, the right to sell the products which the state did not purchase.

Sixth, the right to retain part of the foreign exchange they earned to import new technologies and raw materials.

Seventh, the right to award the employees bonus.

Eighth, the right to punish the employees who were lazy or caused the heavy losses to the firm.

Five years later, in May 1984, the State Council announced new guidance for the further economic reform. These are summarised below:

1. Production. Businesses have the right to produce whatever is needed or in short supply, after fulfilling their state plans and orders.

2.Sales. With certain exceptions, firms have the right to sell products they retain for themselves, products in excess of state quotas, their own trial-produced or overstocked items, and those refused by state purchasing agencies. Special accounts should be kept for the sale.

3. Pricing. Within a 20 percent range of the state price, firms can sell their exceeding quotas products.

4. Purchasing. Businesses can choose their suppliers when they order state-distributed raw materials.

5.Enterprises can decide whether their share of profits goes into expanding production, trial production of new products, a reserved fund, the welfare fund, or bonuses.

6.Firms can lease or transfer unneeded fixed assets, the income must be used to upgrade their own facilities.

7.Firms can set up internal organisations according to their needs if they stay within authorised size.

8.A director or manager can appoint or dismiss cadres under him except his deputies. He can reward or punish his workers and staff.

9. Firms can adopt any wage system, in line with state standards. Factory directors may promote 3 percent of their workers each year, with the increased wages counted as a cost of production.

10. Firms can set up joint projects which cut across official division, as long as they maintain their present system of ownership and subordinate relationships.

(See Beijing Review, June 11 & 18, 1984).

The new regulations enlarged the power of the individual enterprises, including selling their products in excess of state plan (this would encourage them to produce more) and trial production of new products (this might stimulate them to innovate), pricing their own products (with some very strict preconditions), purchasing raw materials outside the state controlled supply chain, and rewarding and dismissing workers. However, the new regulations did not go far enough. First, all enterprises should still first fulfil the state plan and deliver the 'quota' products to the state commercial departments, although this 'quota' became relatively lower in some production areas; Second, enterprises had not got the real power to price their products.

Taxation system underwent a big change in 1983 and 1984. In early 1982, four out of five enterprises covered by the state budget were still on some form of profit sharing system. Later a 'tax-for-profit' system was introduced nation-wide. Under the system, enterprises would pay a series of well-defined taxes and keep net profit. Taxes would include the fees imposed for the use of fixed and circulating capital, the industrial and commercial (sales) tax, profit tax, and finally an 'adjustment tax to collect differential rents arising from arbitrary conditions, such as location, natural resources endowment, and the price structure. So in late 1984, a pure tax collection regime had been established.

Price reform

No matter how perfect a taxation system may be, given the huge distortion of the prices, it will not work. The new taxation system was designed to give firms more incentives to run efficiently and to make more profit. However, an extremely irrational price system had prevented it making any visible effect. For example, a box of matches (with 100 matches inside) was priced at two fen (roughly equal to 0.2 pence) in early 1950s, it was still two fen in 1980s, although the main materials (wood and paper) were becoming more and more expensive. As a result, the match producers could not make any profit at all, because the more matches they produce the more the losses they incurred.

It is untrue to say that the Chinese decision-makers and economists did not want to solve, or at least to alleviate the problem of price distortion in the past. They did try several times, but failed and finally gave up. There were two big problems associated with the failures, one was technical, and the other, political.

The political problem originated from socialist ideology. To many Chinese leaders, especially Mao, the Chinese economy should be reconstructed within the socialist framework. Replacing the market by planning is the major characteristic of the socialist economic system in China. So prices cannot be left to the market to decide.

The extreme complexity of the price relationship between the different commodities far exceeded the capacity of the government bureaucrats. Even with the most powerful computers available and the modern statistical capability, the state still cannot decide the prices properly and timely. This is a technical problem. As Xue mu-qiao, one of the most famous Chinese economist, remarks:

> 'The reason was that there were up to one million prices. Cost calculation for each and every product was extremely complicated. There were endless disputes between producers and users with their divergent interests. Therefore, no single price control agency, no matter how competent, could hope to handle this complicated problem well through subjective plans.'

For example, in 1983, there was a big price adjustment in textiles, which raised the price of cotton and lowered that of synthetic fibre. The preparation for the price change took more than six months. And nearly 10,000 price department personnel were directly involved. This was due as much to the political sensitivity of price reform as to its inherent complexity. It is very true that a frequent price adjustment of all (or even many commodities) is clearly beyond China's technical and political capabilities.

It had been recognised by many economists and some top leaders in China in the early 1980s that the price reform was necessary and should be carried out before any radical economic reform can take place. Thus in October 1984, the Chinese government took a brave action to adopt a price reform proposal. The proposal greatly reduced the number of the products subject to mandatory planning and allowed their prices to fluctuate in response to market conditions. And in 1985, the price of meat, poultry, fish, eggs, and vegetables were decontrolled. The number of industrial product categories subject to the state control fell from 120 to 60. And mandatory purchase quotas in agriculture were to be reduced from 29 types to 10. A three-tiered price system had been adopted by the state:

> Fixing the prices for the most important goods, such as steel, coal, petroleum and key producer goods;
>
> Setting the boundary for the price fluctuations for most intermediate products;
>
> Freely floating the prices for a host of consumer and small producer goods.

As a part of price reform, all enterprises would be charged for the use of investment fund. In the past, all investment funds were allocated by government agents to enterprises free of charge, which was blamed for creating many problems, such as overextended capital construction and piling up of working capital. Now, these 'free of charge' funds are replaced by the bank loans, which would bear interest. The new method was intended to force the enterprises to economise on the use of their capital.

Many economic experiments and reforms over the last twelve years or so have produced both positive and negative effects on the Chinese economy. And it was only a starting step to move to a market economy.

Summaries and Conclusions

With 22 percent of the world's population and just 5 percent of the world's arable land, the Chinese economy has performed quite well over the past decades. The real GNP of China rose at an annual average of 7.7 percent between 1965 and 1988. Industrial expansion has contributed 62.5 percent of total economic growth in China over the same period. And the manufacturing sector has been responsible for 41.2 percent of the overall increase.

Compared with the previous thirty years (1949-1979), the 1980s saw a dramatic improvement in performance of Chinese economy. This can be attributed mainly to the economic reform which started in 1978, the shifting of investment priority from heavy to light industry and active engagement of international trade. Although most of the major industrial products have expanded rapidly since 1980, the growth of major agricultural products is even more impressive. As a result, the per capita consumption of grain increased from 215 kilograms in 1960 to 390.5 kilograms in 1984, the corresponding figures for cotton were 1.6 and 6.05 kilograms, and for oil bearing crops were 2.9 and 11.85 kilograms, respectively.

Within the first ten years of the founding of the PRC, the state-owned sector mainly controlled the heavy industry, the state-capitalist sector dominated the light industry, and the private sector took the bulk of commerce and handicraft industry. However, according to the new constitution, all enterprises and industries vital to the economic life of the country and to the people's livelihood were to come under unified operation by the state, and the co-operative economy was to be promoted and given preferential treatment. It was predictable that the these two sectors would come to dominate the economy.

The land reform which started in the summer of 1950 boosted the morale of the majority of the rural population, the poor peasants, and encouraged the key and dynamic forces of the agriculture, the middle peasants, and did not hurt the rich peasants too much. It also avoided the radical change aiming to reach complete economic equality. As a result, agriculture progressed quickly. However, the sudden and breathtaking acceleration of the process of the co-operativization from August 1955 onwards changed the whole picture of the Chinese agriculture sector entirely. And the communisation programme during the period of 'Great Leap Forward' delivered the vital blow to the already troubled sector. Facing two fundamental problems- the methods for income accounting and the mechanism for income redistribution, the communisation led to the stagnation of the Chinese agriculture. The grain production began to decline sharply after 1958, and dropped to an all time low in 1960. In fact, the grain output did not reach the 1958 level until 1965. The economic reform, which dismantled the commune system, returned the farm land to individual household and raised the prices of agricultural products significantly with successive years between 1978 and 1984, brought a dramatic change of the sector. The GVAO grew by no less than 9 percent per year between 1978 and 1984, an unprecedented achievement in China.

The economic reform over the past fifteen years also brought a radical change into the industry and commerce sectors. It has enlarged the power of the individual enterprises considerably, including selling major part of their products, pricing their own products under the certain maximum ceiling and purchasing raw materials on the open market. The introduction of the new taxation system has also given firms some incentive to improve their economic efficiency. However, the tax levied on firms are too high, the depreciation rate is also very low, the ratio of retained profit is even lower. Furthermore, a fundamental price reform has not been carried out yet. However, some recent development are quite encouraging. With the free of all agricultural products and most industrial products and with a small planned sector (which has kept declining over the last ten years) in all production, the Chinese economy is moving toward the market economy steadily and firmly. Moreover, boldness, encouragement and relentless effort would be needed to make the transformation irreversible. Any sudden stoppage and turning-bach would lead to a dangerous consequence, not only economically but also politically.

Chapter Four

Technology Transfer and Development in China

4.1 Review of technology transfer over the last decades

If taking into account the political, economic and technological circumstances in China, we can divide the period since 1949 into four sub-periods:

First period	1949-1959
Second period	1960-1971
Third Period	1972-1977
Fourth period	1978 onwards

The objectives defined and methods used for technology transfer varied between the different sub-periods. Even within the same sub-period, the strategies and tactics also varied very much from time to time, mainly because of discontinuity of government policies leading, inter alia, to sudden change in development direction and in the degree of preference of foreign technologies.

The first period: 1949-1959

In 1949, the Communists took power in mainland China, after defeating the Nationalists (Guomindang), who fled to Taiwan. Thirty-eight years of civil war (1912-1949), including eight years' war resistance against the Japanese (1937-1945), had made China one of the poorest countries in the world. The economy was war-torn, inflation-plagued and disorganised. The transport system had been badly damaged and was in chaos, worsening the already terrible situation of food shortages and the lack of supplies of raw materials. Poverty and starvation were rife. The fleeing of hundreds of thousands of talented engineers, technicians and entrepreneurs from mainland China mainly to Taiwan and to HongKong had produced catastrophic effect on the Chinese economy. Not only did they take capital and equipment with them. But their departure also deprived mainland China of their invaluable skills and experience.

The Korean War made the Chinese situation even worse. It had greatly aggravated the already difficult situation of the Chinese economy, making the recovery process of the war-torn economy far more painful than it was expected. Over one million PLA soldiers (there had been even more civilians) had been involved in the terrible and bloody war, which swallowed uncountable quantities of valuable goods, especially food, cloth and medicine, which were then in a terribly short supply in China.

Ideological reasons made the Soviet Union the closest friend of the new found communist China. Consequently, China had its technologies transferred from the Soviet Union. It is noted that the most massive technology transfer in the history of modern China took place during the 1950s. The Soviet Union conducted the large-scale, comprehensive technology transfer programme. During the period, 156 key projects had been given the top priority, among which were seven iron and steel plants, twenty-four electric power stations and sixty-three machinery plants. It was estimated that 11,000 Soviet technicians provided guidance and technical advice to China to startup these projects. Additionally, approximately 25,000 Chinese had been sent to the Soviet Union for advanced education and technical training. More importantly, however, the Soviet Union had also shaped the development of both China's production structure and S&T system-both of which replicated the highly centralised, heavy industry- oriented Soviet system. It is perhaps in this area where the Soviet Union had its most long-term impact on the economic development of post-1949 China.

China's foreign trade expanded very quickly during the 1950s. The value of total foreign trade increased from US$ 1,210 millions in 1950 to US$ 4,265 millions in 1959, a 352.48 percent growth. One major characteristic over the decade was that the share of Communist block in Chinese foreign trade expanded dramatically, from 28.9 percent in 1950 to 69.4 percent in 1959. The total value of foreign trade between China and the Communist block increased 746 percent during 1950-1959 from US$ 350 millions to US$ 2,960 millions, among which, Soviet Union provided nearly 50 percent of all China's imports, with 8 billion US dollars worth of goods. One-quarter of Soviet's export to China took the form of complete industrial plants and another 16 percent for other machinery and equipment.

The second period: 1960-1971

The failure of the "Great Leap Forward", the schism between China and the Soviet Union, the withdrawal of all Soviet assistances and successive natural disasters marked the beginning of the Second period of technology transfer in PRC.

The period saw the rapid recovery and growth of the Chionese economy. We can see this from the indicators in the table below.

Table 4-1 The comparison of selected indicators of the Chinese economy in 1952 and 1957 (at 1952 constant prices)

item	1952	1957
GNP (billions US$)	$59	$82
Population (millions)	570	642
GNP per capita (US$)	$104	$128
Grain (million metric tons)	154	185
Steel (million metric tons)	1.35	5.35
Foreign trade (billions US$)	$1.89	$3.06

Source: Government Statistics of PRC.

The pace of economic progress at the initial stage made the government under Mao become so impatient that they set unrealistic production targets for the Second Five Year Plan period. This inevitably brought out the first major tragedy- "Great Leap Forward"- to post-1949 China. This manmade disaster took place in 1958 and heavily damaged the Chinese economy, which had only recovered a few years earlier.

Table 4-2 Selected indicators of the Chinese economy after the "Great Leap Forward" (at 1952 constant prices)

item	1957	1958	1961
GNP (billions US$)	$82	$95	$72
Population (millions)	642	658	701
GNP per capita (US$)	$128	$144	$103
Grain (million metric tons)	185	200	160
Steel (million metric tons)	5.35	13@	8
Foreign trade(billions US$)	$3.06	$4.29@@	$2.68@@@

Note: @: in 1960; @@: in 1959; @@@: in 1962

Source: Government Statistics of China

We can see from the above table that all key economic indicators decreased from 1957 to 1961, except that of the population, which increased from the 642 millions in 1957 to 701 millions in 1961. The three successive years (1959, 1960 and 1961) of natural disasters- first drought, then flood and pest plague-aggravated the situation. Hundreds of thousands of lives were lost during these years. The changes in policy since 1962 had helped the economy to recover slowly and regain its 1959 level in 1966. Unfortunately, the "Cultural Revolution", which started in 1966, immediately interrupted the recovery process. As a result, the Chinese economy grew slowly in late 1960s. For example, the total value of foreign trade only increased by 1.4 percent. This contrasted sharply with that of Japan, South Korea and other newly industrial countries, who benefited enormously from the 'golden period' of the post-war world economy. However, the share of non-Communist block in total

Chinese foreign trade had kept rising quickly, from 30.7 percent in 1959 to 80 percent in 1970.

The ideology war and schism between China and Soviet Union did cost China very dearly. The sudden withdrawal of all Soviet assistances brought the massive technology transfer programmes to a halt. Most projects had not been finished, some had even just begun to be constructed. All Soviet managers and technicians had gone, taking with them all know-how, designs and blue prints. Most equipment ordered in the late 1950s, especially key parts of the projects had not been delivered to China, and never been delivered since then. All Chinese who were studying and training in the Soviet Union were either recalled or sent back. All economic, technological and cultural exchanges between these two countries stopped. The Chinese were asked to pay their debts to the Soviet Union. Most of these were paid in kind, mainly food, meat, fruits, and vegetables, which had inevitably led to a serious shortage of supply of these commodities in China in the early 1960s.

Without technical and financial assistances from the Soviet Union, the Chinese people had to assume full responsibility themselves to carry on the giant technology transfer programme. The great difficulties they had met are imaginable. However, through the long process of trial and error, they had accumulated valuable experience and developed their own indigenous technological capabilities, although most of these capabilities were rather of 'trouble-shooting' type than 'innovation-motivated'. Nevertheless, this was the first time since 1949 that Chinese technicians tried to absorb, modify and diffuse the modern technologies by their own effort. Without any help either from the East or the West, copying and reverse engineering became the effective way to develop indigenous technology.

However, the situation began to change several years later. Even though the United States was still carrying on a total trade embargo policy, China had resumed foreign trade with some Western countries, including Japan, the U.K., and France. As a result, many new foreign technologies had been imported either to complete the existing projects which were left by the Soviets or to start new ones. The major phase of the importing foreign technology and equipment took place during the 1962-1966 period. Some technologies imported from Japan during the period can be seen from the following table.

The technology transfer during the period had four major characteristics. First, the confrontations with capitalist block led by the United States, and also with Eastern block led by the Soviet Union isolated China entirely, which had strongly influenced China's policy in the next decade and stimulated China to pursue a self- reliance policy. Second, copying, imitating and reverse- engineering were the major ways of technology transfer, diffusion and development. Third, the new sources of foreign technology supply had been eagerly explored. Advanced technologies and equipment had been imported from Japan and some Western European countries, mainly through HongKong, and also from some other places. Fourth, under whatever standards, the technology transfer in the first half of the 1960s was very moderate both in terms of plant scale and money spending.

Table 4-3 Some technology imports from Japan 1963-1965 (US dollar million)

Vinylon plant	(20.0)
Acetylene gas generating plant	(3.0)
Air liquefying plant	(1.7)
Oil-pressure equipment manufacturing plant	(1.8)
Wire drawing plant	(0.5)

Source: Japan Planning Agency.

The Cultural Revolution quickly spread out all over the country in the late 1960s and brought all foreign technology acquisition to a standstill. During the period, an all-out attack on the acquisition of foreign technology had been deliberately organised to serve the political purpose of some people. Self-sufficiency at both the local and national level was greatly encouraged as a result of the domination of the government by the left-wing radical group.

The Third period (1972-1977)

The official visit of President Nixon of the United States marked the beginning of the period. Although the ice between China and the West had began to thaw before this event, it was the establishment of formal relationship between China and the United States which opened the new era of Chinese foreign policy. It strongly influenced the decision-making of the new technological policy in China. Before 1972, a future war between China and her major enemies- the United States and Soviet Union- was perceived as inevitable. Since 1960, China had spent a substantial amount of human and capital resources on military and defence-related industries. Agriculture and light industry had consequently not received adequate investment for a long time. The PRC successfully made its first atomic bomb in 1964, and exploded the first hydrogen bomb in 1967, and launched the first satellite in 1969. However, these high technologies in military area did not help to improve the efficiency of the Chinese economy at all. The Cultural Revolution had disorganised and disrupted the Chinese economy very severely. The border clashes between China and the Soviet Union in the late 1968 and also in the early 1970 had negatively affected the Chinese economy. Facing a seemingly impending war, China had been on state emergency for several years. And a huge amount of scarce resources had been channelled to the defence area. A large number of construction projects had been completed to assist the Chinese military effort. Most of the projects were hardly justifiably from the economic point of view.

The sudden rapprochement and normalisation between China and the United States changed the situation. The tension of the seemingly impending Sino-Soviet War began to ease. This strongly influenced the Chinese domestic politics and helped to reverse- to a limited extent- the left-wing policies adopted since beginning of the Cultural Revolution. A group of pragmatic politicians, who were accepted by Mao, backed by Zhou and led by Deng, had been put back to the key positions in the government. Following this change in political circumstances, the government launched on a big technology transfer campaign for the second time in the PRC history. Between 1972 to early 1975, whole plants and equipment were purchased abroad. The State Council which was firmly controlled by Deng Xiao Ping approved a budget of US$ 4.3 billions for the importation of foreign technology. The striking character of the technology transfer during this period was that the industries which can satisfy consumers' needs and improve people's living standard, including agriculture, food, clothing and energy, were given top priority.

It was during this period that China purchased eight ammonia plants for chemical fertiliser production from Pullman Kellogy of the United States and eight urea plants from the firm's European Subsidiary- Kellogy Continental. Because most technologies and related equipment imported under the programme were large-scale, capital-intensive, high efficiency and high level of automated control, the Chinese were very willing to receive foreign engineers and technicians for guidance and supervision. As a result, over 3,000 foreign technicians and engineers visited China to assist with the transfer of technology. In the case of Pullman Kellogy, approximately 150 technicians were in China at one time or another, who did not only oversee the construction but also provide basic design, engineering, procurement and commissioning of the plants.

The table 4-4 lists the major technology acquisitions of China from 1973 to 1975.

From the table below, we can see that sixteen whole plants had been imported for increasing fertiliser production, twenty whole plants for developing petrochemical industry and several others for improving the energy sector. Technologies were imported on a large scale during the early 1970s than in the 1960s.

Unfortunately, the massive technology transfer program was again interrupted in the late 1974. The radical left-wing political group led by the 'Gang of Four' fought back

Table 4-4 Whole Plant Acquisitions by China

Nation/Firm	Type	Value (Mn US$)	Contract signed	Completion
1973		1,259		
Japan				461
Toyo Engineering	Ethylene and butadiene	50	Feb.73	1978
Mitsubishi	Ethylene and poval	34	Feb.73	N.A.
Asahi chemical	Acrylonitrile monomer	30	Mar.73	N.A.
Kararay	Vinyl acetate and poval	26	Mar.73	1976
Toyo Engineering, Mitsui Toats	Urea and ammonia	42	Apr.73	N.A.
Toray, Mitsui ship building	Polyester chips	50	May.73	1976
Sumitomo	Benzene, toluene and aylene	5	May.73	N.A.
Mitsubishi	Polyethylene, low pressure	22	Jul.73	1975
Sumitomo	Polyethylene, high pressure	47	Aug.73	1976
Hitachi Ltd.	Two thermal electric power plants	72	Sep.73	1975
Toyo Engineering, Mitsui Toatsu	Urea and ammonia	43	Sep.73	N.A.
Mitsui petrochemical and Mitsui ship-building	Polypropylene	25	Oct.73	1976
NISSO petrochemical	Ethylene glycol	15	Dec.73	1977
France		400		
Alsthom	Hydroelectric turbines (2)	10	Feb.73	N.A.
Speichem	Vinyl acetate and methanol	90	May.73	1976
Technip and Speichem	Petrochemical complex	300	Sep.73	N.A.
United States		205		
M. W. Kellogy	Ammonia plants (3)	75	Mar.73	1976
M. W. Kellogy	Ammonia plants (5)	130	Nov.73	1976-77
Netherlands		89		
Kellogy Continental	Urea plants (3)	34	Feb.73	1976
Kellogy Continental	Urea plants (5)	55	Sep.73	1977
West Germany		4		
Friedrich Uhde & Hoechst	Acetaldehyde	4	Jul.73	N.A.
United Kingdom		8		
Technicolor Ltd.	Motion picture processing plant	8	Jul.73	N.A.
Italy		79		
G. I. E.	Electric thermal power plants (2)	79	Nov.73	N.A.
Denmark		13		
Haldor Topsoe	Ammonia Catalyst	13	Dec.73	N.A.

Table 4-4 (continued)

1974		831		
Japan		348		
TeiJin	Polyester spinning	16	Jan.74	N.A.
Toho Titaniun	Polypropylene catalyst	5	Jan.74	N.A.
Kararay	Polyvinyl alcohol	19	Feb.74	1976
NISSO petrochemical	Synthetic fibre	14	Mar.74	1976
Nippon Steel, Hitachi	Hot strip rolling mill & silicon steel plate	229	Jan.74	1977
Nippon Steel	Ancillary equipment for steel mill	65	Oct.74	1977
West Germany		296		
Uhde	Vinyl chloride monomer	19	Jan.74	1976
Demag	Cold rolling mill	200	Mar.74	1977
Uhde	Polyethylene	15	Mar.74	1976
Demag	Continuous casting mill	57	Aug.74	1977
Brown Boveri	Electrical substations	5	Aug.74	1977
France		171		
Heurtey	Ammonia and urea complex (2)	120	Feb.74	1977
Electromechanique	Thermal electric power plant	41	Apr.74	1976
Rhone Poulenc	Nylon spinning	10	Aug.74	1977
Italy		16		
SNAM progetti	Polypropylene	16	Jan.74	N.A.
1975		371		
Japan		59		
Nippon-Seiko	Spherical bearings	3	Apr.75	1976
Noyo Seiko	Cylindrical bearings	8	Apr.75	1976
Ibigawa	Laminated board	1	Jul.75	N.A.
Ataka	Air separation	11	Nov.75	1977
Japan Gasoline	Aromatics complex	36	Dec.75	N.A.
West Germany		76		
Linde	Benzene	20	Jul.75	N.A.
Krupp	Dimethyltherephthalate	50	Dec.75	N.A.
Siemens	Turbine	6	Dec.75	N.A.
United Kingdom		200		
Rolls Royce	Jet engine plant	200	Dec.75	1980
Italy		36		
Mechanche Moderne	Defergent	1	Sep.75	N.A.
Eurotechnica	Defergent alkalation	35	Oct.75	N.A.

and gradually took control of the whole process of Chinese decision-making. As a result, foreign technology purchasing had been sharply cut from almost US$ 1.3

billions in 1973 to US$ 185 millions in 1976 and 59 millions in 1977. Besides the political struggle and instability, rising inflation in the world market as a result of the OPEC oil price rise and growing domestic economic problems had also imposed serious financial constraints on China's ability to pay for additional plants and equipment. Moreover, the year 1975 saw the biggest natural disaster in Chinese history, when the severest flood for a century had wiped vast areas of central and southern parts of China. As a result,hundreds of millions of mu agricultural crops had been ruined, more than 100 million people became homeless, and the North-South transportation and communication systems had been cut for many days. Furthermore, in the early 1976, successive earthquakes occurred, affecting many parts of China. The whole Tangshan City had been destroyed by an early morning earthquake, at least half a million people had been killed, and billions of Yuan worth of property lost. The nearest city Tianjin (the third largest city in China) had also suffered from the earthquake. This tragedy was followed by the successive deaths of the Premier Zhou En-Lai and the Chairman Mao Ze-Dong in 1976, which left a political vacuum. Very fortunately, the political instability quickly ended in late 1976 as the result of purge of the 'Gang of Four' and their supporters.

The Fourth period (1978 onwards)

The 'Great Leap Outward' in the late 1978 and early 1979 marked the beginning of the period. It was also a drama of Chinese technology transfer. To boost the morale of the Chinese people, the new leadership under Hua Guo-Feng proclaimed commitment to the ambitious programme of "Four Modernisations program" in February 1978. The aim of the programme was to develop and modernise China's technological and defence capabilities to world super- power level by the year 2000.

The programme of "Four Modernisations" (Hua, 1978) was aimed to accomplish the following tasks: to build or complete 120 large-scale projects, including ten iron and steel complexes, nine non-ferrous metals complexes, eight coal mines, ten oil and gas fields, 30 power stations, six new trunk railways, and five key harbours. These projects would provide China with 14 'strong and fairly rationally located industrial bases'.

Some foreign economists estimated that the ambitious programme would need over US$ 70 billion. With apparently little thought about the overall costs of these projects or about how they were to be paid for, all provinces, government ministries, cities, and even big enterprises quickly submitted their own purchase plans. As a result, by the end of 1978, TECHIMPORT, the foreign trade corporation responsible for plant and technology purchases, had negotiated about US$ 40 billions worth of complete industrial plants and technologies.

Many scientific and economic delegations had been sent overseas to seek the state-of-the-art civilian and military technologies available. Every member country of the OECD group had been visited by many Chinese delegations. It was reported that an average of 140 Chinese commercial, technical and cultural delegations per month visited the United States in 1980. Another 'miracle' had been achieved for the speed of signing contracts. Within ten days time in December 1978, China rushed to sign contracts worth US$ 3 billion, which pushed the figure for the year to 7 billion US dollars. The figure was 2.5 times higher than that of the total US$ 2,778 million of the previous six years (1972-1977), and was 8,642 percent higher than that of 1977. Ironically, exactly 20 years after the 'Great Leap Forward', Chinese leaders coined yet another economic slogan- the 'Great Leap Outward'.

Since 1979 the policies and strategies of technology importing have undergone some big changes. First, the importing priority shifted from heavy industry related technologies to the light industry, agriculture and energy related technologies. For about thirty years before 1979, heavy industry had been on the top of China's investment list. It became clear even before the reassessment programme that the 'over-investment' in the heavy industries (compared with light industry, agriculture and other sectors) had created many bottlenecks to economic growth, of which low capability of transportation and the shortage in the supply of energy (including electricity, coal and oil) were the most acute. The inadequate investment in light industry and agriculture had in turn resulted in an insufficient market for heavy industry products.

Second, the approaches used for technology transfer had shifted from the previous whole-plants importing to key equipment importing. It is not surprising that with more than a decade of isolation and almost no technological exchange with the outside world, China was eagerly buying what they considered as advanced technologies without much comparison and selection. The door for foreign technology importing fully opened suddenly, many technologies that China had tried very hard to copy mainly through scientific literature for long time became available now. It was natural for inexperienced Chinese importers to buy everything in a whole package. Although whole plant importing was quite effective, it was too costly and often unnecessary because China was capable of manufacturing many equipment, especially the ancillary equipment for the imported technologies. As a result, imports of precision equipment increased nearly 200 percent from US$ 215 millions in 1979 to US$ 407 millions in 1981. The imports of electric machinery grew even more significantly from US$ 542 millions in 1979 to US$ 1,333 millions in 1981. The imports of machinery and equipment as a whole reached to US$ 3,843 millions in 1979 and US$ 5,407 millions in 1980.

The rapid expansion of exports greatly enhanced China's technology importing capability. The total Chinese foreign trade nearly quadrupled between 1976 to 1984, from US$ 13.44 billions in 1976 to US$ 51.77 billions in 1984. The value of imports increased by more than 400 percent during the same period from US$ 6.58 billions in 1976 to US$ 26.75 billions in 1984.

During the period, 'Nine Point Directives' of technology import policies were issued by the central government. They are summarised below.

1.Do not import any plants or equipment that can be produced domestically, if the quality of the domestic items is lacking, improve them.

2. In those fields where items have already been purchased from abroad, no further items should be acquired if they can be produced domestically.

3. Do not buy complete plants if they can be manufactured domestically, or if a sizeable percentage of the components is available within China.

4. When buying a specific set of equipment or machinery, the sourcing of components and other items should not be diversified if this will produce *incompatibility among the various elements.*

5. Foreign specialists should be employed when necessary to ensure successful assimilation of the imported technology.

6. Foreign consulting firms should be used to propose projects, as well as to assist with technical feasibility studies for particular projects.

7. Avoid duplication of purchases, improve communication among importers of technology and equipment.

8. Within China, teams of scientists, economists, and engineers should be set up to analyse proposals regarding the import of foreign technology and equipment.

9. Attempts must be made to standardise Chinese components so that missing, broken or inferior parts in imported plants and equipment can be replaced by domestic suppliers when necessary.

The 'Nine Point Directives' at least indicated that China was becoming more and more familiar with the practice of importing advanced technologies. It encouraged domestic firms to use foreign specialists and consulting firms when necessary to ensure successful assimilation of the imported technologies. It called on setting up multi- disciplinary teams consisting of scientists, economists and engineers to analyse and evaluate importing proposals. It also addressed the problem of standardisation facing Chinese industry. The new policy itself, nevertheless, showed that the process of technology transfer in China had moved one step towards the right direction. However, one very important, also a fundamental, factor was missing in the new policy. That was the principle of economic analysis. The 'Nine Point Directives' did not mention the criterion of cost-benefit evaluation. It is exactly this criterion which would eventually decide whether to accept or reject a foreign technology in question.

Many new channels for technology importing had been created since 1979, including foreign direct investment, joint venture, co-production, compensation trade, contract production... To attract more foreign investment and foreign technologies, four special economic zones had been formed in August 1984 in Shenzhen, Zhuhai, Shantou and Xiamen. Nearly 4 years later, in April 1988, 14 port cities, including Dalian, Qinhuangdao, Yantai, Qingdao, Lianyungang, Nantong, Shanghai, Ningbo, Wenzhou, Fuzhou, Tianjin, Guangzhou, Zhenjiang and Beihai, were designed as open cities. In January 1985, the Zhujiang River and Changjiang River deltas, and the triangular area of Xiamen, Zhangzhou and Quanzhou became open economic zones, and in April 1988, 140 additional coastal cities and counties, including some in the Shandong and Liaoning penisulars, were added to the list. Hainan island became a province and a special economic zone. This giant open belt along the coast covers 320,000 square kilometres (128,000 square miles), and encompasses 291 cities and counties with a population of nearly 200 millions.

Along with the opening of special economic zones and port cities, procedures for technology importing had been greatly simplified, with much power given to local authorities. For example, local authorities in Shanghai and Shenzhen had the rights to approve a foreign investment project up to 50 million US dollars. The corresponding figure for other big port cities, like Tianjin, Dalian, Ningbo, was 30 million US dollars. As a result, foreign technology imports accelerated.

Many petrochemical- and electronic-related technologies have been imported since 1985. Many world famous technology leaders in petrochemical, electronic and transportation areas were involved in the process of technology transfer. Du Pont Co., Shell, BP, Mitsubishi, BASF, CGE-Alsthom, Siemens, Hitachi, AT&T and NEC are just some examples. Moreover, more and more companies from HongKong, Taiwan, Singapore and Thialand began to invest in China in a considerable scale. South Korea has shown great interest in investing in China since 1980. Many giant Korean conglomerates have already invested more than 2,000 million US dollars in China. For example, Samsung Co. Ltd. invested US$ 60 millions in Beijing in July 1989 to build a refrigerator plant; Hyundai Motor Corporation and Kia Industrial Corporation formed a joint venture with Shandong Province to produce automobiles, microbuses and trucks in August 1988. Daewoo Electronics set up a joint venture (with a investment of US$ 12.6 millions) in Fuzhou to produce 300,000 refrigerators annually in June 1988. Goldstar Co. built a glass bulb plant in China to manufacture television picture tubes in May 1988. Samsung set up a joint venture to produce glass bulb. Kia Motors set up a wholly owned auto assembly plant to manufacture trucks, vans and cars in Shandong Province in May 1988.

4.2 The Effect of Technology Transfer on the Chinese Economy

Given the scarce data available, it is quite difficult to draw some correlation between technology transfer and economic performance in China, especially during the 1950s and 1960s. Some links between technology imports and industrial growth, however, can be set up. For example, the 156 key projects, which were mainly in steel-, electric power- and machinery-related industries and used imported Soviet technologies, in the 1950s had been mainly responsible for rapid industrial expansion in these sectors during the late 1950s and early 1960s. As a result, steel production rose at an average annual rate of 31.66 percent during 1949 to 1965, from 0.15 MT in 1949 to 1.35 MT in 1952, 5.35 MT in 1957 and 12.23 MT in 1965. The corresponding figures were 18.8 percent for electricity generation and 22.2 percent for cement production. The production of coal also rose fast, from 32 million tons in 1949 to 220 million tons in 1962. Although it is difficult to give a quantitative description of the efficiency of the technology transfer during the period, some major economic indicators, which did show that the Chinese economy grew quite fast at least before 1958, might indicate that the process of transfer and adoption during the period was fast and effective, although it is difficult to tell whether it was efficient.

For example, GNP at 1952 constant price rose from 59 billion in 1952 to 82 billion US dollars in 1957, with an average annual rate of 6.8 percent.

The importation of sixteen large-scale ammonia and urea plants in the 1970s helped to boost the production of chemical fertiliser in China significantly. The total production of nitrogenous fertiliser jumped from 3,812 thousand tons in 1976 to 5,509 thousand tones in 1977 and further to 7,639 tones in 1978, with an average annual increase rate of 41.5 percent.

The increase in the productivity of major farm crops were certainly closely related to the increase in the use of chemical fertiliser in Chinese agriculture. China used 64 Kg chemical fertiliser per hectare of arable land in 1977. This was more than double that of India (25.3Kg) in the same year, but was much lower than that of South Korea (329.9 Kg) and Japan (428.1 Kg). However, the use of chemical fertiliser per hectare of arable land ir China jumped to 109 Kg in 1978 and 128 Kg in 1979, while the corresponding figure was less than 9 Kg in 1965. The average unit area yield (Kg/mu) of rice from 1965 to 1979 rose 44.4 percent (from 196 to 283 kg/mu), 110.3 percent for wheat (from 68 to 143 Kg/mu) and 97 percent for corn (from 101 to 199 Kg/mu).

However, it is difficult to single out the contribution which had been made by the increase in the use of chemical fertiliser, because many other factors had also been responsible for the production increase. For example, the rise of agricultural production and land productivity in 1978 and 1979 had also reflected the good weather and improved economic incentives in the period. The growth in yields per cropped hectare in China, however, has been clearly higher than in many developing countries. This, and increased stability of yields in the face of weather changes, has been obtained by refinement of traditional labour-intensive cultivation techniques, by extensive irrigation (45 percent of arable land in China in 1979 was irrigated), flood control and land improvement, by improvement of seed varieties and more recently, especially since late 1970s, by increased use of machinery and also chemical fertiliser.

The total spending on technology purchase abroad, including equipment purchase, has well passed the 100,000 million US dollars mark since 1980. This undoubtly overwhelmed the total investment in technology transfer during the first thirty years (1949-1979). The advanced foreign technologies (which were imported and accumulated quickly) have definitely played a very important role in the development of the Chinese economy over the last decade or so. First, many technologies have been dedicated to the development of export industry, which brought a total 249.7 percent increase of China's foreign trade in nine years from US$ 29,170 millions in 1979 to US$ 102,000 millions in 1988 (State Statistical Bureau, 1990). Second, these technologies at least partially transformed the industrial structure and upgraded the production level considerably, and boosted the production of many major industrial products. For example, coal production increased from 620 MMT in 1980 to 928 MMT in 1987 and 970 MMT in 1988; crude oil increased from 105.9 MMT in 1980 to 134 MMT in 1987 and 137 MMT in 1988; steel production increased from 37 MMT in 1980 to 56 MMT in 1987 and 59.2 MMT in 1988; electricity increased from 300.6 billion Kwh in 1980 to 496 billion Kwh in 1987; cement increased from 73.9 million tons in 1980 to 180 million tons in 1988; chemical fertiliser increased from 12.3 MMT in 1980 to 16.7 MMT in 1987 and 17.7 MMT in 1988. However, the full effect of the technologies imported during the period on the Chinese economy can only be felt in the mid-1990s.

Efficiency improvement in the use of energy and raw materials

One increasingly important area in which the Chinese industry is strikingly inefficient is in its use of energy. Industry accounts for over 70 percent of total commercial energy use which on a per capita basis was nearly four times the average for other low-income countries in 1960s and 1970s. Energy consumption per dollar of GDP in China in the same period was about three times the average both for other developing countries and for industrialised market economies. The low level of efficiency in Chinese industry was partly the result of technological isolation. But it was also a reflection of weakness in planning and in economic system-in particular, inadequate contact between producers and users, and insufficient incentives for producers to use scarce resources economically or to introduce technical innovations.

Table 4-5 Major indicators of efficiency utilisation

Year	energy consumption per RMB 000' of total product of society (ton of standard coal equivalent andard coal equivalent	energy consumption per 10,000 of gross output value of industry and agriculture (ton of st-	energy consumption per RMB 10,000 of national income (ton of standard coal equivalent	total product of society product per ton of energy consumption (RMB)
1980	8.52	7.07	16.34	1,174
1981	8.03	6.66	15.36	1,245
1982	7.78	6.41	14.95	1,286
1983	7.44	6.13	14.36	1,344
1984	6.94	5.74	13.58	1,442
1985	6.45	5.35	13.14	1,551
1986	6.21	--	12.84	1,611
average of 1981-85	7.23	5.98	14.15	1,384

Notes: Figures on total product of society, gross output value of industry and agriculture and national income are in 1980 constant prices.

Source: State Statistical Bureau, China, 1989.

Substantial savings could be obtained at negligible cost by minor operational improvements of many exising technologies. Further savings, and substitution of coal

Table 4-6 Consumption of materials in some industries (1980=100)

Item	1980	1981	1985	1986	1987	1988
coal industry						
timber consumption in coal productions (cu.m/10,000 tons)	100	96.15	70.64	66.0	56.75	
explosive consumption in coal production (Kg/10,000 tons)	100	95.06	90.58	83.41	78.23	77.34
rolled steel consumption(ton/10,000 tons)	100	99.59	93.39	93.14	88.10	91.74
petroleum industry						
crude oil used in oil field (%)	100	93.90	92.68	94.15	100	103.6
loss of crude oil in oil field (%)	100	101.3	72.69	69.16	68.28	--
power industry						
standard coal consumption in power generation (gram/kwh)	100	98.55	96.37	96.37	96.37	96.13
standard coal consumption in power supply (gram/khw)	100	98.66	96.21	96.43	96.43	96.21
transmission loss (%)	100	100.6	91.60	91.27	94.96	91.60
metallurgical industry						
iron ore consumed in iron-smelting(kg/ton)	100	100.3	101.5	100.0	98.83	98.44
electricity consumption for ferro-silicon prod. (kwh/ton)	100	103.1	96.90	96.73	94.70	96.21
chemical industry						
coke and anthracite consumption for synthetic ammonia (kg/ton)	100	99.62	96.76	95.17		

Table 4-6 (continued)

electricity consumption for synthetic ammonia (kwh/ton)	100	100.3	96.11	98.40	87.44	
natural gas consumption for synthetic ammonia (mn.kcal/ton)	100	99.90	95.93	97.02	95.24	93.55
electricity consumption for synthetic ammonia (kwh/ton)	100	102.3	81.88	81.88	78.47	84.72
coke consumption for calcium carbide (kg/ton)	100	98.81	94.89	95.40	95.06	95.06
electricity consumption for calcium carbide (kwh/ton)	100	100.7	98.16	98.27	96.74	94.08
propylene consumption for polypropylene (kg/ton)	100	99.66	99.32	96.75	99.66	96.92
calcium carbide consumption for chloroprene rubber (kg/ton)	100	102.2	94.71	94.80	94.80	94.58
building materials ind.						
standard coal consumption in cement production (kg/ton)	100	100.5	97.38	95.93	93.61	92.49
electricity consumption for glass fibre (kwh/ton)	100	96.72	93.70	--		
textile industry						
standard coal consumption for viscose fibre						
short staple(kg/ton)	100	96.68	86.42	81.07	81.22	86.86
long staple (kg/ton)	100	108.4	89.25	79.42	79.34	83.32

for oil, could be achieved at moderate cost by limited equipment and technology improvements, including the replacement of many industrial boilers by updated and more efficient ones. Beyond that, major changes in some process are called for; and in certain industries (most notably metallurgy), it is both desirable and feasible to eliminate most small plants. These measures could very substantially reduce energy use per unit of industrial output, at a capital cost far less than that for achieving an equivalent increase in energy supply.

It was obvious that the technology transfer, adoption and diffusion in the late 1970s and early 1980s had improved the efficiency of energy utilisation in Chinese industrial sector, indeed the Chinese economy as a whole. The table 4-5 shows the improvements.

The saving in energy consumption per 10,000 RMB of national income between 1980 and 1986 was 21.4 percent. And the total savings in energy consumption, given the size of Chinese economy, were huge: 37.9 million tones in 1981, 17.3 million tons in 1982, 27.4 million tons in 1983, 40.5 million tons in 1984, 26 million tons in 1985 and 18.6 millions in 1986. However, with its energy consumption per dollar of GNP three times as high as other countries in the world in the late 1980s, the Chinese economy should be able to improve its energy efficiency considerably.

Besides the improvement in energy consumption, the imported technologies have also played a part in reducing material consumption in many industrial sectors. The following table shows the improvements in material consumption in some Chinese industries in the 1980s.

4.3 Major Problems of Technology Transfer in China

Market has never played any important role, or even a role at all. What technologies were needed, how much money should be spent, and when they should be spent, all these had been decided by the central government. Economic criterion had never been applied in the process of technology transfer. The prices of cost factors have never been taken into consideration to evaluate whether a technology is appropriate. It was quite often that the most advanced technology was most likely to be accepted as the most appropriate one.

Politics has strongly influenced the process and policies of technology transfer in China over the last decades. During the 'Cultural Revolution', the whole process of foreign technology importation had been brought to almost a halt by the political struggle. Once again in the late 1974, a massive technology transfer programme was derailed by a group of radical politicians and their supporters. China spent US$ 1,300 millions on foreign technology purchase in 1973, but only US$ 185 millions in 1974 and US$ 59 millions in 1975. The 'Great Leap Outward' in 1978 was an inevitable consequence of Chinese politics. After the purge of 'Gang of Four', the new leadership under Hua had promised to lessen the discontent of the mass of population whose living standard had declined or stagnated for more than a decade. But the ambitious character of the programme of modernisation made it more of a 'political joke'. From the economic point of view, it was naive. With 80 percent of the population in agriculture, mechanisation of agriculture would have the effect of displacing labour on a large scale. But would the Chinese economy be capable of creating so many employment opportunities to absorb the several hundred million rural labour force within a short period? With nearly two decades behind the advanced nations both economically and technologically, how could China catch up the U.S., Japan and Western Europe by the year 2000? Moreover, the notorious slogans of 'grasping revolution' and 'promoting production' were still often used in the Party's and government's publications, newspapers and televisions. Class struggle was still treated as a prerequisite to successful economic growth and scientific progress. In agriculture, Dazhai remained the model to emulate; and in industry, Daqing. All of these were quite consistent with the approaches used in Mao's time.

From what has been said, we can see that the first massive technology transfer in

PRC took place in 1950s. The strategies and emphases adopted by the policy-makers were obviously heavy industry and defence industry oriented. Although the whole process of adoption and assimilation was not slow, comparing with the 1960s and 1970s, many big projects had been delayed for several years mainly because the departing Soviet personnel had taken all blue prints, original designs and technological 'know-how' with them. The supply of additional equipment which was desperately needed to complete these projects had also been cut off.

The carefully planned and monitored technology importing in the early 1960s, although moderate in scale, at least amended the damage caused by the sudden Soviet withdrawal. Most giant projects had been completed both by the domestically made equipment and the newly imported machinery from the West. This helped the Chinese economy recover quickly. In 1965, the Chinese economy became stronger than before and ready for importing and absorbing more advanced foreign technologies. But unfortunately the Cultural Revolution, which started in 1966, dramatically changed the situation.

Generally speaking, the technologies used in most sectors of Chinese economy before the third period (1972-1977) had not been upgraded or advanced perceivably. During the whole second period, only a limited number of foreign technologies and equipment had been imported, mainly for completing the projects left by the Russians. Although a big effort had been made on copying and reverse- engineering of these imported technologies, no impressive technological advance had been achieved. By and large, most of technologies used by China in the early 1970s were of the very low level type. Despite the resumption of technology imports on a fairly large scale in the third period (1972-1977), the level of Chinese technology continues to lag behind that in most advanced and some less developed countries. According to Ma (1982), even into late 1970s, only 20 percent of China's present industrial technology was of 1960s and 1970s vintage while another 20-25 percent was backward but can still serve present needs. Of the remaining 55-60 percent, 35 percent urgently needed to be renovated or scrapped (because of excessive energy consumption, outmoded products, etc.) and 20-25 percent to be gradually scrapped. There is also abundant evidence from individual sectors of widespread use of old and inefficient equipment or production of low quality products. It is fair to say that Chinese people did relatively well in mastering and adopting Soviet technologies to Chinese conditions, although it took longer than it should under the normal conditions. But in the fields of innovating and creating new technologies, they obviously failed. Many examples can be cited here. For example, Chinese industries were still massively producing energy- and material- inefficient industrial boilers even in early 1980s. Another example was the production of 'Liberation' brand truck, which had been manufactured for more than thirty years based on the same 1950's model.

The economic system in China before mid-1980s severely restrained the country's ability to absorb the massive technology imports. The negative experiences from the third period had strongly indicated this. The delay of plant construction and inefficient operation was a major drag on the Chinese economy. Nearly two thirds of the imported plants had not either been completed on schedule or reached 'design capacity' within a reasonable time period (see 'JingJi GuanLi', April 15th 1981).

By the end of 1977, 11 of the 24 projects scheduled for completion by the end of the year were delayed for 12 months or more. The Sichuan Shangshou Vinyl Plant, for example, experienced a three year delay. The majority of the plants have frequently been operating under capacity. Of the 17 plants finished before 1978, 9 were operating at an acceptable energy efficiency/ output ratio of 90 percent, including 7 of the large chemical fertiliser plants. The other plants were all operating at a significantly low rates, including the Yanshan Petrochemical Plant (76 percent), the Ethylene Chloride Plant at the Beijing Second Chemical Industry (65 percent), and the Wuhan Iron and Steel Mill (50 percent). Four of the Synthetic Ammonia Plants (Guizhou, Guangzhou, Nanjing and Anqing) were also operating at the 50 percent level.

The return on investment for many projects was poor. In fact, only 25 percent of the projects have produced an acceptable rate of return since their completion. The Wuhan Iron and Steel Mill project was one of the typical problem-plagued plant. Furthermore, six of the thirteen chemical fertiliser plants imported during the 1970s were also plagued by operating problems. The plants at Hubei and Hunan, for example, were unable to startup at the projected time due to difficulties with the peripheral design equipment quality and management, resulting in a 3 billion Yuan loss in state revenue. The delay of raw material supply was another major reason for delaying the startup and operation. Shortage of energy, especially electricity, was another major reason responsible for the delay. In the case of Wuhan Iron and Steel Mill, this problem was very serious. Immediately after the completion of the Mill, not enough electricity could support its operation, even after cutting dramatically domestic supply in the whole region (including Wuhan City, with population about 4 millions). So the time of startup was rescheduled again and again. The emergency supply system later was built up and connected to the electricity supply network in another region, the operation finally began, but still on the very low capacity. To make the situation worse, some products of the mill were too advanced to be used by its many customers whose technology and equipment had not been improved and upgraded quickly enough. So the whole co- ordination of the different ministries and different regions had not been efficient and effective.

According to Chen (1981), only one third of major turnkey projects (more than thirty) undertaken in the 1970s met the three criteria of short construction periods, high utilisation rates after start of operation, and good operational results. But almost none of the complete plant projects met the construction schedule in the contracts: 11 were delayed for more than one year and some for three years. Of the 17 projects completed before 1978, only nine (comprising 32 percent of total foreign exchange costs) reached 90 percent of projected capacity by 1979 and six (absorbing more than half of total foreign exchange costs) reached less than 50 percent of capacity. About one-quarter of the projects achieved good economic results, defined as projected increases in profit and taxes. The main successes were fertiliser and chemical plants.

The principal problems encountered in other projects were availability of power, raw materials, or complementary domestic plant and equipment, as well as difficulties encountered in adapting the equipment to use domestic raw materials with different specifications.

Summaries and Conclusions

Same ideology, confrontation between the East and the West and economic embargo led by the United States induced China to side with the Soviet Union. It was naturally that the Soviet Union became the key supplier of technologies to China. During the first ten years of the People's Republic of China, first large-scale and comprehensive technology transfer programme took place, which consisted of 156 key projects mainly in the areas of iron and steel-making, coal, electricity-generating and machinery-manufacturing. Basically speaking, the programme was heavy-industry oriented. Some highly demanded light industries, as a result, were neglected. However, most industries covered by the programmes also deserved the promotion. It is, however, difficult to evaluate the efficiency of these projects, given the scarce data available. It is reasonable to say that the massive technology transfer programme did make great impact on the Chinese economy in general, and considerably enhanced China's technological capability in particularly. This can be seen from the rapid expansion of many Chinese industries. In many of these industries, China had very weak technological capability. And, in fact, some were new to China. In addition, approximately 25,000 Chinese had been sent to the Soviet Union for advanced education and technical training. This had made important contribution for the technology transfer and development in the late 1950s and afterwards. However, this also made China very much dependent on the Soviet Union both technically and politically and vulnerable for any sudden change of the relationship between the two countries.

During the first part of the second period (1960-1971), the massive technology transfer programme which started in the early 1950s almost came to a halt. Manmade and natural disasters in the late 1950s and early 1960s had significantly weaken the Chinese economy as well as China's technology import capability. Furthermore, the row between China and the Soviet Union and sudden withdraw of all Soviet assistances in the early 1960s cost China dearly. The Soviet Union did not only call back all their managerial and technical personnel, taking with them all know-how, designs and blue prints, but also stop supply of all key and accessory equipment of many projects. Under the circumstances, the Chinese managers, engineers and technicians had to assume full responsibility to complete the remaining projects and to develop indigenous technologies. Copying and reverse engineering became the main means of technology transfer and development in the period. Although foreign technology imports assumed again soon from Japan, U.K., France and some other western countries, the scale was quite moderate. Therefore the foreign technologies imported during the period did not make any significant impact on the Chinese economy. In addition, the Cultural Revolution, which started in 1966, quickly brought all foreign technology acquisition to a standstill.

The scale of technology transfer in the 1972-1977 period was very large scale. Most technologies imported during the period fell into the industrial categories which were economically desirably. Many projects were well targeted and had strong economic rationality. For example, the imports of eight ammonia plants from pullman Kellogy in the United States and eight Urea plants from its European subsidiaries could indicate the change. The striking character of the technology transfer during this period was that the industries which can satisfy consumer's needs and improve people's living standard were given top priority. During the process of technology transfer, more and more foreign engineers and technicians were invited to China to give guidance and supervision. Unfortunately, the massive technology transfer programme was again interrupted in the late 1974.

The 'Great Leap Outward' (GLO), a drama of technology transfer in the late 1978, marked the beginning of the fourth period. The ambitious programme, which included

120 large-scale projects and was estimated to cost over US$ 70 billions, failed to provide economic rationality. As a result, China had already negotiated about US$ 40 billions worth of complete industrial plants and technologies by the end of the 1978. It proved soon that such a 'shopping spree' was far beyond China's financial capability. Thus a reassessment programme was adopted in 1979.

After about two years' setback from the GLO, technology transfer in China began to accelerate. Since 1980, China has spent over US$ 100,000 millions on foreign technology purchase. This undoubtly overwhelms the total investment in technology transfer during the first thirty years (1949-1979). Moreover, the fourth period also saw the reinforcement of priority shift from heavy industry related technologies to the light industry, agriculture and energy related technologies. Key equipment importing also started to replace whole-plants importing quickly. The Nine Point Directions listed earlier in the Chapter also showed that process of technology transfer in China had moved one step towards the right direction. The new policy encouraged domestic firms to use foreign specialists and consulting firms when necessary to ensure successful assimilation of the imported technologies. It also called on setting up multi-disciplinary teams consisting of scientists, economists and engineers for technology importing. Some new channels for technology transfer had also been created since the late 1970s economic reform, including foreign direct investment, joint venture, co-production, compensation trade and contract production.

The impact of imported technologies on the Chinese economy can be seen not only from the rapid growth of the agriculture and many industries and dramatic expansion of the export but also from the efficiency improvement in the use of energy and raw materials. However, the full potential of these imported technologies can only be measured in the late 1990s and beyond, given the overwhelming significance of imported technologies in the fourth period. Given the huge size of the Chinese economy, the total savings in energy and raw material consumption were very impressive. By international standard, the levels of both energy and raw material consumption in China are still quite high. It should, therefore, be possible for the country to continue to improve its efficiency regarding to these two important areas considerably in the future.

Insignificant or even absence of market role has been the most single important factor for the low efficiency of technology transfer in China over the past decades. Political upheavals and ideological struggles have, in addition, created many more problems for smooth and efficient technology transfer. The economic reform that started in the late 1970s has, to some extent, helped to accelerate the process and improve the efficiency of technology transfer, diffusion and innovation in China. It is, however, far from sufficient to create a competitive economic environment to improve the efficiency of technology transfer, diffusion and innovation. It is, therefore, very necessary that a fundamental reform, including price reform, should be carried through first as quickly as possible before any significant improvement can ever be achieved.

Chapter Five

Comparative Analysis of Factors Behind the Experience of Technical Progress and Economic Growth in Japan and South Korea

5.1 Introduction

The post-war period witnessed rapid economic growth and technological advance both in Japan and South Korea. In the 1950s, Japanese producers were internationally competitive in making toys, clothing, shoes and many other labour-intensive products. During the 1960s, The Japanese emerged with a competitive edge in many capital-intensive and skill-intensive industries, such as consumer electronics, steel, shipbuilding and automobiles. After the mid-1970s, more and more Japanese producers began to show competitiveness in the so-called 'high-tech' industries.

South Korea took after Japan in its pursuit of economic growth. Korean producers became quite competitive in the world textile and clothing market in the late 1960s. In the late 1970s, Korea had already become one of the most efficient steel producers in the world. In the early 1980s, Korea became one of the most competitive shipbuilders, and also the second largest shipbuilder in the world. Since the 1980s, Korean car makers have become more and more competitive in the world market, particularly in the US, the Middle East and certain developing countries. Consumer electronics, such as television, video recorder, Hi-Fi systems, became Korea's biggest export earners in the 1980s. More recently, some high-tech industries, especially electronic- and computer- related industries, have started to expand rapidly. Japan and South Korea seem to have experienced a broadly similar growth pattern, although significantly different in time and scale. Japan has always been in the lead and it has already become an international technological leader in many industrial areas. Korea has on the other hand been an imitator and a follower.

There are many factors accounting for the rapid technological advances- from labour-intensive to capital- intensive, then to technology-intensive-both in Japan and South Korea. Among these are: structural difference and environment of a nation's economy, deliberate and full exploration of scale economies; firm commitment to economic growth by both governments; rapid and effective formulation and implementation of appropriate economic policies during the different periods; competent entrepreneurs and bureaucrats; high level of education and skills of labour force; outward-looking economic development strategy; historical and cultural factors; close and effective co-operation between business and government, and between management and employees; foreign aid and favourable economic environment for technology transfer.

Whether a country can achieve successful technology transfer will depend on many inter-related factors, including economic, political, demographic and cultural. To analyse these factors more comprehensively, the present chapter is divided into following sections: structural difference and environment of a nation's economy; government's firm commitment to the economic growth; changes of main economic policies and technology transfer; exploiting economies of scale and improving economic efficiency; financial assistance and economic discipline; cultural factors; foreign aid and favourable economic environment.

5.2 Structural and Socio-economic Environment Context of the Japanese and Korean Economies

A nation's competitiveness is certainly different from the competitiveness of the micro-economic type, which refers to the capacity of firms to compete in terms of costs and prices and increase their profits and growth prospect. National competitiveness refers to competitiveness at macro level and is something more than the collective or 'average' competitiveness of its firms. It may be defined as the degree to which, under open market conditions, a country can produce goods and services that meet the test of foreign competition while simultaneously maintaining and expanding domestic real income.

Why, it may be asked, have the textile and clothing, steel, shipbuilding, automobile and electronics industries, become very successful both in Japan and South Korea but not in most other developing countries? Why have similar policies or development strategies, which proved to be very effective both by Japan and South Korea, turned out to be ineffective elsewhere? Why has government financial assistance, which has been used as strong leverage or mechanism for imposing economic discipline and raising performance standards in South Korea been counterproductive in many other developing countries?

The successful adaptation, modification and diffusion of foreign technologies and the competitiveness and rapid expansion of Japanese and Korean industries have depended not only on the large number of their brilliant industrial leaders and corporation managers but also- probably more crucially- on the structural difference and entire environment of their national economies. The structure of capital markets, the role of banks in the long-term funding of technology transfer and development, the supplier/subcontractors system and the close relationship between manufacturing firms and financial institutions constitute the most important elements of structural difference between the Japanese and Korean economies and others. Moreover, high propensity to invest, high educational attainment and strong mutual understanding and co-operation between the state and the business community and between management and labour force, have together with the above structural elements, helped to create a unique national environment under which successful technology transfer and rapid economic growth could take place in each country. The structure and the environment of a nation's economy appear to exert a strong influence on firms' performance. It is widely accepted that the competitive performance of firms and industries in a country reflect not only successful management practice by entrepreneurs or corporate executives but also the prevalence of a favourable environment.

Over the last decade or so, there has been a growing feeling among many governments', industrial and even financial circles that investors' thirst for the highest possible short-term returns may be unfavourable to the long-term expansion of industrial enterprises. When investors demand high returns in the short term, they pay more attention to increases in the prices of their shares on the market than to the actual long-term value of their capital to the firms using it. It is widely felt that the cost of capital may be less important than the nature of the institutions and the arrangements that influence its supply. Both Japanese and Korean firms have for a long time raised capital mainly from financial institutions such as banks and marginally from open-market sales of securities. Equity capital accounts for more than 60 percent of total company assets in the United States and Canada, 50 percent in the U.K., 40 percent in Germany, more than 30 percent in France and less than 20 percent in Japan. Banks and insurance companies provide long-term finance for Japanese industrial firms in ways that they do not in the United states. Typically, they own equity and are represented on the board of directors of the companies to which they lend. Korean firms have also adopted an approach similar to that of the Japanese. Financial institutions' stock holdings appear to have contributed in part to the development of long-term strategy of business investment and innovations by productive firms with high R&D orientation. The main bank system has substantiated the promotion of such long-term strategy of innovative business investment and R&D expenditure. The main bank monitors the borrower's corporate performance on a basis of long-term relationship and takes an active strategic role in financing the borrower's innovation through internal information exchange, and performs as last resort lender in the case of the borrower's extreme financial difficulties. (see Yoshimoto, 1990.).

In contrast, a large and growing share of the capital of the firms in the west, especially in the U.S. is owned through the public stock market by mutual funds and pension funds. However, most fund managers have no long- term loyalty to the companies in which they invest, and they have no representation on their boards. Although some fund managers invest for the long term, most turn over their stock holdings rapidly in an effort to maximise the current value of their investment portfolio, since this is the main criterion against which their own performance is judged (see Dertouzos and Solow, 1989). Most firms in the west, therefore, respond to this financial environment by maximising their short-term profits in the belief that the market would penalise them for taking the long view. The wave after wave of take- overs and leveraged buy-outs, many of them hostile, has certainly contributed to the creation of a very strong focus on short term returns by corporations working in unsheltered financial environments in US and many other western economies. However, in Japan, take overs are very rare, because any such attempts would be discouraged and blocked both by the government and financial institutions. Consequently Japanese and Korean firms have had the highest leveraged ratio in the world with most of the leading companies far exceeding the level which would be considered too high and inappropriate for investment in the US and the U.K.

Investment behaviour in Japan, and to some extent in South Korea, has been influenced by the strong belief that management and employees would make all effort to ensure the firm's long-term success. Life time employment and seniority wage system have played a very important part here. For example, many Japanese investors tend to be much more patient for reaping the benefits of long-term growth. They do care about the short-term fluctuations of the profits and dividends. However, they put much weight on the long-term growth and prosperity of the firm in which they have invested.

The development and widespread application of supplier/ subcontractors networks is another source of Japanese and Korean competitiveness. Such a system has been proved to be very useful and effective in ensuring the rapid diffusion of technology from leading manufacturing firms to their subcontractors. Subcontracting is one of the distinctive characteristics of Japan's industrial organisation. Such a system has also been transplanted into South Korea and Taiwan. As early as in 1960, some 60 percent of all small companies were partners in some kind of subcontract relationship with a large company, while 88 percent of large companies had some of their parts manufactured by these companies (see Small and Medium Enterprises Agency, Japan, 1976).

Such a supplier/subcontractor system enables big companies to exploit economies of scale by concentrating on manufacturing the key parts and getting assessories and periphal parts from their subcontractors. Big companies can help their subcontractors to improve production efficiency, raise equality and productivity through training in inspection standards and tight quality control and the organisation of just-in-time inventory management systems. Over the last decades, large companies in Japan, and to some extent in South Korea, have not only expanded their demand for supplies from their subcontractors but have also voluntarily and enthusiastically transferred new technologies and management methods to them.

The competitiveness of the economy as a whole certainly depends on the competitiveness of individual firms. But the competitiveness of manufacturing firms depends crucially on the performance of key infrastructure services: transport and delivery systems and telecommunication systems, the role played by business service in helping to raise the standards of management practice in manufacturing firms (in areas such as finance, accounting, corporate organisation, use of IT, etc.). Many firms in western countries stress arm's length market relationships and offer fairly standardised packages to user firms, while Japanese firms adopt a 'customer-specific' approach. The special 'downstream' relationship between the manufacturing firms and wholesale and retail trading firms in Japan has played an important role in Japanese competitiveness. It offers manufacturing firms durable, trustworthy and firm- specific relationships based on reciprocity and exchange of information.

The strong mutual trust, understanding and co-operation between government and business, and between management and labour force is another important factor behind Japanese and Korean competitiveness. One should never underestimate the huge impact of such mutual trust, understanding and co-operation on a nation's economic growth when they are recognised and valued by the people in general and by the firms in particular in the nation as representing a specific source of increasing return. This is very important for building a strong national consensus for economic development. The different investment behaviour, strong mutual trust and co-operation have been influenced or shaped by these two countries' cultures, which will be fully explored in another section in this chapter.

The high level of educational attainment by their people in general and by their government officials and business elite in particular is another factor which has contributed to Japanese and Korean competitiveness. Education has always been one of the most important investment sectors and on the top of government expenditure agenda both in Japan and South Korea. Both Japan and South Korea achieved universal secondary education many years ago. The ratio of their age group entering tertiary education has been among the highest in the world, probably just behind that of the United States. The education level of Korean labour force in the early 1970s has not been matched even today by many developing countries. It is commonly believed that education can spur the process of industrialisation by imparting skills, improving health and allowing more women to enter the labour force. Investment in education and other physical assets should go hand in hand. Both Japan and south Korea have paid great attention to technical education over the past decades. This can be seen from the high ratio of enrolment in technical subjects, particularly electric and electronic engineering in both countries. In fact, Japan has produced four times as many graduates in electrical and electronic engineering as the United States on per capita basis over the past two decades. This has certainly contributed to the strength and growing competitiveness of Japanese electronics industry.

Business leaders in South Korea have been extraordinarily well educated. Two national surveys (in 1970 and 1972) revealed that none of the entrepreneurs (190 leading businessmen) was without education-just 3.1 percent of them had primary education, but 27.8 percent of them had completed secondary education, 60.8 percent of them had graduated from college and junior college and, even more remarkably, 8.3 percent of them had attended post graduate education. In the category of higher civil servants, none of them (total of 1,564 people) was without formal education, 5 percent had primary education, 32.3 percent had secondary education, 59.1 percent had college or junior college education, and 3.6 percent had post graduate education. In the category of chaebol leaders (45 people), none was without formal education, 8.9 percent had primary education, 40 percent had secondary education, 37.8 percent had college or junior college education and 13.3 percent had post graduate education. In the category of managers of public company, the results were even more impressive. None of the managers (357 people) was without formal education or primary education, only 15.8 percent had secondary education, but 84.2 percent had college, junior college or post graduate education. (see Economic Planning Board, South Korea, 1970; and Hoon, 1972.). The figures above show that the education attainment of Korean entrepreneurs and civil servants was very high. In addition, the surveys covered just the first generation of the Korean entrepreneurs and civil servants, the second and third generations are even better educated.

5.3 Government's Firm Commitment to the Economic Growth

Government commitment to the economic growth is one of the most important prerequisites for the successful technology transfer and development in a developing country.

Both Japanese and Korean governments have demonstrated their firm commitment to the technology transfer and economic growth. Technology transfer and development has always been given top priority by policy-makers in both countries. Post-war Japanese government has continuously and very vigorously pursued economic growth policy. The Japanese economy benefited greatly from a long period of political stability. The Liberal and Democratic Party dominated the government for more than 40 years. This in turn produced policy consistency. The consensus and commitment to economic growth by government and business laid down strong basis for harmonious co-operation between politicians and entrepreneurs both in Japan and South Korea.

Since early 1960s, the Korean government had, under the leadership of Park, played an increasingly important role in promoting economic growth. Park was not a democratic ruler and Korea was not a democratic country. However, the political stability and government's firm commitment to economic growth helped to create a favourable environment for technology transfer and its effective utilisation. Economics taking priority over politics was the major character of the Korean government under Park. Park's obsession and dedication to economic development and growth can be seen from his following words:'In order to ensure efforts to improve the living conditions of people in Asia, even undemocratic emergency measures may be necessary... it is also an undeniable fact that the people in Asia today fear starvation and poverty more than that the oppressive duties thrust upon them by totalitarianism... in other words, the Asian people want to obtain economic equality and build a more equitable political machinery afterward... The gem without lustre called democracy was meaningless to people suffering from starvation and despair.' Like Park in South Korea, many political leaders in Japan have also dedicated themselves to Japanese economic development and growth. Among them was former Japanese prime minister Ikeda Hayato. Under his strong leadership, Japan had successfully fulfilled 'the Income-Doubling Plan' within the decade of 1960s. Ikeda Hayato was so enthusiastic and obsessed to his Income-Dubling Plan that he took every opportunity to pursue an aggressive policy towards economic growth, even abroad. Many people in the west dubbed him as a 'transistor radio salesman'.

Firm commitment to economic growth is certainly one of the big differences between these two East Asian governments and many other governments in the developing world where, quite often, fighting between different religious, racial, political, or tribal groups in many developing countries dominates the national scene.

5.4 Major Economic Policies and Technology Transfer Implications

The main strength of the Japanese policies lies not in any particular instrument or set of instruments, but rather in the way in which these various instruments were made to complement with each other, and, more importantly, in the way in which they have been effectively implemented and co-ordinated.

Government policies in Japan have been designed to promote private sectors' confidence in general, and more specifically in targeted sectors. This has led to the high level of investment and growth. Government industrial development plans have been implemented mainly through taxation, loan and subsidy policies, although administrative measures have been often used. Moreover, the monetary and credit policies designed by the Bank of Japan have also had very strong effect of 'window' guidance.

The tax system in Japan has made a great contribution to economic growth by encouraging savings and investment. During the first stage of post-war development, the taxation policies were deliberately biased in favour of basic manufacturing industries. Taxation policies have been favourable to investment in high-tech areas since mid-1970s. This pro-investment environment was created mainly through the use of broad-based measures. However, some specific measures directed at particular industries or a group of firms have also been important. The overall tax burden of the nation has been kept very low, approximately 20 percent of national income, which provided the opportunity for high level of private saving and investment.

Certain forms of income have been exempt from taxation since the 1950 reform. Among them, two are particularly important for promoting savings and investment.

First, interest received on 'small-size ' savings accounts and certain accounts in the postal savings system are exempt from taxation. This has provided incentive to save. Through this way, the government has been able to mobilise a huge amount of funds for investment in the targeted sectors. Second, capital gains accrued from the sale of shares or other kinds of securities are also exempt from taxation. This helps make the capital gains more attractive to shareholders than dividends, which are taxed either at the corporate or individual level.

In the corporate tax area, several features surely deserve special attention. The effort has been made to minimise double taxation of corporate income. Moreover, as also noted above, most capital gains income received by individuals is untaxed, while dividend income received by individual is taxed. This obviously encouraged people to reinvest their earnings rather than taking dividend payments.

Certain measures within the corporate tax system are used to target specific industrial objectives. These can be divided into several categories: added depreciation, tax- free reserve funds and tax credits. Although many other measures have also been used, they are not used as widely as these three. The general appreciation rules used in Japan are similar to that of most other developed countries. The difference is that Japan uses them more flexibly and more target-orientedly. Furthermore, the Special Taxation Measures Law permits a wide range of special types of depreciation to be used. Moreover, many special appreciation measures have dedicated to 'designated plant and equipment'. This gives the bureaucrats the power for manipulation. The pattern of special depreciation measures is biased towards manufacturing in general by stimulating markets for types of good for which the government would like to see in greater domestic production.

Another policy measure frequently used for purpose of industrial growth is allowance of a special tax-free reserve. Many kinds of available tax-free reserves are very valuable to the Japanese corporations. For example, the tax-free reserve for bad debts can provide the corporations with cash before the expense or loss is actually incurred. Among the special reserves, two deserve mention here. First, the reserve for losses caused by the repurchase of electronic computers; second, a reserve to be used as a the guarantee for domestically produced computer programmes. The former was designed to promote the use of domestically produced computers, which permitted the computer manufacturing and sale corporations to deduct a certain fraction of revenue growth as an expense. Because most computer sales are based on lease arrangements, a company forced to buy back a computer ahead of schedule can realise a loss. With the reserve provisions, however, such a loss can be debited against the reserve fund and thereby its effects mitigated. The latter was mainly aimed to speed up the domestic computer software industry. These special tax measures and incentives stimulated R&D expenditures and activities in Japan.

The Japanese tax system has thus played a very active role in promoting savings and investment. It did not only help to create a favourable economic environment for massive foreign technology transfer but also provided the required amount of financial resources. The high rate of savings and investment in Japan has been achieved by avoiding double taxation of corporation income, by excluding interest income for smaller savers from taxation, by favouring capital gains over dividend income, and by keeping the average tax burden low. Many special tax measures made the manufacturing sector top priority area receiving the lion's share of investment. The investment has been focused on the high technology areas since the mid-1970s.

From time to time, MITI published the lists of desirable manufacturing technologies and recommended domestic industries to acquire them. The table 5-1 was one of them published by the Government of Japan in 1950.

Moreover, in order to set a target for the technological development, MITI and other leading economic agencies of the Japanese government scanned United States manufacturing industries thoroughly and selected some as 'desirable' targets for Japanese industries. In order to help the domestic industries to see what sorts of technological innovations were being commercially utilised in the U.S. and what sorts

Table 5-1 The manufacturing technologies recommended in 1950 as desirable for Japanese to acquire

Industry	
Textiles:	Acetate flake and acetate fibres, other synthetic fibres.
Chemicals:	Granulation of calcium cyanamide, calcium phosphate, synthetic phenol, vinyl chloride, melamin resins, silicon resins, pigments, furnace black.
Petroleum products:	Lubricants by solvent refining method, catalytic cracking, cracked olefin gas, lubricant additives.
Ceramics:	Furnace bed materials.
Machinery:	Continuous welded pipe drawing, continuous wire drawing, continuous spinning machinery, gyrocompass for marine use, dynamic pressure log for marine use, welding of ship's hull.
Electric equipment:	I-50 type integrating wall hour meters, demand meters, monopole type mercury rectifiers, plastic insulated wires and cables, power and telecommunication cables, frequency modulation system of radio communication, hyperbolic marine radio navigation system, microwave vacuum tubes, G. T. tubes and M. T. tubes, X-ray tubes of revolving anode type.
Mining equipment:	Coal preparation.
Drugs:	Streptomycin, chloromycetin, aureomycin.
Metal products:	Soaking pit, reheating furnace, and annealing furnace for steel.

Source: First Announcement of Desirable Technologies, Ministry of International Trade and Industry, 1950.

of scientific and technological capabilities were needed, MITI made available many kinds of industrial reports on the United States to the Japanese firms.

It is believed that the special emphasis of the industrial policies both in Japan and South Korea has been on establishing internationally cost-competitive industries after a period of infant industry promotion. mergers among small firms in the same industrial sector has been encouraged and promoted in order to obtain necessary economies of scale of production. More importantly, the subsidies have been particularly used to lower prices and widen the domestic market.

Moreover, the Japanese government indulged in such time- tested support to industry in the form of direct subsidies, restriction of manufactured goods, tax reliefs and procurement policies in railways, telephones and telegraphs. At the early stage of post-war economic development, such key industries as public utilities, iron and steel, shipbuilding and coal were extensively subsidised by the government. Later, government shifted its attention to new industries such as motor vehicles, machine tools, synthetic fibres and plastics and electronics.

It seems that the change in major economic policies in the 1960s helped to release Korea's growth potential. There are many similarities between South Korea in the 1960s and China in the 1980s. It would, therefore, very useful to analyse these policy changes in South Korea in detail.

It is true that the direct effect of these policy changes on technology transfer and technological advance is difficult to be directly measured. However, some intermediate variable, such as saving, investment and export, can be used as a basis for determining the empirical relationship. Before the early 1960s, South Korea had experienced chronic inflationary problems fed by large annual government budget deficits, overvalued exchange rate with stringent controls on imports and capital movements, a weak financial system whose potential role was severely limited by government- controlled interest rates, and generally inefficient government enterprises that generated little savings.

The new government under Park raised the interest rate on time deposits of over one year from 10 percent to 15 percent in July 1961, and the rates on shorter-term deposits by one-half of one per cent. As a result, the growth rate of money supply had been reduced to 12 percent from the average 38 percent annually between 1954 and 1961. (see Finance Ministry, South Korea, 1972.)

The decision in May 1963 to adopt a new budget that curtained expenditures and increase revenues enough to almost balance the cash budget did not reflect any slackening in efforts to increase investment and achieve more rapid growth.

The search for increased saving to finance investment has been a fundamental characteristic of Korean fiscal policy from May 1963, and indeed of all major economic policy decisions thereafter. While exchange rate reform was intended primarily to deal with balance of payments problems, the decision to devalue in 1964 was taken with full awareness of the very substantial benefits it would have for the government budget and saving.

Consolidated government saving had increased steadily each year from a negative (dissaving) rate equal to minus 1.4 percent of GNP in 1962 to a positive 7.1 percent of GNP in 1970. Consolidated government revenues, rose by 215 percent in constant prices between 1962 and 1970, while current expenditures rose only 75 percent. As a consequence, growth of government savings accounted for 44 percent of the increase in national saving between 1962 and 1970 and in 1970 amounted for more than 40 percent of total national savings.

Another important feature was the nature of government expenditure in South Korea. More than 70 percent of annual capital expenditures of the central government and those major local governments had been allocated to economic production services (primarily agriculture, manufacturing, power, transport and communication) through the 1960s. This figure would vary annually from 80 percent to 95 percent if roads, water and sewage were added. Furthermore, education had consistently claimed slightly over 20 percent of total government expenditures. Roughly one-third of annual government savings had been transferred to the private sector via loans to industrial and agricultural financial institutions.

The dramatic increase in the real interest rate had been the driving force behind the rapid growth of time and savings deposits, which, at the constant-price value, rose nearly 50 percent in the final three months of 1965, by 110 percent in 1966, and by 80 percent and 100 percent in each of the next two years. The average rate of domestic saving rose from 4.3 percent of GNP in 1964 to 15.9 percent in 1968 and 17.1 percent in 1970. (See Finance Ministry, South Korea, 1972.)

Higher interest rates caused an upward investment on the saving function as people desired to save a larger share of their incomes. This was reflected in the very sharp increases in average saving rates in 1965 and 1966. Saving also grew in response to the growth income induced by higher levels of saving and investment.

The exchange rate reform was mainly responsible for the rapid growth of Korea's exports from US$ 55 millions in 1962 to US$ 835 millions in 1970 and US$ 1.6 billions in 1972. About 90 percent of Korea's export during the 1953- 59 period were agricultural and primary products, such as fish, seaweed and seaweed products, raw silk, tungsten and iron ores, and ginseng. The overvaluation of won cost Korea much of its limited export market and resulted in unrealistically low prices for imported goods. On May 3, 1964 the government introduced the unified floating-rate system in which the minimum exchange rate was 255 won per dollar, compared with a previous official rate of 130 won per dollar and a current market price for export dollars of at least 200 won. The 1964 devaluation decision has become the symbol of Korea's export-oriented growth strategy.

It is very obvious that these major policy changes led to annual GDP growth of 12 percent between 1965- 1970, compared with about 3 percent during the 1958 to 1962. The rapid increases in saving, investment and export had certainly had very significant effect on technology transfer and development. The dramatic reduction in government deficit, increase in real interest rate and the devaluation of Korean won helped to lower people's expectation of inflation and finally bring it under control. This subsequently made productive investment relatively more attractive, compared with real estate speculation and investment in inventory. The rapid growth stimulated by initial increases in saving and investment certainly increased profit rates and expectations of profits, thus further encouraging entrepreneurs to save and reinvest and to borrow additional funds for investment purposes. The increase in investment confidence is certainly one of the preconditions for rapid technology transfer and advance to take place. The growth of national saving and exports had provided the firms with necessary financial resources to embark on capital investment projects and import foreign technologies. Value-added in exports increased from 2.6 percent of GDP at current factor costs in 1963 to 6.4 percent in 1968. In the two years between 1966 and 1968, the increase of value added in exports accounted for an impressive 45 percent of the increase in GDP. Export industries had not only been the key generator of foreign exchange, but also the major recipient of foreign technologies.

5.5 Government Assistance and Economic Discipline

Governments both in Japan and South Korea have provided consistent, effective and comprehensive support to their domestic firms in the forms of preferential credit, tax allowance, government purchase and home market protection. Many of these measures have also been widely used by governments in the developing world. However, in Japan and South Korea, unlike in most developing countries, most firms have turned out to be very competitive, not only domestically but also internationally in spite of the policy of subsidies. What, it may be asked here, has made subsidies work in Japan and South Korea, while in most developing countries it has often turned out to be ineffective at best and gross wastage of resources at worst?

There are certainly many factors which together have made subsidies work quite well both in Japan and South Korea. However, the single most important factor might be the exercise of economic discipline in Japan and South Korea. Assistance and support in these countries were performance related. This is very much unlike the experience in many developing countries where government assistance is often given in return for political favour or bribery.

Table 5-2 Japan Development Bank loans for development of technology (in billion of Yen)

	FY1977	FY1978	FY1979	FY1980
New loans	Y71.2	Y129.0	Y108.5	Y96.4
Development of electronic computers	38.2	55.3	47.1	55.4
Domestically-manufactured	35.5	53.5	45.0	54.0
Data processing systems	2.3	1.6	1.7	0.8
Use of high technology in certain electronic and machinery industries	8.3	7.8	10.2	14.5
Electronic industry	3.8	2.1	7.0	12.0
Machinery industry	4.5	5.7	3.2	2.5
Development of domestic technology	24.7	65.9	51.2	26.5
New technology	20.4	57.4	40.9	22.6
Heavy machinery	3.4	4.5	9.1	3.6

Source: Japan Development Bank, Facts and Figures about the Japan Development Bank (1981), p.26.

Loans constitute another main mechanism of government intervention in Japan. Through this, the government can effectively express its desire and 'vision' for the future direction as well as the pace of economic development. The Japan Development Bank, The Export- Import Bank, and other government institutions have been mainly responsible for making loans to targeted sectors. Although the total amount of the government loans has been relatively small in comparison with the private investment spending, its 'window' guide effect has been overwhelming. The government lending to an industrial sector or a project has been regarded by many private investors as an indirect guarantee. The following table presents the scale and areas of JDB's lending for development of technology during 1977-1980.

In Japan, subsidies are either in the form of grants, which in turn take the form of conditional loans, or government contracted work, which take the form of consignment payments. Conditional loans tend to have low, and in some cases, no interest rates. Repayment depends on the success of the project--if no successful technologies result from the research, then loans tend to not have to be repaid. If the research is successful, then a five-year grace period is allowed before the loan has to be repaid. Typically, these loans represent about half the total expenditure of the project, with the remainder provided by the firms. Allocations of conditional loans are at MITI's discretion.

Normally, subsidies will be channelled to the firms which belong to one of the research associations recognised by MITI. These associations are specially designed and non- profit legal entities. The whole process of subsidy assignment will be conducted in the following way: having extensively consulted the leading private corporations, MITI will announce the most desirable research areas and ask the interested private corporations to take part collectively. Typically, many corporations will respond actively and enthusiastically and present their proposals to MITI for consideration. In the meantime, these private corporations will communicate with each other very frequently and reach an agreement among themselves to work collaboratively. They then announce that they want to form a research association. At that point, the government selects those firms that appear the most able to contribute to the research under discussion. The selected firms then submit a proposal to MITI requesting authorisation as a legalised research association. MITI typically grants authorisation after further negotiations with prospective members. The following list presents the major subsidies to the computer industry by the government of Japan.

Subsidies to the computer industry (in billion Yen)

1. Subsidy for R&D for mining- 10 billions (April 1950-March 1968)
2. Super high performance electronic computer 10 billions (1966-1971)
3. Subsidy for R&D for imported technologies-3 billions(April 1968-)
4. Fontac subsidy (April 1962- March 1966)
5. Subsidy for IPA operation (April 1971-)
6. Pattern information processing system-22 billions (1971-1980)
7. Subsidy for promotion of developing new types of computers-57.1 billions (April 1972- March 1977)
8. Subsidy for promotion of developing computer peripherals-8.7 billions (1972-1976)
9. Subsidy for promotion and development (April 1973-March 1975)
10. Subsidy for promotion of information processing industry and software production development program-9.6 billions (April 1973-1981)
11. Subsidy for promotion of developing VLSI for next generation computers-30 billions (April 1973-March 1980)
12. Subsidy for developing basic technologies for next generation computers-47 billions (July 1979-1983)
13. Optical measurement and control system-18 billions (1979-1987)
14. High speed computer system for scientific and technological uses (1981-1989)
15. Next generation basic technology-104 billions (1981-1990)

16. Fifth generation computer (1981-1990)

There have been many successful stories about these kinds of research associations reported in Japan. For example, in March 1976, the VLSI Technology Research Association was formed under the collaboration of MITI and NTT and commenced a four year programme with a budget of 70 billion yens. Basic research was conducted at the joint laboratory of the association, while the Joint Computer Development Laboratory and Information Systems Laboratory had taken responsibility for applied research. The VLSI programme was a success. It had produced over 600 patents and processes, and demonstrated the willingness and capacity of private corporations to work co-operatively under the aegis of a specially formed association, and with the technical and financial support of the government (see EIAJ, 1988).

From late 1950s, the Japanese government started to support the development of a domestic computer industry. A number of laws concerning the development of computer industry have been enacted. On July 1957, the Law on Extraordinary Measures for the Promotion of Electronic Industry was issued. MITI was given the authority to formulate overall plans for the reorganisation of the computer industry as well as for designing specific support packages. In April 1971, the Law on Extraordinary Measures for the Promotion of Electronics and Machinery Industries was issued. This law was specifically designed to deal with direct foreign investment. To meet the potential threat of more foreign ownership which was thought unfavourable to Japanese economy both by the government and private businesses and to upgrade the technological level of domestic producers were the main purposes of the law. As specified in the law, 37 types of machinery in the electronic industry and 58 types in the machinery industry had been selected for special promotion. In July 1978, the Law on Extraordinary Measures for the Promotion of Specific Machinery and Information Industry was issued. It was structured much like its predecessors.

Table 5-3 Export promotion schemes, South Korea

Types of incentives	Duration
Tax incentives	
commodity tax exemption	April 1950-
business tax exemption	January 1962-
reduction of corporation and income tax by 50 percent on earnings from exports	Jan.1961-Dec.1972
accelerated depreciation on allowance for fixed capital directly used for export production in mining, fishing and manufacturing	January 1961-
Tax credit for foreign market development expenditures	August 1969-
Tax credit for losses due to operations in foreign markets	March 1973-
Tariff incentives	
tariff exemption on capital equipment for export production	March 1964- December 1973
tariff payments on an instalment basis for capital equipment used in export production	January 1974-
tariff exemptions on raw materials imports for export production	April 1961- January 1975
tariff drawback on imported raw materials used for export production	July 1975-
wastage allowance	July 1965-

Table 5-3 (continued)

Financial incentives	
financing for export sales	February 1948- July 1955
export shipment financing	June 1950- July 1955
export promotion fund financed by counterpart fund	November 1959- January 1964
financing imports of materials to be used in export production	October 1961- February 1972
export credits (trade credit before 1961)	June 1950-
financing suppliers of U.S. offshore military procurement	September 1962-
fund to promote the export industry	July 1964- September 1969
fund to convert small and medium size firms into export industries	February 1964-
fund to prepare exports of agricultural and fishery products	September 1969-
foreign currency loans	May 1967-
financing exports on credit	Oct. 1969-
Other promotion schemes	
Foreign exchange deposit system	June 1949- January 1961
trading license based on	

Table 5-3 (continued)

export performance	January 1953-
an export bonus with preferential foreign exchange	1951-May 1961
payment of export subsidy	1954-1955 and 1960-1965
discount on railroad freight rates	1958-
monopoly rights on exports of special items to specific areas	April 1960-
creation of exporters association on various export products	September 1961-
financing KOTRA	1962-
export-import link system	November 1962-
discount on electricity rates	1965-1976
waiver insurance for shipping	1965-
local L/C system	March 1965-
differential treatment of traders based on export performance	February 1967-
export insurance	January 1969-
general trading company	May 1975-
export- import bank	June 1976-

Source: Wontack Hong, 'Trade, Distortions and Employment Growth in Korea'.

Very much like Japan, the government of South Korea has been using the measures mentioned above extensively and effectively. Tax incentives, government loans and differential rate credits have strongly influenced the behaviour and economic activities of private businesses there. The following table presents the major promotion schemes used by the government for exporting industries.

Perhaps of more relevance to China is the interest rate reform in early 1960s in South Korea. Since 1968 the constant-price cost of commercial bank loans has been between 10 and 15 percent in South Korea. At these rates borrowers are not likely to use their loans for unproductive purposes. This certainly helped to increase the efficiency of allocation by making officials conscious of opportunity cost of 'subsidized' interest rate funds. Furthermore, even promoters of particularly favoured investment projects had to count on average interest costs generally in the nominal range of 15 percent or more, plus substantial non-interest borrowing costs. Thus there is a strong presumption that most investments had been undertaken with the expectation of rather high productivity of capital.

Fierce market competition, especially on international market, also helped to promote production efficiency and quality improvements. Since the early 1960s, government financial assistance has been deliberately linked to export promotion. The government of South Korea granted direct and indirect subsides to exporting firms to improve the competitve efficiency of these firms and enable them to increase their export market share. Prior to 1960 the chief form of export subsidy was a modest amount of direct subsidy payment. The reduction of taxes on income earned from exports began in 1961. Interest rate subsidies on credit for exports became significant during 1960-63, when the interest on loans for export production was lowered in several steps from 12.8 to 8.0 percent, while the interest rate on regular loans was raised from 15.7 percent to 16.0 percent.

The decision to adopt a realistic exchange rate in May 1964 was accompanied by directions to the Ministry of Commerce and Industry to prepare a comprehensive export promotion plan. The Ministry drew up a list of export promotion incentives, some of which were adopted during 1964 and the remainder in early 1965. Virtually every export incentive was included, including low-interest credit to finance export purposes, subsidies for export firms suffering losses, the assignment of commercial attaches to embassies and the sending abroad of other official export promotion personnel, removal of restrictions on travel for business purposes, and an amendment of the banking export finance structure.

In July 1965 the interest rate on export loans was lowered from 8.0 percent to 6.5 percent, and in 1967 to 6 percent. In July 1964 these loans were granted at the rate of 110 won per dollar gross value of the export order. In January 1965 the figure was raised to 200 won per dollar of net foreign exchange earning (value of the export minus the cost of imported materials), and in 1968 to 275 won per dollar.

The 1965 programme provided that import of raw materials for export production could be financed by obtaining a bank guarantee for which the annual interest charge plus guarantee fee was 9.5 percent during 1965 and 1966, then only 8 percent from 1967. Exporters have also been favoured in obtaining long-term foreign loans from the Bank of Korea.

Tax benefits were increased in 1965 by granting accelerated depreciation privileges on plant and equipment and agricultural land improvements used for export production, and in some cases complete exemption from taxes of income earned on new and expanded exports during a limited development period. Customs duty exemptions were given to capital equipment for export production. Also since 1966, exporters have been allowed to divert significant portions of their imports of raw materials for re-export to sale on the domestic market under the guise of liberal material loss or wastage allowances. The profitability of such domestic market sales was frequently high because no customs duties had to be paid, and goods that were subject to import restrictions often commanded substantial premiums. In 1966 the export-import link system was revived as a way to subsidise exporters who otherwise would have suffered losses.

In addition to these export incentives, there were a number of other major export support programmes. Perhaps the most significant of these was the monthly export promotion committee meetings with the president, initiated in early 1966. Cabinet members, business association leaders, and individual businessmen attend these meetings. Businessmen were asked to report their problems, difficulties, and opportunities, and the government officials must respond before the president to criticisms of past government performance and suggest recommendations for improvement. These meetings were served to emphasise the importance attached to exports by the president and have resulted in quick administrative decisions and problem solving.

Unlike many other developing countries, South Korea under Park made exports a compulsory rather than a choice for the private sector. Very often, the approval of subsidised loans was linked to the export performance. This has proved a very effective measure of improving production efficiency of Korean firms. With its support, encouragement and protection, the government of Korea induced domestic firms to face up fierce competition in the world market. Market competition has perhaps been the most efficient mechanism to discipline domestic firms both in south Korea and Japan.

Several months after the 1961 coup, the military nationalised the banks. This proved a critical move in the long run, allowing the government to determine where, when and how much to invest and in which industries. To stimulate lending to Korea, the government amended the Foreign Capital Inducement Law in 1962 and provided government guarantees to lenders, which eliminated the risks of default and of exchange rate depreciation. Control over credit guarantees, together with nationalisation of the banks, extended the government's reign over all capital flows.

A regime of multiple interest rates had been created to support the implementation of industrial policies. The cost of borrowing at home far exceeded the cost of borrowing abroad. This afforded the government the opportunity to discriminate in favour of particular industries and firms. Actually, the real costs of borrowing abroad was negative for the most part of 1960s and 1970s. But, to qualify as a regular customer of the government for long-term subsidised credit, firms, big and small, young and old, chaebol and nonchaebol, had to export.

To get financial support and industrial licenses from the government, the firms should present the attractive and competitive investment packages, and hand in the agreements of foreign technology transfer on the best terms, and show their achievements of inventions or innovations.

Many newly independent developing countries shared a political commitment to industrialisation. Yet not all governments possessed the same capacity to implement effective policies. What appears to distinguish the East Asian NIEs is the determination of the governments to extract certain 'performance guarantee' from firms in exchange for state support. In particular, export requirements were an important means of imposing discipline on firms that received subsidised credit, tax incentives or other concessions from the government. These subsidies were administered on a highly selective basis to direct both investment funds and other resources into certain industries and activities. The difference between East Asia and Latin America was not between protected and unprotected domestic markets. In East Asia, governments frequently combined import substitution with export promotion. However, firm were not left to hide behind tariff walls or import bans indefinitely. They were to 'pay back' for the special treatment they received by demonstrating their capacity to export and earn the much-needed foreign exchange for the import of capital goods and intermediates to sustain the industrialisation process.

The better performance of Japanese and Korean firms cannot only be attributed to the financial discipline imposed upon them by their governments, but also to their strong self-consciousness. The economic motivation has beem a driving force behind this. The strong financial discipline is one of the most important factors which set apart the firms in Japan and Korea on the one hand and the firms in China on the other, where the absence of the financial incentives led to low morale and weak motivation to improve their performance. In 1966, MITI of Japan conducted a survey among 917 leading Japanese manufacturing firms and found that the main reasons for technology importing were:

to develop and defend the market position in Japan	61 percent
to strengthen international competitive strength; to develop and defend the export market	52 percent
lack of time to develop new technology and meet the competition at home	36 percent
to diversify product line in a hurry	31 percent
to economise R&D expenses	24 percent
to keep in touch with the development of technologies abroad	15 percent
to reduce risks and uncertainties inherent in R&D work	5 percent
force to buy technologies together with production equipment	2 percent

notes: 917 firms= 100 percent

Source: MITI, Japan, 1966.

From the above, we can see that the key factor for the Japanese manufacturers to import foreign technologies was market competition both at home and abroad. Technologies were aslo imported with the aim to save time in research and to economise R&D funds. It is very wise for the government of Korea to make the export compulsory for domestic firms, because the competition in the world market is perhaps the most effective way to impose financial discipline upon domestic firms. Given its small size of domestic market and all kinds of financial incentives, most Korean firms have explored foreign markets very vigorously. The high export ratio of many important industrial goods, including steel, shipbuilding and electronics, has demonstrated their outward-looking development strategy. The export ratio of many Japanese industrial products, such as radio, cassette player, TV sets, VCRs, ships, automobiles, micro chips and computers, have been even higher. As a result, Japanese firms have been exposed to continuous and fierce foreign competition, not only from America and the Western Europe but also from some NIEs, especially Taiwan, and South Korea since late 1970s.

5.6 Exploiting Economies of Scale and Improving Production Efficiency

Economies of scale are best analysed in terms of three categories: product-specific economies, associated with the volume of any single product made and sold, plant-specific economies, associated with the total output of an entire plant or plant complex; and multiplant economies, associated with a firm's operation of multiple plants.

Most modern industries need large-scale production. Shipbuilding, auto-manufacturing, steel-making and electronics assembly are just some of the examples. Rapid industrialisation tends to favour the setting up large scale firms. The trend moving towards the large-scale production both in Japan and South Korea has been particularly strong over the past three decades. The whole process has been facilitated and accelerated partly by the rapid industrial expansion and partly by the governments' deliberate policies.

Under the remnants of the Anti-Monopolies Law imposed upon Japan by the occupying forces following World War II, sizeable mergers must be registered with the Fair Trade Commission for review to ensure that a controlling position does not result. The first test came in 1969, when Yawata Steel and Fuji Iron and Steel, broken apart after the war, were reconstituted in a merger to form Nippon Steel Corporation.

Yawata had 18.5 percent of Japanese steel ingot capacity at the time, Fuji 17.0 percent. The Fair Trade Commission opposed the merger, angering other government agencies, who threatened to have the FTC stripped of its powers. The deal was finally approved. There is no evidence to suggest that the Anti- Monopolies Law had ever been effectively implemented in Japan before the late 1970s. In South Korea, there had been no Anti-Monopolies Law until recently. The government of South Korea had made great effort to promote large-scale enterprises mainly by controlling the right to foreign technology importing. Normally, Korean government only grants the right to one or two companies in an industrial sector to import key foreign technologies, as in the cases of steel-making, shipbuilding, auto-manufacturing and electronics industries.

In 1984, the combined sales of top three chaebols in South Korean accounted for 35.8 percent of the country's GNP, while the corresponding figure was just 9 percent in 1974. The combined scales of top five and ten chaebols were 52.4 percent and 67.4 percent of the country's GNP in 1984 respectively (see Kim, 1987). Furthermore, the average share of the top three producers in all manufacturing industries was 62 percent in South Korea in 1981 and 56.3 percent in Japan in 1980. This put South Korea and Japan as two of the world's most concentrated economies. The data for 1982 covered 2,260 commodities and suggested that only about 18 percent of all commodities that year, or 30 percent of all shipments, were produced under what are typically considered to be competitive conditions- that is, a three-firm concentration ratio of less than 60 percent (or a combined share of the top three producers of less than 60 percent). The remainder was produced by either monopolies, duopolies, or oligopolies (see Lee, 1986).

Concentration of the Korean economy has not, however, precluded competition. According to estimates of Chenery et al. (1986), total factor productivity as well as output grew faster in Korea's highly concentrated economy than in that of almost any other countries studied. For example, POSCO, Korea's giant steel maker which accounts for over 90 percent of country's steel output, is one of most efficient steel producers in the world. Hyundai Shipbuilding Company, which is the largest shipbuilder with over 50 percent of the Country's turnover, has also been one of the most competitive shipbuilders in the world.

What helped to make South Korea, a highly concentrated economy, so competitive? There are certainly many contributing factors. Among them are government's financial disciplines, firms' self-consciousness and market competition.

There are benefits which large Korean and Japanese firms can gain from 'economy of scale' and also 'economy of scope'. In the case of Hyundai, for example, managers from its construction arm were transferred to its shipbuilding arm to aid in project management. Later, engineers from its shipbuilding arm, who had a knowledge of anti-corrosion, were loaned to its automobile officiate by a central 'brain' and a uniform culture.

Under conditions of rapid growth and a succession of diversifications and capacity expansions, Korean management appears to have accumulated experience in the areas of feasibility studies, task force formation, purchase of foreign technical assistance, training, equipment purchase, new plant design and construction and operation startup. Investment costs were also kept to a minimum, which enabled new affiliates to start operations with a relatively light financial burden.

The high industrial concentration ratio in South Korea and Japan can also be partially attributed to the rapid industrial expansion, especially heavy chemical and other capital-intensive industries. Most of these industries are large-scale by nature. The unit cost can be, to a very large extent, determined by production scale itself.

Where economies of scale exist, unit costs fall with increases in product volume, plant size, within limits. Sooner or later a point is reached at which nearly all opportunities for making further cost reductions through increased size or volume are exhausted. At this point, the minimum unit cost can be attained, this is what we called the 'minimum efficient scale' (MES).

The minimum efficient scale is the level of output at which almost all attainable unit cost saving are realised. The crucial question remains: Is the MES large or small in relation to the demand for an industry's output? Whether there is room for many firms in the market, each large enough to enjoy scale economies, or for only one firm (a natural monopoly situation) or just a few (natural oligopoly) depends on the relevant technology and the size of the market. Generally speaking, advance of technology has had an effect on the tendencies which appears to have favoured rising plant size. In the early 1950s, Joe S. Bain found that a least- cost flat-rolled steel products plant had a capacity ranging from 1.0 to 2.5 million tons per year. By 1965, the MES capacity had risen to 4.0 million tons. Further advances in blast furnace, basic oxygen furnace, and continuous casting technology raised the optimum scale further by the late 1970s- most likely to a capacity of about 12 million tons per year. Lieberman found that new plant size grew by 8 percent per year on average from the late 1950s into the early 1980s. (see Lieberman, 1987).

There are many advantages which large-scale, especially large-scale multiplant enterprises can enjoy in the areas of finance, investment, marketing risk spreading and R&D. They will be able to economise on management services by having a common central pool of financial planners, accountants, market researchers, labour relation specialists, purchasing agents, lawyers and the like. There is statistical evidence that size, both absolute and relative, does yield overhead cost savings. Economies of scale are also encountered when firms raise capital through borrowing and common stock issues.

There are important marketing advantages associated with scale. A large firm can carry losses incurred when it enters or builds up a market, and it can absorb losses on part of its operations while independent producers may be forced to close or merge with other firms.

A large firm has a greater ability to take risks, to try new products and models, and to absorb changes in the tastes of consumers or government policy, and the effects of mistaken decisions. These advantages are particularly important in rapidly evolving industries. An important distinction between the scale advantages for risk taking and the technical and marketing economies should be noted. The scale advantage for risk taking relates to the total output of a firm, rather than the output of particular products.

A number of studies have shown that expenditure on R&D is positively related to scale of firms, both for all firms and for firms within industries. Also the proportion of employees engaged on R&D, and R&D expenditure as a percentage of scales, tends to increase with scale for all firms and for firms within industries. A large firm can and often does spend more heavily than its competitors on research, and spread the cost over a larger output, or it can spend the same amount and have lower research costs per unit of output.

On the contrary, unit cost will rise, even substantially in some industrial sectors, at the level below MES. For example, at 50 percent level of MES the cost of ethylene production will rise 9 percent, the relevant figure for brick production is 25 percent. The following table lists the MES in absolute terms (at late 1960s level) and the increase in production cost at 50 percent of MES in selected industrial products.

From Table 5-4 we can see that scale economy has played a very important role in determining unit cost in many industrial sectors, from petrochemical to cement, from diesel engines to electrical applicances, from steel making to automobiles. The production cost for brick making and aircraft manufacturing will be substantially higher, over 20 percent in both cases, at 50 percent of MES level. However, the increases in production cost for some other industries, including spinning mills, weaving mills, and knitting mills would be very moderate at the 50 percent level of MES. Generally speaking, scale economies matter more in modern capital-intensive industries than in conventional and labour-intensive industries.

Table 5-4 Summary of the estimates of the minimum efficient scale (MES) and the economies of scale

industry	MES in absolute terms	MES as percentage of U. K. output in 1969 the MES level	percentage increase in cost at 50 % of MES compared with
Oil	capacity-10m.t.p.a.		
a general purpose refinary		10	5
Chemicals	capacity-300,000t.p.a.		
size of ethylene plants	ethylene product	25	9
Synthetic fibres			
plant for the manufacture of polymer	80,000t.p.a. polymer product	33	5
Cement (a portland works)	2m.t.p.a.	10	9
Bricks			
plant of non-Fletton bricks	725m bricks p.a.	0.5	25
Steel (blast& L.D. furnaces)	9m.t.p.a.		5-10
Steel works			
making rolled products	4m.t.p.a.		8
Motor cars			
a firm making one model and its variants	500,000 cars p.a.	25	6
a firm with some models	1mn cars p.a.	50	6
Aircraft (a type of aircraft)	750 aircraft		20
Diesel engines			
modes ranges in 1-100h.p.	100,000 units	10	4
Factories at which large marine diesels are made	an annual output 100,000 h.p.	10	8
Domestic electrical applicances			
a firm making a range 10 applicances	at least 0.5m applicances p.a.	20 (of all applicances)	8
Spinning mills			
making standard products	60,000 spindles	2% of UK spinnig inning capacity	small increases in cost only
Weaving mills			
making standard products	<1,000 looms	<2% of UK weaving capacity	small increases
Warp knitting mills making standard products	a mill with less than 100 knitting	<3% of warp knitting machines installed in U.K.	small increases
Footwear factories	<300,000 pairs p.a.	0.2	2
Plastic products	substantial economies	100	substantial economies
Individual products	continue to large outputs of many products	for many products	

Source: Scherer et al., Multiplant Operation.

Both Japanese and Korean 'economic miracle' can, to a great extent, be attributed to their successful exploitation of scale economy.

It has been argued that the most important factor for the dramatic expansion of Japanese electronic industry has been the continuous flow of massive capital investment and the application of innovative techniques. However, only the giant Japanese electronic producers were capable of making these investments possible.

With 20 billions US dollars or so revenue per year, a single top Japanese conglomerate is not only capable of investing 1,000 millions or more US dollars on R&D per year, but also capable of spending another billion dollars or more on their plant and equipment. For example, dozens of new and advanced corporate laboratories had been built between 1986 and 1988 in the Japanese electronics sector. Most Japanese electronic corporations are investing more and more on R&D as well as equipment. For example, Hitachi is now pouring more than 2,000 million US dollars a year into R&D, accounting for 10 percent of its annual sales; NEC's budget is now 1,800 million US dollars (9.2 percent of sales); Toshiba, 1,400 million US dollars (7.1 percent of sales); Fujitsu, 1,300 million US dollars (10.9 percent of sales). The following table shows more details about the R&D and capital expenditure of selected Japanese giants in 1988.

Table 5-5 R&D and capital expenditures of selected Japanese firms, 1988
(in billion Yen)

Firm	R&D	Capital expenditure
Matsushita Electrical Ind.	271	66
Hitachi	262	103
NEC	250	172
Toshiba	190	109
Fujitsu	184	119
Sony	128	134
Mitsubishi Electric	122	59

Source: Japan Company Handbook.

Most Japanese and Korean giant corporations are highly integrated vertically. They can mobilise huge financial resources to tackle some strategically important research areas, such as the semiconductor and integrated circuits in the electronic industry, where there is even no profitability in the short run. For example, in 1974 South Korea had no chip manufacturing firm. Then the big chaebols-Japanese style conglomerates- began to invest heavily in the industry. More than one thousand million US dollars had been invested in the chip manufacturing from several Korean giants within several year's time. The first to do so was Samsung. Another Korean electronics giant, Lucky-Goldstar, also started making chips in 1979. By 1983, Hyundai and Daewoo, with interests from cars to shipbuilding, had also joined in. South Korea has come from nowhere in a decade to challenge both Japanese and American supremacy in the memory-chip market since the mid-1980s. Although there were certainly many factors responsible for the Korean success, the willingness and the ability of these giant conglomerates to invest in spite of the potential risks ahead was the key one. The considerable initial loss of their semiconductor divisions had been compensated by other member firms.

Most giant conglomerates have their own marketing networks, through which they can trade directly with their customers all over the world. Consequently their marketing ability can be developed and strengthened. An independent data and information collecting system can be established and expanded along with the development of their trade network. Information feedback about demand for their products, quality and competitiveness of both their own and their major competitor products can be collected from their customers, their overseas salesmen and their own market analysts and then analysed. With these information, they can improve the quality of their products either with the existing production techniques and equipment, or with new techniques and equipment, as found necessary. If they feel they must adopt new techniques and buy machinery, they are capable of finding out what they should buy, where they should go to buy, and under what kind of prices (given the experience and data of the production cost and market price of their products) they should buy. Through this process, the giant conglomerates are able to strengthen their investment capability quickly.

The giant Japanese and Korean firms have had very strong R&D capability. They can easily pool both their human and capital resources together to tackle the most difficult problems in the technological frontier effectively and efficiently. For example, in 1985, Sharp Corporation had five main pure research centres and four main application research centres, with 5,700 research staff supported by a large research and development budget. Even more remarkably, Hitachi had 21 research laboratories on a consolidated basis, of which the parent company has 10, featuring the most modern R&D facilities available. There were 16,000 R&D staff, of which 862 were PH.D holders. A unique aspect of Hitachi's R&D is its 'Tokken', the formation of 'special research groups' of experts from different R&D fields to carry out the projects that no single work alone can handle. Some 40-50 of these groups are active at any given time.

These giant corporations are also the national and international technological leaders and inventors. In the Japanese electronics sector, almost all important technological breakthroughs and patents are held by the top ten giants. In South Korea, the top four giant conglomerates dominate the area. Hitachi alone had obtained more than 35,000 patents in Japan and overseas by the end of 1986. The giant Japanese and Korean corporations have been technological developers, inventors and promoters. This can be seen from their active role in the international technology licensing and cross-licensing. The speed and efficiency of developing, transferring and diffusing the new techniques within the giants' own member firms are even more impressive. Many Japanese giants, such as Hitachi and Toshiba, employ more than 100,000 people world-wide, with more than 10,000 R&D personnel, equipped with the most advanced research centres and laboratories. Many new technologies, production techniques and products have been invented by these giants every year. They have worked hard on diffusing these new technologies within their own company. Sony, one of the world technological leaders in the electronics area, especially the consumer electronics, has, for example, been holding its 'technology fair' annually. This fair, also called 'Technology Exchange Convention' gives all divisions and project teams the opportunity to set up their own exhibition sections and display new process equipment and materials, and also to give demonstrations with engineers and technicians are on hand to answer questions. More than 10,000 Sony's employees, especially the research and managerial staff, all over the world come to attend the convention. The visitors often find technologies which they can apply to their work. This is a very good chance for them to exchange cards and research information, just like a regular trade show.

5.7 Cultural Factors

Assessing the role of cultural factors in the growth and development of the Japanese and the Korean economies is surely a formidable task. However, it is generally recognised that cultural factors play a crucial role in the process of development. Without considering these factors, it would be difficult, if not impossible, to fully explain the astonishing success of the economies of contemporary Japan and Korea.

The following section will discuss the effect of Confucian culture on industrial organisation, work attitude, education, investment behaviour, national economic consensus building, formulation and implementation of nation's industrial and technological policy, co-operation between business and the government, and between labour and management in Japan.

Japan, like its several neighbours, is a Confucian society. Confucianism, being imported into Japan around the sixth century from China, had been modified and adapted to Japanese conditions over the centuries, so that some Japanese now prefer to call it Japanese Confucianism. Nevertheless, its principles, which remain the same, have had a very strong influence for centuries on such countries as China, South Korea, Japan, Taiwan, Hongkong, Singapore, Malaysia, and even Thailand. It has been suggested that Confucianism has helped to create and preserve the special Japanese 'corporate culture'- including the 'seniority wage system', 'life time employment' and 'loyalty to the company'-which many believe has been the key factor behind the success of large Japanese corporations and the Japanese economy as a whole.

The 'Japanese seniority wage system' means that a person's wage is determined by the person's age, family responsibility, years of service with the company, educational background and sex. Although some similar wage systems had already existed before the World War Two, the widespread application of the seniority wage system in middle and particularly large Japanese companies began during the post-war period. Since a firm's wage costs increases automatically as the age of its employees increases annually, the firm will face an automatic profit squeeze unless it increases its annual sales over its increase in wage costs. This specific wage structure forces many Japanese firms to make all-out effort to increase their market shares, and also makes them think consciously and consistently about their growth potentiality and diversification opportunities.

Confucianism gives very high priority to loyalty, which has been passionately advocated and emphasised in Japan since the Meiji period. The value of loyalty to the emperor, to the state, to his family, to his friends and to his company has been deeply instilled into the hearts of most Japanese people. The Imperial Rescript on Education of 1890 was one of the most influential and most widely circulated Confucian scripture in Japan, which must be repeatedly read out in schools something like the Bible in the West. The individual freedom in the extreme sense of the West has never been given a place to survive in this kind of society. In a Confucian society, each individual must demonstrate his or her loyalty to the society to which he or she belongs.

The Japanese companies have consciously and consistently used every opportunity to strengthen the employees' loyalty feeling toward their own company. Almost all employees of the large Japanese companies have been directly recruited from the universities, colleges and schools annually. At the moment of entering the gate of the company they choose, the new recruits will be ready to devote their whole life to the company. Their career and future will be tightly bound to the very existence of the company. They may be only able to work thirty or forty years for the company, but they will belong to the company forever.

Very few people quit the big companies in Japan. This is considered to be a hallmark of loyalty. Small companies employ people on a very flexible basis, but, then, unlike the big companies, do not have life time employment system. Moreover, wage rate and other social and economic benefits are lower in small companies than in the big ones. The labour market for the medium and small companies has been very flexible, but the chance of getting employed in a big company comes only once in a lifetime. Thus to quit a big company seems like committing suicide.

Almost all top executives in large Japanese companies have been promoted within the same companies. Individuals outside the organisation but with exceptional expertise and talent may get jobs in some big companies. However, these 'outsiders' would not be treated on equal terms with others for promotion. The 'outsiders' would normally be kept away from playing any important role in management, because the company would be unwilling to destroy the unity among the existing company employees. The harmony and loyalty of the existing employees are best preserved by not recruiting 'outsiders'.

Loyalty to ones company has been regarded very important and even sacred in Japan. The feeling of loyalty has be strengthened in many ways, such as provision for training during the whole employment period, moral and also material rewards, and the seniority wage system. The life time employment system also reinforces the close relationship between the employees and their company. This system makes Japanese companies keen to invest in their employees, with the aim to upgrade their skills and competitiveness during their life time employment. Employees are also keen on learning. The generous investment on training from the employers and enthusiastic co-operation from the employees have contributed greatly to the high skill and competitiveness of the Japanese labour force. On the other hand, many American high-tech companies reportedly encountered a serious problem of high turnover of engineers, managers and skilled workers in the 1970s and 1980s. These employees not only took the skills and experience with them but also with the secrets of R&D, production and marketing. The prospect of such tendencies certainly made it unattractive for companies, especially electronics and semiconductor companies, to invest on their manpower like in Japan.

Under the seniority wage system and life time employment system, the level of wages and salaries is a direct function of the age of employees. But the starting salary for new recruits is not fixed at too low a rate either, the aim being not to lose talented young graduates. The relatively high starting salary rates and the system of life time employment have put strong pressure on the company to upgrade the techniques of its production and the skills of its employees quickly and efficiently.

Normally, workers in Japan spend their whole work life in a single company. They, however, change jobs in the company through work rotation or promotion, so that they do not have any strong ties or particular feelings to any trade like that most workers in the West. There is, for example little distinction between white- and blue-collar workers in Japanese companies. On the other hand, workers have strong ties with their companies. This may explain why in Japan most worker's unions have been formed on the basis of company, not on the basis of trade.

The big Japanese companies also run many sorts of clubs, such as sports club, literature club, film club, tea ceremony club, photography club. Moreover, employees could deposit their savings with the company and receive higher interest rate than they could get from the banks. Mutual aid and co-operative association are also very popular and active in most companies. In the Japanese companies, every employee is treated equally as a member of the same family. All employees in a company, from new recruits to top management, wear the same uniforms and use the same catering service. This kind of company is very different from that of most companies in the West, where the relationship between companies and their employees is impersonal and where a company and its employees are bound only by contract.

Since it is life time employment, most companies tend to regard an employee's personal character, sense of loyalty and potential ability to contribute to the company over the long term as much more important than his or her initial productivity, skills and work experience. By Japanese standard, the Western style management is cold and de-emphasising the human effect. The Japanese believe that the consistent high efficiency and high productivity cannot be guaranteed only by the scientific but 'cold' management alone. High morality, strong solidarity, and the feeling of being satisfied are more important in the long run.

The strong feeling of mutual trust, understanding and co- operation has helped to make the labour relation in Japan much better than that in the United States and the United Kingdom. For example, in 1984, Japanese industry lost only 354,000 man-days to labour disputes, while the Unites States lost 8,348,000 man-days, and U.K. 26,564,000 man-days. Most large Japanese companies rarely lay off their labour force. So most companies are careful and prudent about increasing their labour force during boom times. During period of boom, employees would be required to work longer daily, and weekends and even holidays would be sacrificed for work. During period of recession, workers would be called on to cut their working days, and working hours. Moreover, some special and voluntary holidays may be also arranged by the company for its own staff. However, when a strong recession sets in, the whole company will be mobilised to fight. Fate-sharing is the key principle of the Japanese management in the time of difficulty. Companies sacrifice their profits to keep their employees to work. The employees also know very well that their salary increases and bonus might have to be sacrificed. Unlike their counterparts in the West, Japanese workers trust their management very much, because they know that the top management cut their own salaries first when the company faces big difficulties.

A company's long-term profit growth very much depends on factors which affect the employees' motivation and working attitude, including whether they feel secure for their continuous and long-term employment, whether they are satisfied with their working environment and also whether they feel their hard and efficient work has been appreciated by the company. In Japan, employees and investors are all the owners of a company. It is also very true that most Japanese executives and employees are themselves the investors of their own company. The Japanese believe that a company should look after its employees as well as its investors. Many executives in big Japanese companies strongly believe that the company will gain more benefit in the long-run by keeping their employees at the expense of short-term profit when an economic recession sets in.

Cultural factors have strongly influenced the whole process of government policy formulation both in Japan and South Korea. This has in turn greatly facilitated the implementation of their policies. During the course of drawing up the plans and policies there were frequent communications between the representatives of relevant government ministries, private interest groups and intellectuals. So that the plans were effective in promoting mutual understanding between all parties involved. Furthermore, in the countries like Japan and South Korea, the idea of harmony is valued, and where there is a national tendency to believe that harmony means listening to what the government says. So most firms followed the government's 'vision' plans very closely.

One of the distinct cultural features in Japan and South Korea is the exceptionally strong co-operation between the government and the business communities in these countries. A wide-range, well-designed industrial policies have been carried out effectively over the past decades in these two countries. These policies have been formulated through long, deep and wide consultation between the state and business groups. However, after a national consensus about a development strategy has been built up, and a subsequent government plan or policy announced, almost all business groups would follow voluntarily and enthusiastically. This does not only include manufacturing firms but also banks and financial institutions. There has been a very strong 'window effect' both in Japanese and Korean financial sectors, where the government can influence the lending policies of commercial banks and financial institutions through the symbolic lending of the public financial institutions, such as development bank and export and import bank. Such kinds of loans are often quite small and symbolic, they, nevertheless, were as a green light for the massive private bank loans to come. In Japan and South Korea, whenever a consensus is reached for developing or promoting a new industry, a comprehensive industrial or sector policy will be formulated very quickly, then financial resources will be mobilised. The electronics and shipbuilding industries in both countries have benefited greatly from quick and effective government policies. Behind this mobilisation lies the mutual understanding and co-operation between government and the business sector.

The mutual understanding and trust between the business and the government, between the companies and their employees, between the management and investors are extremely important for an economy to become successful. The legal contract alone cannot guarantee a mutual trust and genuine co-operation. Sometimes, a moral constraint or obligation seems desirable to strengthen the trust and to promote co-operation.

The Confucian culture has helped Japanese not only to establish but also preserve the seniority wage system and life time employment system within their mid- and large-size companies. Loyalty, one of the most important Confucian principles, has been particularly emphasised in Japan for many centuries. Loyalty to one's companies is considered to be the basis for loyalty to the state.

Loyalty, seniority wage system and life time employment together have strongly influenced the investment behaviour of both Japanese companies and individual investors and the working attitude of the Japanese labour force. First, Japanese companies are very willing to invest heavily in labour training, including both new recruits and existing employees. Labour training and retraining are the quickest and the most efficient way to increase productivity. In Japan, companies do not need to be bothered by the possibility that some of their highly skilled employees will leave for another company some day. So they can spend money on labour training as much as the company thinks necessary. Loyalty enables employees to co-operate very well with the management side and to accomplish successfully their training or retraining.

Second, most Japanese companies have been pursuing a very aggressive investment strategy which very few companies in the West can or are willing to take. Japanese companies have been keeping a very high ratios of their sales on R&D and also plant and equipment. This is specially true in the Japanese electronic and semiconductor sector. Most Japanese electronics corporations have consistently invested a very big portion of their sales revenue on R&D and capital and equipment. Having worked with their companies for several decades, many top executives in Japan know better than their western counterparts where to invest, when and how much to invest. It is believed that investment is geared to achieving long-term interest rather than short-term profits.

Third, loyalty and life time employment strongly encourage both management and the employees to work harder and longer. These have helped form the special Japanese working attitude: hard working, high efficiency and self-conscious quality control. Most workers are highly self-conscious to achieve the goal of zero-defect production. The loyalty and life time employment have also helped create the speciality of the Japanese industrial relation- fate-sharing. When facing difficulties, both management and employees are willing and able to make sacrifices for one another. These mutual understanding, solidarity and trust make the relationship between the management and employees very smooth, flexible and harmonious.

South Korea has a similar culture as Japan. The feeling of loyalty to the state among the Korean people has always been extremely high. Most firms and business leaders have followed government policies voluntarily and enthusiastically. 'We work for the government, through our business we contribute to the nation' said the chairman of Daewoo, one the three biggest conglomerates in South Korea. The mutual trust and co-operation between the government and business community in South Korea has been as strong as that in Japan. Furthermore, the co- operation in South Korea has different characteristic. Given the power of controlling the financial system and owning commercial banks and the undemocratic political system before the late 1980s, a mutual understanding and co-operation between the state and the business had not only been reached by extensive consultation but also enhanced by the government's political superiority and financial dominance. This had at least helped to make the co-operation more effective, if not more successful.

In February 1976, a national survey was conducted by the Korean economists, sociologists and anthropologists in KDI (Korea Development Institute) and other institutes. When the business leaders and entrepreneurs were asked the question that 'in general, how important do you think the following factors are in motivating successful Korean entrepreneurs?', they gave the following answer.

Ranking: very important moderate important unimportant
1 2 3 4 5

Personal goal achievement	Mean responses
pursuit of excellence	3.39
fame and power	3.04
wealth	2.56
Family responsibility	2.44
Community responsibility	1.78
Patriotism: North-South conflict	1.95
Nationalism: catch up Japan	2.28

The result above revealed that 'community responsibility' and 'patriotism' were the two most important factors to motivate Korean entrepreneurs to become successful. They were followed by 'nationalism' (catch up Japan), 'family responsibility' and 'wealth'. However, the 'fame', 'power' and 'excellence achievements' were at the bottom of motivation category. This shows the big cultural difference between South Korea and many other developing countries. Given the cultural background, it is perhaps easier for us to understand why non-pecuniary incentives had worked very effectively and successfully in Japan and South Korea. The South Korean government has deliberately and extensively used various non-pecuniary incentives. Official and also social approval has provided a real marginal incentive, increasing the total pecuniary and non-pecuniary returns to entrepreneurship.

5.8 The Role of Foreign Aid

It is widely believed that the foreign aid, especially grants and concessionary loans provided by international agencies, foreign governments and commercial banks, can play a crucial role in the economic development of developing countries. It is particularly true during the early stage of the development.

One of the big problems which many developing countries face in the early stage of development is the scarcity of foreign currency. Developing countries are often unable to import foreign technology for lack of foreign exchange. They would consequently need to increase their exports or, short of this, to obtain foreign aid. Foreign capital is needed to supplement domestic savings particularly when domestic savings are low. Saving as a proportion of national income in most developing countries in the early stage is low. This was also the case even in some new industrialising economies, such as South Korea, Singapore and Taiwan.

To reach a national saving level equal to the average capital/output ratio times the rate of population growth is not easy, and to exceed it substantially is even more difficult. It is in the light of this that the role of foreign aid, including mainly foreign grants and concessionary loans, is seriously considered as a crucial basis for growth.

Table 5-6 Savings as percentage of gross domestic product in South Korea and Taiwan

year	South Korea	Taiwan
1952	--	5.2
1953	4.4	5.0
1954	1.4	3.3
1955	0.5	4.9
1956	-7.4	4.8
1957	0.9	5.9
1958	-0.1	5.0
1959	-1.3	5.0
1960	-4.8	7.6
1961	-2.3	8.0
1962	-2.4	7.6
1963	3.9	13.4
1964	4.0	
1965	1.9	
1966	7.0	
1967	6.2	
1968	10.3	

Sources: For Taiwan, Council for Economic Planning and Development (1981). For South Korea, The Bank of Korea (1978).

Given the moderate domestic saving rate, in fact it had been too moderate (with dissavings for 6 years), how did a poor country like South Korea manage to increase its domestic productive capacity? From above table we can see that the domestic saving rate as the percentage of GDP in Taiwan had been higher than that of South Korea, but it had never reached to 9 percent before 1963. Taking the high rate of population growth in these two countries into account, it seemed extremely difficult, if not impossible, for South Korea and Taiwan to increase the per capita income quickly and impressively with their own domestic savings. It was particularly true for the South Korea, because it had not accumulated any net domestic saving before 1963. But very fortunately the domestic investment in South Korea had been financed largely through the foreign aid during 1950s and also 1960s. As a result, South Korea had managed to increase its productive capacity even without any net domestic saving before 1963.

For Taiwan, aid from the United States was particularly important from 1951 through 1962, when it constituted over 90 percent of all foreign capital commitments and between 35 percent and 45 percent of gross domestic capital formation each year. The aid from the United states declined rapidly in the early sixties, and direct foreign investment then began to rise. During 1952 to 1961, foreign aid was responsible for more than 40 percent of gross domestic capital formation in Taiwan. In the case of South Korea, the foreign capital had played an even more important role. About 48 percent of gross domestic capital formation During 1953 to 1955, can be attributed to the foreign capital inflow (excluding the direct foreign investment). The corresponding figures were 77.8 percent in 1956-1960; 59.5 percent in 1961- 1965; and 38.8 percent in 1966-1970. The major part of the foreign capital inflow was grants, and the rest of them was concessionary loans.

Foreign capital in all its forms made an important contribution to the Korean economy. In the years immediately following the Korean War, aid from the United States was massive and accounted for all resources available for investment.

In 1960, Korea engaged in little foreign trade, had low rate of investment, and generated practically no domestic savings. The exports of goods and services were about 3 percent of its gross domestic product and the share of merchandise exports did not reach even 1 percent. As the imports of goods and services were 13 percent of the domestic product, capital inflow equalled 10 percent of GDP. Notwithstanding the large inflow of foreign capital, the share of investment in Korea's GDP was only 11 percent in 1960, indicating that domestic savings were negligible.

During the 1950s and early 1960s, South Korea had received a huge amount of financial aid both from the United States and the United Nations. The aid funds had been mainly channelled through following organisations: United States Ministry Government in Korea, ECA (Economic Co-operation Administration), UNKRA

(United Nations Korea Reconstruction Agency), CRIK (United Nations Command, Civil Relief in Korea) and ICA (International Co-operation Administration). At the very early stage of the aid programme, the priorities had been given to provision of sufficient quantity of consumer goods and raw materials, especially food and medicine. A large proportion of funds had been also used to develop the coal resources and to expand thermal power generating facilities, which were then in short supply. In addition, fertiliser production capacity was planned to be developed in line with the view that agricultural exports were to be increased through the growth of output of that sector. However, almost all fertiliser consumption had been imported during the 1950s. 171,400 tones fertiliser was imported in 1946; 419,100 tones in 1947; 529,300 tones in 1948; and 766,100 tones in 1949.

In most respects, aid during the early 1960s followed a similar pattern set in the 1950s. Aid as percentage of the imports in South Korea were 83.6 percent in 1960; 73.1 percent in 1961; 51.2 percent in 1962; 41.8 percent in 1963; 38.6 percent in 1964 and 32.2 percent in 1965. (see IMF, 1976; and Bank of Korea, 1976.)

The major part of the foreign aid received by South Korea in 1950s and in early 1960s had been grants rather than loans. There had been no loans received prior to 1959. Thereafter some aid was channelled through the development loan fund.

The unique composition of the foreign aid had a very strong positive effect on the Korean economy during 1950s and 1960s. Without the foreign aid, net investment in South Korea would probably have been negative for several years. The domestic saving rate during 1954 to 1959 was too low to be sufficient even to keep per capita incomes constant.

As to the 1960s and early 1970s, the diminishing relative importance of aid has already been noted. Before borrowing is considered, however, one contribution of aid in the 1950s to growth in the 1960s, must be noted. Korea emerged from the 1950s virtually debt free and without any debt-servicing obligations. Had aid in the 1950s been in the form of loans, rather than grants, the prospects for growth in the 1960s would have been significantly diminished, or alternatively, the same volume of commercial borrowing in the 1960s would have provided for smaller net resources for growth. Cumulative U.S. aid from 1954 to 1963 was US$ 2,369 millions. If a grace period until 1964 had been extended on all grant aid in the 1950s, and a concessionary interest rate of only 3 percent had been charged, the interest obligation in 1964 would have been US$ 71 millions, or 60 percent of exports in that year. Had interests accrued in earlier years, the debt would have been bigger.

Heavy financial burden and growing unwillingness were mainly responsible for the changing of the American aid policy since mid-1960s. Significant scale of aid had been replaced rapidly by the successive inflow of concessionary loans both in South Korea and Taiwan. In the meantime, Korean producers had been encouraged to export by Korean government and Americans. Easy access to the huge American market provided great incentive to Korean exporters. Between 1960 and 1965, the share of Korea's exports to the United States in total Korean exports increased from 11.1 percent to 35.2 percent. This share kept rising all the time during the second half of the 1960s, reaching just over half of Korea's export in 1969. Even though the share began to decline a little in early 1970s, the absolute value of Korean export to the United States had increased. According to the estimates of Suk (1975), the direct contribution of total export to GNP growth in South Korea was 9.3 percent during 1963-1966; 9.4 percent for 1966-1968; 7.5 percent for 1968-1970; and 23.6 percent for 1970-1973. If we only consider the direct contribution of light manufacturing export to the growth of light manufacturing industry, his estimates were: 17.9 percent for 1960-1963; 18.4 percent for 1966-1968; 19.0 percent for 1968-1970; and 40.9 percent for 1970-1975. If we also take the indirect effect of the export increase into account, its contribution would be much higher. The preferential treatment granted to Korea to sell in the American market was as important as foreign aid. It encouraged Korea to be outward-looking. The quick expansion of the exporting industries helped Korea greatly to improve its resource allocation and production techniques.

In the case of Japan, the Korean War brought a very good chance for Japanese economy to recover. Even in the early 1950, no relaxation on the monetary situation seemed forthcoming, and a full-scale depression was feared. The Korean War, which began that June, however, changed the situation completely.

After the Korean War broke out, American changed its policies of enforcing a programme of disarmment in Japan. American authority instructed MacArthur to rearm Japan. A Japan with a military force as strong as its economy was considered vital to containing the Soviet Union and its allies in the Far East. Japanese foreign trade did not really take off until after the Korean War broke out in June 1950. American procurements alone in 1950-1952 totalled US$ 1.57 billions, and US$ 5.6 billions for the whole decade, or 37 percent and 11 percent, respectively, of all foreign exchange for the two periods. These procurements helped to boost Japan's industrial production index from 90 in 1950 to 140 in 1953 (1951=100). Japanese exports expanded vigorously during the period, with a 270 percent increase between 1949-1951 (see Slaughter and Parker, 1989). This rapid production expansion led to greater economies of scale which in turn lowered prices and improved quality. The Foreign exchange received from exports and the military procurement had been quickly reinvested in new capital and technology to enhance the Japanese competitive advantage further. Between 1960 and 1967 Vietnam War procurements had earned Japan a further US$ 2.646 billions (see Independent, 1988).

Like Japan being the beneficiary of the Korean War, South Korea had made profits from the Vietnam War. The construction projects for American troops in Vietnam had earned Korea a considerable amount of foreign currency. In addition, other manufacturing goods delivered to the American military in Vietnam had also produced a very positive effect on the Korean exporting industries.

China was deeply and directly involved in the Korean War and only indirectly in the Vietnam War. In Korean War, China had spent billions of US dollars for the military goods, especially for purchasing airplanes and weaponaries from the Soviet Union.

More than one million PLA soldiers took part in the War for more than three years. The Korean War had a devastating effect on Chinese economy. It had not only led to acute shortage of supply of food, clothing and medicines, but also had the whole Chinese economy geared to military mobilisation. It was a very costly war both in the terms of human resources and capital. The debt payments for the military spending in the Korean War had drained out a considerable portion of foreign currency which China had earned from her export and the overseas Chinese remittance. During the Vietnam War, although China had not publicly declared to join in, it had provided huge military and economic supports directly and indirectly for many years before it changed its policies at the later stage.

From what discussed above we can see that the foreign aid (including mainly foreign grants before early 1960s and concessional loans thereafter) had played a very important role in the early development of Korean economy. The easy access to the huge American market was another key contributing factor to the extraordinary long and high growth of both Japanese and Korean economies. Having said these, we should also emphasise that just foreign aid and market access to the United States alone could not create the economic miracle in Japan, South Korea and Taiwan.

Chapter Six

The Experience of Technology Transfer and Development in Japan With Particular Reference to the Electronics Industry

Introduction

In comparison with the United States and some major Western countries, Japan was relatively backward in technology development both in the pre-war and early post-war period. Some very important inventions and innovations as Nylon and continuous rolling equipment in the steel industry, which had come into practical use in Europe and the United States before the War, had not yet been introduced into Japan. From the early 1950s, the world technology 'reservoir', accumulated during the pre- war and the wartime, began to 'irrigate' the Japanese 'fields'. Japan has been the greatest beneficiary of world technology transfer on a massive scale.

From 1950 to 1971, there were total 17,015 technology purchase contracts approved under the Japan Foreign Investment Law (Japan Science and Technology Agency, 1972). These did not include capital goods purchases during the period. Of which 9,875 contracts had an effective life of more than one year with the payment of royalties guaranteed to be made in foreign currency; and the other 7,140 contracts had royalty payments paid in Japanese Yen and with an effective life of less than one year. (see Japan Science and Technology Agency, 1970).

From the beginning of 1950s, the Japanese government gave priority to technology import for the development of the capital sector. It was not until 1960s that consumer goods sector was permitted to import 'know-how'. So the major part of the investment fund had been spent on building productive capacity. This was important since the inadequate capacity in basic industries, like electric power, steel, marine transport, and coal, constituted a bottleneck that limited the expansion of Japanese economy during 1950s.

Table 6-1 Plant and equipment investments by industry in Japan, 1951-1958. (Yen 100 million)

fiscal year	1951	1952	1953	1954	1955	1956	1957	1958
steel	369	379	396	256	267	625	1,119	1,197
industry	8.4%	7.7%	6.4%	4.8%	4.5%	6.1%	8.8%	9.4%
Marine	640	615	465	313	390	741	967	744
transport-	14.6%	12.4%	7.5%	5.9%	6.5%	7.2%	7.7%	5.8%
Electric	553	1,054	1,461	1,422	1,583	2,010	2,437	2,901
power	12.6%	21.3%	23.7%	26.8%	24.8%	19.6%	19.2%	22.7%
Coal	208	202	206	137	143	135	301	338
industry	4.8%	4.1%	3.3%	2.6%	2.4%	1.3%	2.4%	2.5%
Total	1,770	2,256	2,528	2,128	2,283	3,511	4,824	5,180
key indus.	40.4%	45.5%	40.9%	40.1%	38.2%	34.2%	38.1%	40.4%
Total	4,389	4,955	6,170	5,303	5,989	10259	12647	12789
including	100%	100%	100%	100%	100%	100%	100%	100%
other industries								

Almost all major technology imports in the areas of steel, electric power, shipbuilding, electrical machinery, automobile and petrochemicals had taken place during 1950s and 1960s. The following table is a summary of the major technology imports and developments in Japan during the 1950s and 1960s.

A very important aspect of the technological progress in Japan was the order under which it developed: beginning with materials and basic industries, such as steel and electric power and then shifting to manufacturing. As new materials appeared, previously produced materials were improved, then new products were born. It was

Table 6-2 Major post-war technological advances in Japan

Steel Industry

1950-54: rationalisation announced in June 1950; blast furnace enlargement-leading to 20% decrease in proportion of coke; introduction of continuous rolling technology.

1955-59: Conversion to LD convertersprocess; After-1965: Set up large-scale integratedplants

Electric power-industry

1950-54: Introduction of large-scale steam-powered generating equipment from the U.S..

1955-59: Researchonnuclear power generation.

1960-65: Experiments with nuclear power generation.

Shipbuilding industry

1950-54: Adoption of electric welding, block construction method and automatic gas cutters.

1960-65: Establishing very large scale docks; adoption of precedent setting methods for fittings.

After-1965: Development ofcombinationcarriers and automated ships.

Electrical machinery industry

1950-54: Introduction of large-scale generators & electronics.

1955-59: Development of TVs, transistor radios and tape recorders.

After-1965: Development of air conditioners and pocket calculators.

Petrochemical industry

1955-59: Introduction of Naphthacracking process.

Synthetic fibres

1950-54: Purchasing technologyfrom Dupont

1955-59: Introduction of polyester fibre technology.

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a result of progress in Japan's steel technology which raised the quality of the special steel used in automobiles, and it was also as a result of technological progress in the casting of parts, that Japan's automobiles industry for the first time became very competitive in the international market.

Between 1973 and 1978, the average annual rate of increase in labour productivity for all manufacturing industry in Japan was 4.0 percent. On the other hand, during the same period, labour productivity in electrical equipment and precision instruments increased by 9.3 percent and 19.3 percent respectively. So these industries became more desirable for Japan because of their low rates of dependence on raw materials and also because they could compete technologically in the international market. The Ministry of International Trade and Industry anticipated in the early 1970s that future industrial development would be in the direction of these industries and other knowledge-intensive industries, especially electronics and related industries.

From Table 6-2 we can see that during 1950s and 1960s, Japan had made great technological advances, especially in steel industry, shipbuilding industry, electric machinery industry, automobiles industry and petrochemical industry. Technological progress in these areas surely made significant contributions to Japanese economy. Steel, ships and synthetic fibre were among the top export concerns in 1960s and 1970s, thanks to technological progress in these sectors.

As a technologically backward country, compared with Western Europe and the United States, Japan could not have achieved so many big technological advances by itself within such a short time period. The efficient and effective technological transfer and development was the key to Japanese economic success.

In summary, Japan and South Korea (see the first section of the chapter seven) have successfully transformed their economies over the last decades. The rapid and efficient adaptation and diffusion of foreign technologies has played an important role in both cases. Technology licensing and equipment purchasing were the major means of technology transfer both by Japan and South Korea. In both cases, direct foreign investments were tightly controlled, monitored and limited. Only in the later stage of the technology transfer and development had foreign direct investment been allowed, but limited to the areas that were already international competitive. The policy of the liberalising foreign investment had been carefully designed and implemented. The sequence of activities in technology transfer and development in Japan and South Korea was very similar. Emphasis was first on basic industries, such

Table 6-3 Japan's Top Ten Exports

	1950	1955	1960	1965	1970
1.	Cotton textiles 24.9%	steel 12.9%	steel 9.6%	steel 15.3%	steel 14.7%
2.	steel 8.7%	cotton textiles 11.4%	cotton textiles 8.7%	ships 8.8%	ships 7.3%
3.	rayon fabric 4.6%	apparel 5.3%	ships 7.1%	cotton textiles 3.6%	automobile 6.9%
4.	copper 4.3%	staple fabrics 4.1%	apparel 5.4%	apparel 3.4%	transistor radio 3.6%
5.	ships 3.2%	ships 3.9%	transistor radio 3.6%	automobiles 2.8%	synthetic fibre 3.2%
6.	apparel 2.8%	marine products 3.8%	staple fabrics 2.9%	marine products 2.7%	optical instruments 2.6%
7.	silk fabrics 2.7%	rayon fabrics 3.0%	toys 2.2%	transistor radio 2.6%	apparel 2.4%
8.	toys 1.4%	toys 2.1%	automobiles 1.9%	synthetic fibre 2.2%	tape recorders 2.3%
9.	staple fabrics 1.3%	ceramics 2.1%	footwear 1.8%	optical instruments 2.1%	plastics 2.2%
10.	textile machinery 1.2%	chemical fertiliser 2.1%	ceramics 1.7%	toys 1.2%	TV sets 2.0%

source: Japanese Ministry of International Trade and Industry of Japan, white paper on international trade, 1971, Tokyo.

as coal, transportation, communication, electricity and steel. Then there was a shift to manufacturing industries, such as shipbuilding, automobiles and electric machinery, and finally to high- tech industries, such as electronics and computer industries. Investment resources were channelled into these sectors and used efficiently. This paved the way for the effective and efficient adaptation, modification and diffusion of the imported foreign technologies.

6.1 General Review of Electronics Industry

The beginning of the electronics industry is associated with the development of the radio. Radio and related equipment accounted for nearly all of the industry output

Table 6-4 Principal end-user markets and applications.

End-user market	Principal application
Military and space	Missile guidance systems, aircraft
Computer & office	Mainframes,small business computers, personal computers, calculators, word processors
Telecommunications & other communicat.	Private branch exchanges,Central switching systems,local area networks
Consumer electronics	Audio & video equipment,video games, digital watches
Industrial control and measurement	CAD/CAM systems,numerically controlled machine tools,medical monitoring systems, automatic test equipment

until 1939. During Second World War, technology inventions and innovations accelerated. Since then, this industry has been one of the fastest growing manufacturing sectors. Now electronics, especially the microelectronics technology, is rapidly overtaking steel as the corner-stone of industrial systems. It is also rapidly transforming and restructuring all industrial sectors of developed and developing countries.

The electronics industry can be divided according to the end-user market and applications of final goods, as shown in the Table 6-4.

We can also classify the electronics industry into several component sectors. The component sectors of the industry produce only certain parts used in final electronic equipment.

Active components affect or modify an electrical signal through amplification, modulation, generation, and switching operations, and these are the distinguishing characteristics of electronic equipment. Passive components perform different functions; for example, resistors impede the flow of electricity and capacitors store electricity.

In the discussion of technology and technology transfer with respect to the electronics industry, much attention should be paid to the semiconductor industry. This is the foundation on which the entire electronics industry is built. It provides devices for the systems and subsystems of electronic end-user equipment. The Figure 6-2 shows the breakdown of the semiconductors.

The manipulation of signals by electronic means is the central function of semiconductor technology. The semiconductor industry is defined as the industry producing discrete semiconductors and integrated circuits [ICs]. The products of ICs account for the largest and fastest growing share of the semiconductor market. Microelectronics is the collective name for integrated circuits. The mass production of ICs and subsequent development of microprocessors rapidly paved the way of extensive application of semiconductor technology to consumer goods, such as calculators, digital watches, video games, VCRs, home computers, toys and cameras.

Figure 6-1 Components of Electronic Industry

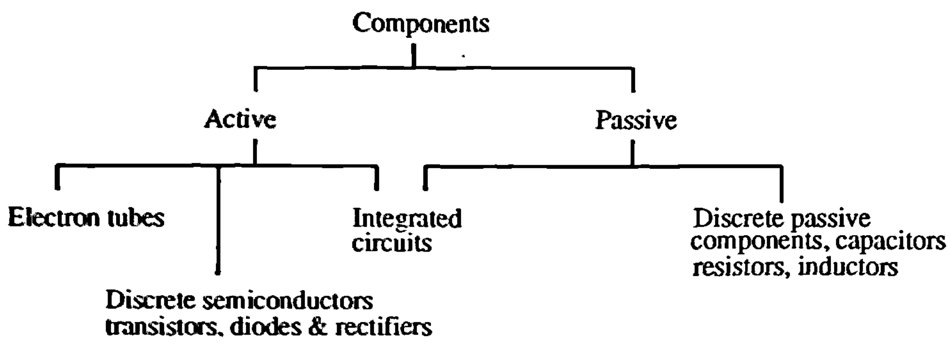
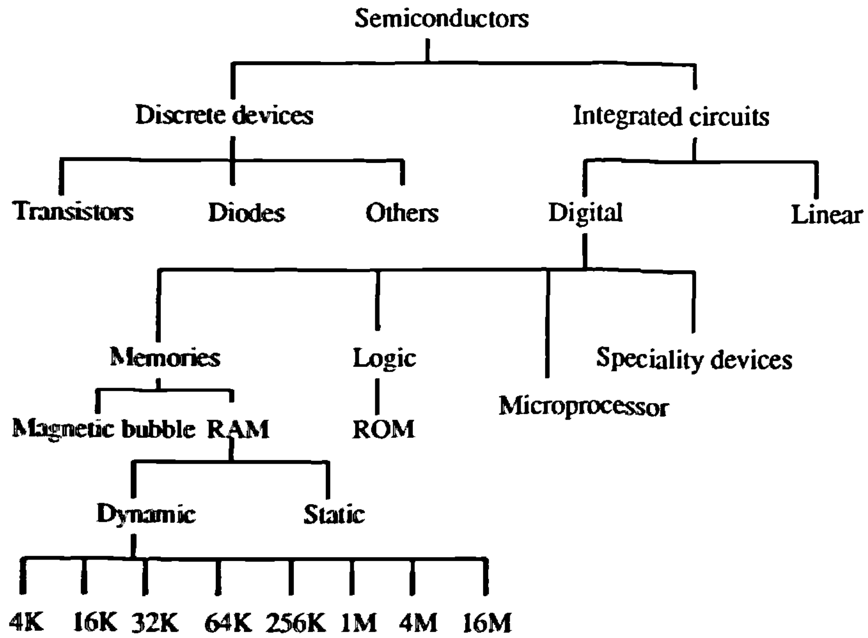


Figure 6-2



It is estimated that ICs will account for 90 percent of total semiconductor industry products in 1990s, in which the products of memories will claim two-fifths. The 256K and one megabit dynamic memories will constitute the key part of the products. It is no exaggeration to say that the electronic industry will be the 'crude oil' of 1990s and beyond.

Technological progress has come thick and fast in electronic industry over last twenty years. From the evolution of the RAM (random access memory) technology we can get a general idea as to how fast the technology has progressed in this sector.

16 K Random access memory was commercially produced in 1980 in Japan and the United States. But in 1984 it was some Japanese producers who first began to produce 256 K RAM circuits. Today most Japanese firms in Japan and some in the United States are able to produce 4 M RAM memory circuits commercially. We know that the RAM circuits is the key part of semiconductor products. They are essential components for computers and telecommunication equipment. A fundamental part of high speed computers is the memory.

Table 6-5 Evolution of RAM circuits

Year	Bit
1966	16 bit
1969	64 bit
1971	256 bit
1974	1 K
1977	4 K
1980	16 K
1982	64 K
1984	256 K
1986	1 M
1990	4 M

Source: EIAJ, 1992.

6.2 Technology Transfer and Development in Japanese Electronic Industry

6.2.1 Shift in Technology Leadership: Ascendancy of Japan

In comparison with Western Europe and the United States, the Japanese electronic industry was backward at the end of the Second World War. Its size was small, and its base was weak. But as early as 1957, the Japanese recognised the important role of the electronic industry and regarded it as a priority sector for development. Since then Japan has implemented a consistent industrial policy and education policy which helped to enhance the development of the electronic industry. Highly effective co-operation between firms and the Japanese government, excellent ability of production and marketing of Japanese producers have accelerated the development of the industry. So within less than three decades, Japan has emerged at the forefront of the world electronic industry.

In the early stage of the industry's development, the British and German were leaders. Marconi and Telefunken together shared the world market before the First World War. The public radio broadcasting was a very important factor which pushed the development of the industry. It originated in 1920s and was widely spread with the encouragement and assistance from the U.S. government. The public broadcasting stimulated the demand for radios and related equipment. In addition, America was a huge market in comparison with small European countries. This enabled American producers to achieve scale advantages and to take the lead in innovation; and the centre of world electronic industry gradually shifted to the United States.

The invention of the transistor was a significant advance of the electronic industry, which was made by Bell Laboratory and pushed the American electronic manufacturers into the position of world leadership. After that, almost all important inventions in semiconductor devices were made in the United States, with a lag of one to four years by European or Japanese manufacturers. The commercialisation and diffusion of new semiconductor devices in the early 1950s and the invention of integrated circuits in the early 1960s enhanced the international leadership of the American electronic industry.

Before the mid-1970s, the American semiconductor industry absolutely dominated the world market. By 1972, U.S. firms accounted for 76 percent of the estimated world semiconductor sales. Entering into the second half of the 1970s, especially into the early 1980s, the dominant position of American semiconductor producers was weakened and declined mainly because of the increasing competitiveness of Japanese producers. In 1979, the world's largest computer manufacturer, the American leading company, IBM, ceded leadership in the world market, dropping behind Fujitsu in Japan. Although U.S. computer manufacturers still retained the largest share of world market, technological leadership was now shared between the Japanese and American industries, and the Japanese had surely gained some important competitive advantages in world market. Exports of integrated circuits by Japan only began in 1973 and remained at a fairly low level until the mid-1970s when exports rapidly increased to US$ 1.8 billion by 1983 (423.8 billion yen) or 38 percent of the production. The growth of exports from 1973-83 was an annual compound rate of 66 percent. In 1979, Japan became a net exporter of integrated circuits, and this marked a significant strengthening of Japanese manufacturers' position in world market, especially for advanced memory devices. Fujitsu led in fielding 64K random access memories (RAM). In 1980, Nippon Telephone and Telegraph, Fujitsu and NEC succeeded collectively in developing the world's first 128K RAM, then 256K VLSI (very large scale integration) chips. In the 'Fifth Generation' of semiconductor devices, technological leadership has shifted from the U.S. to Japan. In 1978, IBM went into the open market for the first time to purchase substantial quantities of the devices from Japanese manufactures. American big firms had to purchase Japanese 64K and 128K RAMs in order to satisfy their customers.

6.2.2 Technology Transfer via licensing agreement

At the early stage of the development, Japanese electronic manufacturers transferred technologies from the U.S. Contrary to the European countries, Japan did not permit U.S. firms to set up wholly-owned subsidiaries in Japan. Texas instruments was the only firm which had gained entry into the Japanese market but only through a joint venture with a Japanese company. Instead of direct production in Japan, most U.S. companies resorted to the sale of technology and in technology licensing policies. At the same time, imports substitution was also adopted in this area by Japanese government. It was believed that these measures reserved the domestic market for Japanese producers and allowed them to reach the required volume threshold to take advantage of learning economies later.

Large vertical integration and broad mix of products strengthened Japanese producers' capacity of transferring foreign technology and developing indigenous technology quickly in the electronic sector.

The extent of diversification of the major Japanese semiconductor producers can be seen by the relatively small share of semiconductors in their total sales. In 1983, four Japanese electronic manufacturers were among the top 10 leading world semiconductor producers, including NEC (Rank 3), Hitachi (Rank 4), Toshiba (Rank 5), Fujitsu (rank 8). A comparison of the share of the semiconductor sales in their total sales between these leading Japanese companies with the leading American companies shows the difference of in the degree of the vertical integration.

As indicated below, the proportion of semiconductor sale of the leading Japanese companies (except NEC) was under 7 percent of their total sales, which was fairly small.

The high degree of vertical integration enabled Japanese manufacturers to carry out huge investment on basic research. The electronic industry is capital-intensive. So

Table 6-6 Share of semiconductor sales in total sales, Japanese and U.S. transnational corporations 1979 (percentage)

Japanese firms	%	U.S. firms	%
NEC	17.8	AMD	89
Fujitsu	6.7	Fairchild	69
Toshiba	5.5	Intel	75
Hitachi	4.1	Mostek	93
Mitsubishi	3.8	Motorola	31
Mashushita	2.3	NSC	85
		TI	36

source: Joint Economic Committee, United States Congress, International Competition in Advanced Industrial Sectors: Trade and Development in the Semiconductor Industry (18th February, 1982)

the huge amount of R&D funds and quick reinvestment are necessary for a firm to hold the technology leadership and gain competitive advantage. Large vertically integrated firms could make these possible. Only the big vertically integrated firms have got strong base for reinvestment. When it is needed, they are able to spend as much money as necessary both on R&D and on new plants and equipment. For example, Mitsubishi Electric of Japan regularly spends 12 percent of integrated circuits sales on research. At the end of the 1970s and the beginning of the 1980s, most major Japanese firms spent as much as 21 percent of current sales of semiconductors on research, and another 22 percent on new plant and equipment. This kind of investment can be done only by highly diversified and vertically integrated manufacturers. Most leading Japanese electronic giants have been using their other divisions to generate cash for investment in semiconductor sector.

The requirement for higher capital expenditure resulted from the increased circuit complexity of semiconductor devices which required more sophisticated equipment in production and even more expensive testing equipment at various stages of production in order to ensure that shipments were of high quality.

Table 6-7 Minimum investment requirements for semiconductor production

Year	U.S.$ required
1954	100,000
1958	300,000
1967	500,000 @)
1972	2,000,000 @)
1976	5,000,000 @)
1978	10,000,000 @)
1982	60,000,000 b)

@) wafer fabrication only
b) total wafer assembly cost

Source: Truel, J. Paris IX, 1980, Professional Press.

Table 6-8 Research and development expenditures in selected high-technology sectors in the United States

	R&D expenditures as % of sales			R&D expenditures as % of profits		
	1978	1982	1983	1978	1982	1983
Aerospace	3.7	5.1	4.6	93.0	167.5	79.2
computers	4.1	6.8	7.2	57.7	73.5	43.7
peripherals services	n.a.	7.2	6.9	n.a.	129.6	68.3
measuring dev. & controls	3.9	5.2	5.4	69.9	122.2	87.9
semicond.	5.8	7.8	8.3	102.3	281.9	neg @)
telecommunications	1.9	1.3	1.5	16.1	13.1	11.0

@) negative pretax earnings

Source: 'R&D Scoreboard', Business Week, 1978, 1983, and 1984.

The costs of research and development have also increased both in absolute and relative terms. Part of this increase in R&D expenditure has resulted from the increased international competition in the industry starting from mid- 1970s, with companies wishing to maintain their 'leading-edge' position placing increased emphasis on R&D. The relative importance of R&D in semiconductor industry can be appreciated when set in comparison with the proportion of R&D expenditures in the sales in other high- technology sectors.

From Table 6-8, we can see that the R&D expenses as percentage of sales for semiconductors is the highest among the six industries selected. As a percentage of profit, the R&D expenses for semiconductors had already passed the 100 percent level in 1978, and it continued to rise to 281.9 percent in 1982. This can be attributed mainly to the rapid increase in R&D costs, fierce international competition, especially from the Japanese, dramatically falling prices of semiconductor products and the squeezing of profit margin since the mid- 1970s.

Although the R&D expenditures as a percentage of sales for semiconductors were not very high, 5.8 percent 7.8 percent and 8.3 percent for 1978, 1982 and 1983, respectively, the American producers were really unable to push this share a little higher, because the 8.3 percent had already driven some of them out of the business. It was in the light of this that the large and highly integrated Japanese producers showed their big advantages. The average investment in R&D by many large Japanese semiconductor manufacturers was approximately 22 percent of their sales, three times as high as that of Americans'. In addition, investments of Japanese semiconductor manufacturers in plant and equipment were running at the rate of another 21 percent of their sales. The resultant improvements in the propensity of Japanese giants to develop new technologies is clearly reflected in the increasing number of patent rights owned by them.

High risk, both technically and commercially, characterises research expenditure in the industry. Projects, with a long development time which have not been technically feasible or have lacked commercial interest, have been common in the industry. On the other hand, as in other high- technology industries, successful technical developments do not guarantee commercial success. Firms vary in their capacity to finance product and process development costs which could be high and risky depending on their size, their cash-flow position and their situation vis-a-vis financial establishments. This capacity has become an important factor in competitiveness in the international semiconductor industry. Large semiconductor firms with a solid financial position often have an advantage. Integrated large firms, as Japanese often are, have the advantages of being able to channel funds from other production areas with good cash-flow position into their semiconductor development.

Compared with their Japanese counterparts, most American firms are small and pure semiconductor producers. They are more concerned with short-- term profitability, because this is strongly related to their share prices. On the contrary, Japanese are more concerned with long- term development and profit making. The growing share of international market and improvements in the technological capability give Japanese enough incentives to invest and reinvest. Negative profit in the short term can be absorbed effectively by their parent firms and totally compensated from the long- term profit making.

Compared with Americans and Western Europeans, Japanese electronic producers appear to be more market-oriented. So Japanese electronic producers are more likely to be sensitive to market changes than their international competitors. The requirements of consumers and the feedback of the market sales have always been dealt very seriously by Japanese producers. The Japanese electronic industry produced a wide range of products-ranging from electronic games to super computers and robots. This broad mix of consumer, office, industrial and medical electronic products provided the Japanese industry with extraordinary flexibility in the market place.

6.2.3 Competition and Survival and Growth of Japanese Electronics Firms

'Cut throat' competition in the international semiconductor market has resulted in crazy prices of many products. For example, average price per unit of transistor was reduced from US$ 23.95 (in 1954), to US$ 1.46 (in 1964), then to US$ 0.27 (in 1972). Another interesting example was the 64K RAM memories. In early 1980, most experts forecasted that 64K RAM memory would be selling for about US$ 50 a unit. In the event, the prices for 64K RAM memory fell below US$ 10 in 1981. The price of a linear integrated circuit was US$ 30 in 1964, but US$ 6.18 in 1967, and only US$ 1.08 in 1972 (see Electronic Market Data Book, 1979, pp. 106-107.). These low prices and the continuous fall in prices squeezed producers' profits all over the world. American and European firms suffered the most because most of them either only or mainly produced semiconductors which made them vulnerable to price collapse. On the other hand, Japanese firms were large, and vertically integrated; and they were consequently able to mitigate the problems by consuming their own semiconductor products. For example, in 1978, NEC consumed 20 percent of its own semiconductor products; Hitachi 28 percent; Toshiba 31 percent; Fujitsu 41 percent. In 1981, a total 304.3 billion yen worth of ICs was used for producing consumer electronic goods such as audio, TV, VCRs, calculators, etc., which accounted for 58 percent of Japan's IC demand by end-use. Among them, audio alone accounted for 15 percent (78.6 billion yen). The corresponding figures for TV, VCRs and calculator/watch were 7 percent (38.2billion), 14 percent (73.5 billion), and 11 percent (58 billion), respectively. (see Electronic Industry Association of Japan, 1983).

The profit squeeze suffered by most semiconductor manufacturers in the United States and the Western Europe, which made it very difficult for them to invest adequately in the sector. This inevitably impeded R&D activity and technology advance. Finally, these manufacturers gradually lost the market share which they held before to the Japanese. With the strong financial support from their parent companies, Japanese electronic producers had managed to live with the falling prices.

The large influx of 64K RAMs in the world market, especially in the U.S. market from Japanese producers pushed down price of 16K RAMs under US$ 1. and put the U.S. 16K RAMs producers almost out of the market. This probably led to Japanese domination of the world 64K and also 256K RAMs production. By the mid-1984, there were five Japanese firms and only one American firm delivering 256K RAMs.

6.2.4 long-term planning and automation

Production automation now plays an increasingly important role in the electronics industry. During the mid-1960s and early 1970s, the increase in wages and the prices of the other input factors induced most major U.S. manufacturers to shift their facilities to offshore production. They made significant investment in developing countries, mainly in South-East Asia. These investments were concentrated on assembly facilities. The very low wages in these countries reduced production costs. Also during the economic recession of 1974-1975, most U.S. manufacturers reduced their capital investment and labour force. This reduced the pace of technology development in the United States. On the other hand, Japanese producers adopted the strategy of automation and assembly lines rather than locating facilities in low wage developing countries. By 1981, Japan employed 70 percent of the world robots. In addition to the high quality consciousness of Japanese labour force, automation had played an important role in increasing yield and improving quality and reliability of the devices. The high degree of automation enabled Japanese producers to bring assembly cost down to the level which was even below that of Singapore and South Korea where wages were very low.

6.2.5 The role of the government

Japanese government has played a very important role in promoting the electronics industry. This can be seen from the following areas.

(a) Direct R&D support

Given the condition of natural resource scarcity, Japan has been keen on energy-saving technologies. As early as in 1957, a special Act was passed to promote the electronic industry in Japan. Since then many research projects have been taken under the guidance of the MITI and funded by the Japanese Development Bank. The first giant project, called 'super High-performance Electronic Computer Systems' project, came into seeing during 1966- 1972. The JDB provided the funds of US$ 30 millions. During the 1970s and 1980s, Japanese government gave many more direct R&D supports. Some of these are listed below.

Table 6-9 Government R&D assistance, Japan

Date	Project	US$ million
1975-81	LSICs for computer, tele-communications & microwave	180.00
1976-79	VLSI	121.20
1980-91	Optoelectronics	77.50
1982-90	Supercomputer	92.30
1982-89	New Function Elements	100.40

Source: Japan Electronic Almanac, 1990.

(b) Home market protection and licensing control

MITI has been a key player in the technology transfer and development in Japan. Without its approval, no technology can be imported and no joint venture can be guaranteed. The MITI scrutinises all technology importing contracts with the aim, inter alia, to lower royalties and seek the favourable terms for Japanese companies, and more generally for the Japanese economy.

Facing superior American technology and giant firms, most developed countries had taken special measures to protect their own electronics industries, classified as 'infant industry'. This seemed reasonable and to some degree justified. However, the approaches adopted by Japan were tougher, such as ban on wholly foreign-owned firms, quotas on electronic- related imports and tight license control. From 1950 to 1972 Japan received 17,600 licensing agreements for US$ 3.3 billion in royalties. By 1980 the figure had risen to over 25,000 contracts for US$ 6 billion. (see Jakahasa Nakamura, 'The Post-war Japanese Economy', P.450). It is believed that Japan had saved billions of dollars by importing foreign technologies through licensing agreements instead of developing them.

The Foreign Exchange and Foreign Trade Control Law of 1949 and the Foreign Investment Law of 1950 gave the government power to control trade, investment, and economic development. Foreign investment was only allowed in the form of minority-owned joint ventures with Japanese firms. Facing these harsh restrictions, only 101 firms invested in Japan a total of US$ 59.7 millions during the 1950s (see Dan Okimoto and Gary Saxonhouse, 'Technology and the Future of the economy' in Japan's Political Economy, P.393).

During the late 1950s, IBM tried to enter Japan as a Yen- base (agreed not to repatriate any profits abroad) company, but was permitted to operate only under harsh conditions that would eventually strip its existing comparative advantage. MITI Vice-Minister Sahashi made it very clear that the entry price was IBM patents. He told IBM that MITI would take every measure possible to obstruct the success of its business unless it licenses its patents to Japanese firms and charges them no more than a 5 percent royalty. 'We do not have an inferiority complex toward you; we only need time and money to compete effectively' (see Thomas Pugel, 'Access to Japanese Markets' P.148).

During the 1960s and the mid-1970s, domestic electronic producers had been effectively protected by Japanese Foreign Investment Law from foreign competition.

Japanese market was almost entirely closed to foreign investment. In addition, strict quotas had been imposed on some electronic-related imports, especially on integrated circuits and some more technologically advanced products. It is believed that these measures provided the Japanese producers with a favourable condition and precious time to take off as they did in the late 1960s.

Foreseeing the potential growth of the Japanese market, some foreign companies did try very hard to invest in Japan. For example, Texas Instruments applied to Japanese government to set up a wholly-owned subsidiary in Japan in the early 1960s. The application, however, was entirely rejected by Japanese government. Instead, an offer was given to Texas Instruments to set up a joint venture with a domestic firm in which the TI would hold a minority share. Obviously Texas Instruments did not take the offer. However, both sides did agree to carry on the negotiation, which, unfortunately, was soon rocked and kept in deadlock because of the inflexible attitude of the Japanese government. With advanced technologies in its hands, Texas Instruments retaliated by refusing to license them to any Japanese firm. This, however, was not very effective. Several years later, many Japanese electronic firms were able to manufacture integrated circuits and export calculators and other equipment incorporated with ICs to the American market. The situation began to change later, and some legal considerations forced Japanese government to make some concessions. But it was Texas Instruments which made more concessions by dropping its requirement of 100 percent ownership and set up a 50-50 joint venture firm with Sony Company. Moreover, some additional conditions had also been fulfilled by Texas Instruments, including the promise to license its technologies to other Japanese firms, such as Nippon Electric; Hitachi; Mitsubishi and Toshiba. And Texas Instruments also had to restrain its sales in Japan so that 90 percent or more of the Japanese integrated-circuit market would be left to Japanese firms.

Before the mid-1970s, no wholly foreign owned electronic firm had been set up in Japan. Even the 50-50 joint venture, like the privilege granted to Texas Instruments, was a special case. Actually, very few firms were given the permit to hold more than one-third interest. For example, Philips held a 30 percent share in the joint venture with Matsushita Electronics; Raytheon with a 33 percent interest in the New Japan Radio Company, and International Rectifier with a 39 percent interest in the International Rectifier Corporation of Japan. ITT held a 12 percent share of Nippon Electric, and General Electric a 10 percent share of Toshiba (see Japan Electronics Industry Association, 1986).

Reaching a licensing agreement in Japan was never an easy job. No licensing agreement can become valid until the government approved it. Japanese government often turned down the licensing agreements which they thought had asked too high royalty fees. The monopoly power gave the government real bargaining strength. Often the foreign licensors lowered their royalty fee and sometimes made other necessary concessions. The Japanese licensees, as well as the Japanese economy as a whole, did benefit a lot from the government approval system. It is unfair to say that the Japanese government was always too stubborn and too inflexible. When necessary, the government of Japan did allow the domestic licensees to pay high royalties. For example, all integrated circuits producers in Japan paid 10 percent of their sales to their foreign licensors--2 percent to Western Electric, 4.5 percent to Fairchild, and 3.5 percent to Texas Instruments (see 'Major Japanese firms win better deals from U.S. Ties'. Electronic News, Mar. 24, 1969, P.32).

Another characteristic relating to the licensing approval system was that the foreign licensors should promise to license their technologies to all firms who required them. The royalty fee should be charged at the same rate to all Japanese firms, regardless of whether they were big or small. This was an unique Japanese way of doing business. The conventional practice elsewhere is that the negotiation of a licensing agreement will be conducted on the firm by firm basis, and normally the established firms with important patents and large R&D operations are allowed to pay lower royalties than the smaller ones. But this was not the case in Japan. For example, Western Electric charged all its Japanese licensees 2 percent of semiconductor sales. At the first glance, it seemed that only the small firms were the beneficiaries of the measure. However, a further examination shows that this measure actually promoted competition between Japanese firms. Its effect was far more reaching. We know that the electronic industry, especially the semiconductor sector, is highly knowledge-intensive and advances very rapidly. Technology invention, innovation and diffusion are vital factors for any company's survival in this industry. A firm's market share is closely related to its level of technology and its capability of managing technological progress. However, without the fierce competition from the small and new firms (they are usually the more dynamic forces in the sector), the few giant firms might have become insensitive to invention and innovation elsewhere to be able to survive in the world market. The measures adopted by Japanese government gave the same opportunity to all domestic firms-giant or small, well established or newly set up-to compete technologically for world market share. This did promote the competition between the firms and improve the production efficiency of the whole Japanese electronic industry. Some new firms did achieve a remarkable growth, Sanyo was a typical case.

(c) Tax incentives and financial assistance

The Japanese government had extensively used many different tax measures to influence, encourage and promote the development of the domestic electronic industry. The aggressive depreciation, tax free reserves (which was mainly used for future investment) and tax credits were the forms mostly used by the government. Besides these, the government supported the R&D programmes by providing interest-free loans. And many more projects had been funded by long-term and low-interest rate loans. The willingness of sharing investment risks by the government not only boosted private firm's confidence but also reduced their financial burden. As a result, more and more private capital became available for technology transfer and also indigenous R&D activities.

In order to encourage diffusion of semiconductor applications and bring costs and prices down the learning curve as quickly as possible, many tax incentives had been adopted. For example, in the early years of color television the Japanese government allowed reduction in high commodity tax on all colour television sets incorporating microelectronic devices. Japanese consumers benefited from the low prices, which in turn stimulated demand and production. As a result, manufacturers had been strongly encouraged and influenced to adopt new technologies and make innovations both in semiconductor devices and final equipment design. Increasing use of integrated circuits had the effect of reducing the number of electronic components, which gave the automation assembly and testing operations good opportunities to substantially improve the reliability of the end product and to increase competitive advantages. The research results (including technology inventions and innovations) through the government funding can be licensed to any firms. This was also important for promoting technological progress in the whole economy. The objective of government policy was to create an attractive and favourable investment environment. Its suggestions about R&D direction were based on extensive consultation with major firms. The specified R&D projects had been designed and carried out mainly by private firms themselves. When some technology inventions and innovations became available, it was up to the firms to decide whether they were economically feasible. The duty of the government was to keep its relevant agencies make and co-ordinate the general policies. Dangers of overall systems inefficiency were largely obviated by leaving the final decision making to the entrepreneurs and the market place.

(d) Purchasing policy.

Direct purchasing of end-use electronic products was a very effective way and had been used by many governments in the developed countries. In the United States, military purchasing and space programmes in the 1950s and 1960s had played a significant role in the development of domestic electronic industry. In France and the United Kingdom, the military purchasing created a market with relatively effective size and provided an opportunity for the growth of their electronic industry. The situation in Japan was different. Because of the limited size of army forces and military pact signed with the United States, the military purchasing was not a key factor in the development of the Japanese electronic sector. However, government purchasing for office equipment and automation did produce a very positive effect on the development of the industry. The procurement of 'IC-intensive' products made deliberately by the Nippon Telephone and Telegraph (under the strong influence and encouragement of the government) was another important contributor. The telecommunication and information processing industry of Japan expanded remarkably over last three decades. Public purchasing of electronic related products was one of the most important means of direct government support for the industry, which had helped firms greatly to acquire volume on which learning economies depended, reduce the risk and increase the profitability.

(e) Organising and guiding co-operative R&D.

Besides the financial support and tax incentives, the government of Japan has been actively involved in carrying, organising, guiding and co-ordinating R&D activities. There were several government research laboratories. They were very famous and provided with the most advanced equipment in Japan. Their prestige and modern facilities attracted many brilliant scientists. The research projects carried out at the laboratories were mainly basic-science oriented. The research results from these laboratories would become public properties and available to all firms. From the national point of view, conducting the research projects with basic science orientation and strategic importance in government-run laboratories were desirable. Avoiding the possible duplication research by different private firms, reducing their requirement on general research budget and shouldering the research tasks which might not be economically feasible from the individual firm's point of view, were the real purposes of the national research programmes. Joint government- firm research was another form of state involvement in R&D activities in Japan. Most research projects in the joint government-firm form were applied research oriented. They were also closely connected to the government purchasing policy and requirements. Through the procurement and joint research effort, the government of Japan actually influenced, encouraged and promoted the research activities among the private firms.

Co-ordinating national R&D efforts towards the common national goals was perhaps the most important role that Japanese government had played in the R&D sector. During 1950s and 1960s, there was a huge technology gap between Japan and the United States. So transferring technologies instead of creating them was the more effective and efficient way to develop Japanese electronic industry. As the technology gap narrowed and Japanese competitive capability increased, the leading American firms became reluctant to transfer their key technologies to the Japanese. This forced many Japanese firms to spend more and more on their own R&D activities.

Innovation has played and will continue to play a very important role in the rapid expansion of electronic industry, especially the semiconductor industry. Having innovation lead, even a six month lead, was important in terms of increasing market share and profitability. However, the technologies were becoming more and more complicated and the research outlay for a single and important research project was becoming increasingly large. Besides, the degree of uncertainty in the direction of any important technology development and its future profitability had been greatly increased. The huge capital requirement and great uncertainty were most likely to bar any single firm from taking ambitious research programmes in many strategically important areas. Thus co-ordinating research programmes in the strategically important areas at the national level were becoming extremely desirable and important.

The first nation wide co-operative research program began in the early 1970s. The law for provisional measures to promote specific electronic and machinery industries

(Public Law 17, 1971) had encouraged and stimulated the co-operation. The government guidance and financial assistance strengthened the co-operative activities. In 1977 three co-operative research associations were formed for specialised development of logic devices. The firms involved were: Nippon Electric Company (NEC) and Toshiba, Oki and Matsubishi Electric, and Fujitsu and Hitachi (see Japan Electronics Industry Association, 1988).

Apart from making strategic policies and co-ordinating the key research projects, the government of Japan had also provided huge financial support for the research projects. For example, only to the VLSI project alone, the government funded US$ 11.5 million in 1976; US$ 31.4 million in 1977; US$47.1 million in 1978; and US$ 31.1 million in 1979. The very large scale integrated circuits (VLSI) project began in 1975. It was aimed at creating new IC technology, such as 256K RAM technology. This project was initiated and encouraged by MITI and in conjunction with Nippon Telegraph and Telephone. Five key Japanese electronic and also computer producers took part in: Fujitsu, Toshiba, Mitsubishi, NEC and Hitachi. The research results of the co-operative project were made available to the two groups of firms to develop applications. The interest free loans provided by MITI for the project were supposed to be refunded when the technologies were further developed, commercialised and became profitable.

The key characteristic of the co-operative research project was that every participating firm took it very seriously and with sincerity. They provided their best scientists and engineers in the research team and gave them full support. Because all firms knew very clearly that the new VLSI technology was fundamentally important to all. Facing the huge capital requirement, no single firm alone could undertake such an ambitious research project. Moreover, without technological leadership in this strategic area, all Japanese firms would suffer. The MITI, as a co-ordinator made this co-operation workable and effective. National consensus among the key firms strengthened the the co-operative activities. As a result, the research programme had produced more than 1000 patents. This certainly put Japanese firms at the leading position to first produce 256K RAM ICs and enjoy the lion's share of the world market.

(f) Competition Promotion

As a result of government policy, Japanese firms had been well protected from foreign competition. In order to improve the production efficiency of Japanese firms, the government had adopted measures promoting competition among Japanese firms. First, it made all research results from the government-run laboratories available to all firms. Second, it provided all Japanese firms, big or small, new or old, with the same right of getting the same foreign technology licensing at the same level of royalty payment. Third, it banned firms from establishing a monopoly position. As a result, no Japanese firm could take a lion's share of any product.

(g) Education policy.

To pursue its goal of industrialisation, the Japanese government has given priority for promoting engineering education, especially electrical and electronic education.

As a result, engineering education in Japan expanded very rapidly in the 1950s and the 1960s. As early as 1970, Japan had already had more degree holders in engineering than the United States. By 1979, Japan produced 60 percent more graduates of electrical and electronic engineering than the United States. In 1977, Japan had almost three times as many electrical and electronic engineers as the United States for per million of inhabitants. The relevant figures were four for Britain and six for France. West Germany produced nearly 60 percent as many as Japan. From 1967 through 1979, the number of engineering graduates in Japan grew at 7 percent annually. In the United States, on the other hand, the total number of engineering graduates during the same period grew at the rate of 2.4 percent. While the turnover of electrical and electronic engineering graduates in Japan increased at the rate of 7.2 percent per annual, it actually continued declining at the rate of 2.9 percent per annual in the US during the 1970s. The following two tables compare the annual turnover of graduates in electric and electronic engineering between Japan and other advanced countries.

Table 6-10 The Total Number of Electrical and Electronic Engineering Graduates in Japan and the United States, 1969-1979

	United States		Japan	
Year	B.S. only	B.S.,M.S.,Ph.D	B.S. only	B.S.,M.S.,Ph.D
1969	11,375	16,282	11,035	11,848
1970	11,921	16,944	13,085	13,889
1971	12,145	17,403	14,361	15,165
1972	12,430	17,632	15,361	16,052
1973	11,844	16,815	16,205	17,345
1974	11,347	15,749	16,140	17,419
1975	10,277	14,537	16,662	18,040
1976	9,954	14,380	16,943	18,258
1977	9,837	14,085	17,668	19,275
1978	10,702	14,701	18,308	20,126
1979	12,213	16,093	19,572	21,435

Source: Engineering Manpower Bulletin (USA)

It is no exaggeration to say that the government of Japan has played a significant role in developing and co- ordinating a coherent education policy, which consequently served the country's industrial policy quite well. Over the last three decades, the tertiary sector in Japan has provided the electronic industry with abundant highly qualified manpower. This makes an interesting comparison with the United States where the electronic industry faced a serious shortage of supply of high level human capital. The availability and quality of high level human resources has been crucial for the successful technology transfer and development in the Japanese electronic industry.

Table 6-11 Graduates in Engineering and in Electrical/
Electronic Engineering (per million inhabitants)

year	item	France	Japan	U.K.	U.S.	W.Germany
1965	Engineering	20	82	32	--	16
	Elec/Elec. Eng.	157	323	145	262	56
1970	Engineering	34	133	46	85	11
	Elec/Elec. Eng.	181	508	205	313	43
1975	Engineering	28	162	45	67	48
	Elec/Elec. Eng.	179	646	213	308	193
1977	Engineering	33	185	46	66	109
	Elec/Elec. Eng.	186	711	256	314	438

Source: International Financial Statistics Year-book, 1980.

6.2.6 Technology Advance and Market Expansion

Government support, guidance and co-ordination of private R&D and a strong consensus of close public-private co-operation helped to create a favourable environment for Japanese electronic firms. Investment in R&D and new equipment has been on the increase since the mid-1970s. The technological gaps between Japan and the United States meant that Japan had to depend on technology importation before 1975 and on increased indigenous R&D activities and extensive international technology exchanges since 1980s. It is believed that Japanese electronic industry is now on the cutting edge of technological progress. Technological advance has been responsible for the quality improvement and the cost reduction of Japanese products, which surely helped them to increase their share in the world market dramatically. From 1975 to 1985, Japanese electronic industry achieved a remarkable production increase of 311 percent (from 4,361.9 billion Yen to 17,932.7 billion Yen) and an export expansion of 497 percent (from 1,704 billion Yen to 9,872.7 billion Yen).

(a) Technological Advance in Japanese Semiconductor Industry

Japanese electronic firms were emerging as world technology leader in VLSI area in the late 1970s. It was the Japanese who first began the production of 256- kilobit dynamic random access memory (DRAM) in the early 1980s. By 1985, many Japanese firms had entered mass production stage. As a result, the lion's share of the world market for 256-kilobit DRAM went to the Japanese. In other areas, such as 256K static RAM (SRAM), one- megabit erasable programmable read only memory (EPROM), Japanese had also made big progress. The technological advance from 256-kilobit DRAM to one-megabit increased the number of elements integrated on a square chip of less than 10mm per side from 600,000 to over 2 million. By 1986, many Japanese firms had already reached the production stage of one megabit DRAM (see the Electronics Industry Association of Japan, 1988).

Standardisation, customisation, miniaturisation and automation are the major characteristics in the LSI area. Many end users today not only use universal ICs but also the custom-made devices. Japanese semiconductor firms responded very quickly to the change in demand structure and developed many kinds of semi-custom devices, such as gate arrays and standard cells which are located between gate arrays and full-custom LSI and VLSI. More and more electronic components and devices have been produced in the chip form. Automatic assembly equipment has become available in a greater variety. Surface-mounting technology has been firmly established.

Technological advance helped Japanese firms to produce a great variety of high quality ICs. The rapid expansion of storage capacity enabled them to lower the price per bit. This gave Japanese manufacturers a great advantage to penetrate world market, especially the U.S. market. The rapid growth of production and export, which was, to some extent, prompted by aggressive export promotion methods, produced huge anxiety among the West, especially the United States, who were tempted to accuse Japan of 'chips dumping' in the world market. The availability of high quality and low price memory devices did not only help the Japanese to increase the export of their ICs products but also many information machines, high-function and low-price computers and high-integration and high- performance models of 16-bit microprocessors. From 1975 to 1984, the Japanese ICs exports saw a 5,654 percent increase, from 13,498 million Yen in 1975 to 776,775 million Yen in 1984. The corresponding rate for computer export was 3,300 percent, from 31,956 million Yen to 1,086,595 million Yen.

Table 6-12 Exports of ICs by Japan, 1975- 1984 (million Yen)

1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
13,498	22,723	31,682	52,221	108,298	183,306	199,640	285,112	423,836	776,775

Source: EIAJ, 1988.

Table 6-13 Exports of Computers by Japan, 1975-1984, (million Yen)

1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
31,956	43,332	44,084	71,379	82,254	123,448	195,513	343,123	679,487	1,086,595

Source: EIAJ, 1988.

The production of semiconductors and ICs both in terms of volume and value has increased very fast in Japan since 1972, and for many years at an annual rate of over 35 percent.

Table 6-14 Production Trend of Semiconductors and ICs in Japan

year	production value (million Yen)	change in volume (%)	change in value (%)
1971	43,191	90.1	90.8
1972	58,969	153.8	136.5
1973	94,635	158.2	160.5
1974	109,893	113.5	116.1
1975	104,746	98.9	96.3
1976	176,217	206.7	168.2
1977	185,233	121.4	105.1
1978	251,690	147.7	135.9
1979	343,202	151.3	136.4
1980	515,624	150.1	150.2
1981	621,968	131.1	120.6
1982	743,813	125.2	119.6
1983	1,039,293	142.6	139.7
1984	1,828,019	154.2	175.9

Source: MITI, 1988.

The rapid technological advance in Japanese semiconductor sector had totally reversed the ICs trade between Japan and the United States. Before the mid-1970s, the superior technology guaranteed American firms a monopoly position in the world market and Japan had a big trade deficit with the United States for many years in this sector. Even in 1979, the United States still exported 77.3 percent more to than that it imported from Japan. However, since 1980, the trade balance between the two countries in ICs products has been favourable to Japan. In 1984, Japan exported 127.5 percent more than what it imported from the United States- and this, in spite of an impressive 120.8 percent of increase of American exports to Japan between 1979 and 1984. It is very clear that the technology leap-frog during the 1980s gave Japanese producers a big advantage to gain a larger market share both in the world and in the United States.

Table 6-15 Exports and Imports of ICs to U.S. by Japan (million Yen)

items	1979	1980	1981	1982	1983	1984
export	418	724	712	1,168	1,843	3,722
to U.S.	241% @	173.0%	98.4%	164.0%	157.9%	202%
import	741	696	705	835	1,076	1,636
from U.S.	182.0%	93.9%	101.3%	118.5%	128.9%	152%

Source: Ministry of Finance of Japan, 1988.

Notes: @ as percentage of the value of the privious year.

Table 6-16 Exports and Imports of Computers from and to the United States by Japan (million Yen)

items	1979	1980	1981	1982	1983	1984
export	270	349	716	1,583	3,859	6,524
to U.S.	109.8%@	129.1%	205.2%	221.1%	243.8%	169.1%
import	849	1,142	1,083	1,192	1,285	1,746
fr U.S.	145.4%	134.5%	94.9%	110.1%	107.8%	135.9%

Source: Ministry of Finance, Japan, 1988.

Notes: @ as percentage of the value of the previous year.

Rapid technological advance in Japan had changed the whole picture of the bilateral trade in computers and industrial electronic equipment between Japan and the United States. In 1979, the United States exported to Japan 214.1 percent more computers than what imported from Japan. However, in 1984, Japan enjoyed a 273.7 percent trade surplus with the United States. Japan also transformed a 30 percent trade deficit in the industrial electronic equipment with the United States in 1979 into a 450 percent high trade surplus in 1984. This demonstrated that the Japanese could now compete effectively with their American counterparts both in quality and price terms. Even before the mid-1970s, Japan had a considerable trade surplus with the United States in consumer electronic goods. The newly established Japanese advantages in ICs, computers and industrial electronic equipment had worsened America's trading position. Hence, America had an annual 50,000 million US dollar trade deficit with Japan in the mid-1980s.

Table 6-17 Exports and imports of industrial electronic equipment from and to the United States by Japan (million Yen)

items	1979	1980	1981	1982	1983	1984
export to U.S.	1,211 120.2%@	1,676 138.4%	2,905 173.3%	4,887 168.2%	7,975 263.2%	13,058 163.7%
import fr U.S.	1,548 133.5%	2,047 132.3%	2,053 100.3%	2,394 116.6%	2,340 97.7%	2,894 123.7%

Source: Ministry of Finance, Japan, 1988.

Notes: @ as percentage of the value of the previous year.

(b) Technological Advance in Electronic Components

Technological advance in the area had been moving towards to the high-efficiency and low cost components. More and more mechanical and functional components have been improved, modified, or totally redesigned because of the higher and stricter requirements for their configurations and functions. Low cost was achieved mainly through the economic use of printed circuit boards and block module techniques. Rapid advance in surface-mounting technology was another key contributor. It also stimulated the wide- spread use of automatic assembly process, including automatic component insertion and component mounting. For instance, switch makers in Japan have developed new products with the same configuration and the same terminal pitch in the area of dual in-line package (DIP) switches. As a result, it is increasingly common for DIP switches to be automatically inserted on printed circuits boards. The technological development allowed Japanese producers not only to automatically mount semiconductor devices and circuit components but also mechanical devices.

Automation was not only influenced and stimulated by the requirement of high-quality and low cost but also forced, to some extent, by the unique nature of the production processes of some components and devices. For example, in the connector production area, because of the trend of miniaturisation and efficient use of the printed circuit boards, many new connectors were designed to reduce their height dramatically. It was very difficult to manually mount them to printed circuit boards. Another example is the production of switches whose stricter requirement for higher reliability made automation an indispensable condition.

There were many other extraordinary technological achievements in Japanese electronic industry in 1980s. The replacement of bulk magnetic head by new 'thin-film' head, and powerful motors by intelligent motors were among them. The new 'thin-film' heads were used in office automation and computers as well as in audio equipment and VCRs. The intelligent motor represented the fourth generation products in the micromotor field. It also achieved a marvellous combination of both electronic technology and motor technology. The new products had been designed to meet user needs for high-performance, low-power consumption, thin, light weight and low-noise characteristics.

(c) Technological Advance in Automatic PCB Assembling

Japanese electronic producers had been very keen on making technological progress in automatic printed circuit board (PCB) assembling. Great efforts had been made both by components producers and automatic equipment manufacturers. As a result, assembly operation costs had been further reduced and product reliability had been considerably increased. New production techniques and methods had been widely diffused. To miniaturise and enhance the stability of their products, Japanese producers adopted models of packaging components which were compatible with automatic assembly. This greatly encouraged the utilisation of automatic assembly technology. Because of the rapid technological advance, automatic PCB technologies can be now used in all areas of components and devices assembling in Japan. Surface- mount technology has also reached a very high level of sophistication in the production of consumer electronic machines. Universal versatility has been achieved for automatic mounting machines, automatic soldering machines for assembling consumer electronic products. According to the report of Japan Printed Circuit Association, Japan had a total of 3,590 automatic inserting and mounting machines in 1984, which was expected to reach to 6,375 in 1989.

In the area of automatic soldering, many modifications had been done to improve the old flow soldering system. In the meantime, new reflow system had been developed. The reflow system had been invented to deal with the printed circuit boards with a high density of electronic components and devices.

There are two different automatic inserting systems, axial and radial systems. The axial inserting system is very powerful, capable of dealing with more than 250 different kinds of components at different insertion pitches and depths. Rapid technological advance and improvements enabled the axial system to insert about 35,000 axial components per hour. This was real incomparable with manual mounting. Radial components inserting machines had not reached such a high speed, however, and it can handle only seven components per second.

(d) Technological Advance in the Passive Components and Chip Component

Both the active and passive components had already entered the 'chip era'. Because of technological progress, the total cost of SMT-compatible mounting systems has been dramatically reduced. So now even the discrete components for consumer products are being replaced by chip components. The resistors, capacitors and transformers, which are main compositions of passive components, are now available at the full variety of chip forms. Furthermore, the size of the chip components had been considerably reduced. The power consumption and cost had been lowered continuously. The size of chip coils had been reduced from 4-mm square to 3.2 mm by 1.6 mm. In addition, ferrite head cores, crystal units and display units were also available in chip forms. It was once thought very difficult to develop a chip crystal unit since the package was required to provide space inside to allow vibration of a crystal chip. However, technology for sealing a small crystal chip with ceramic resin, glass or other sealing materials has been developing since, making it possible to commercialise a chip crystal unit with a minimum size of 12mm by 5.4mm by 3.2 mm. The size of the leading capacitor had been reduced from 3.2mm by 1.6mm to 2mm by 1.125mm. Furthermore, models with a size of 1.6mm by 0.8mm as well as super-low profile products are beginning to be offered on the market.

Production of Japanese electronics industry (1976-1985)

Year	Production Growth	Export Growth
1975-1976	--	62.3%
1976-1977	3.6%	1%
1977-1978	5.7%	-1%
1978-1979	10.3%	16%
1979-1980	22.4%	34%
1980-1981	20.0%	23.7%
1981-1982	5.2%	7.3%
1982-1983	16.5%	19%
1983-1984	32.4%	31.6%
1984-1985	6.1%	10%

Source: EIAJ, 1988.

Technological advances in the above areas gave Japanese electronic producers many competitive advantages over their foreign competitors and stimulated the demand for Japanese products both at home and abroad. As a result, both production and exports of Japanese electronic industry expanded rapidly.

Technological progress in the production of VCR

As early as 1975, two distinguished Japanese companies, Sony and Victor Company of Japan developed and introduced Video Cassette Recorder (VCR). The format systems of the VCR products were different, with Sony developing Beta System and Victor the VHS (Video Home System). After the commercialisation of the VCR on the world market, VHS were becoming more and more popular. After the Beta and VHS systems, Philips, the giant European electronic producer, presented a third format system- VD-2000 (philips). These three systems were not mutually compatible. The VHS format is now dominating the world market, Beta format began to lose its market share to VHS many years ago. The VD-2000 system was only capable of penetrating the European market, though even there it cannot compete with the VHS system.

VCRs has been the most important Japanese consumer electronic product since mid-1970s. The total number of home VCRs in 1984 reached 28,610,000 units, an sharp increase of 57.1 percent over the previous year. To Japanese consumer electronic producers, the period of 1950 through mid-1960s was the era of transistor radios, the mid-1960s to mid-1970s was the era of televisions and tape recorder players. The period starting from the mid- 1970s could be called 'VCR age'. The total production value of VCRs had overpassed 1,000 billion Yen in 1981, which recorded as number one in Japanese consumer electronic sector. In 1984, the production value of VCRs unbelievably doubled its 1981 record, reaching 2,000 billion Yen, which was equal to the total value of Japan's entire consumer electronic production in 1975. In 1985, the total production of VCRs in Japan saw another record high of 31,500,000 units.

The export increase of VCRs has been even more impressive than its production since 1975. An export increase of 5,134 percent had been achieved by Japanese VCR producers from 1976 to 1984.

Table 6-18 Export of VCRs by Japan 1976-1984 (million Yen)

1976	1977	1978	1979	1980	1981	1982	1983	1984
30,965	65,924	126,056	222,398	443,627	853,505	1,079,411	1,260,764	1,620,668

Source: Ministry of Finance, Japan.

Since mid-1980s, the appreciation of the Yen and the fierce competition from other countries, especially from South Korea, have forced Japanese to upgrade their VCR products quickly. The massive investment on R&D and on production equipment have led to the rapid technological advance in Japanese semiconductor, especially ICs sector, which in turn helped Japanese VCR producers to reduce the cost and to improve the quality of their existing products and also to introduce many more up-market models. As a result, Japan's monopoly position in the world VCRs market has been greatly strengthened.

The rapid adoption of advanced digital technology added many very attractive functions to Japanese VCR products. The capability of reproducing jitter-free, freeze-frame still and slow motion pictures were among the most admirable new features. Moreover, a brand new graphic timer system was also introduced. This made a automatic time-recording much easier than before with the great help of the bar codes and a light-pen.

The new generation of VCRs had widely used the VLSI technology, such as 256K-bit DRAMs as well as 64K-bit DRAMs for its digital processing system. The new VLSI technology helped the Japanese VCR producers to achieve new features mentioned above by its great storage capacity of the new DRAMs ICs, which were able to store and retrieve the whole information needed for one TV frame of image. This technological breakthrough granted the new models of VCR a capability of reproducing freeze- frame still picture completely smooth. Moreover, there were many other new functions becoming available, including split-screen, reproduction and picture-in- picture capability, which enabled people to watch two screen images at the same time. These two images came from two totally different sources and one of them will be highlighted through a small screen window.

New time-recording technologies were mainly attributed to two Japanese companies, Toshiba and Matsushita. They both had made great effort on developing new time-recording system. Toshiba invented a digital graphic timer, which was used with the combination of a light pen. And Matsushita developed a digital scanner combining with bar codes. Their inventions had represented an excellent combination of digital and optical technologies and significantly simplified presetting procedure. Unlike Toshiba and Matsushita, NEC had directed great efforts on digital noise reduction. As a result, NEC invented a dubbed 'Noise Wiper', which dramatically reduced spike and beat noise with a maximum improvement factor of 9 dB in S/N ratio.

In the early 1980s, Hi-Fi models of VCR became available, which greatly improved the sound quality. By the end of 1986, the total number of Hi-Fi VCR delivered to the market was estimated as 50 percent of all shipments. In 1986, a new and very advanced random access system had been introduced by most VCR producers in Japan. By using this system, we can locate the beginning of any earlier recorded programmes very quickly and randomly. The random access operation can be used in program playback and also various search operation. In 1987, super-VHS model had been introduced into the world market. This was another technological progress in VCR area by Japanese producers. The S-VHS model VCR had dramatically improved the picture quality by adding a more than 400 horizontal line resolution.

Summaries and Conclusions

The Japanese government has played an important role in promoting the country's electronics industry over the past three decades. To provide R&D assistance has been the most effective way. Through home market protection and licensing control, the Japanese government has been able to not only approve or disapprove certain foreign technologies, but also effectively seek lower royalties and other favourable terms for domestic companies. The failure of foreign, especially the American firms to set up wholly-owned subsidiaries until mid-1970s showed the toughness and effectiveness of the Japanese policies. In fact, 50-50 joint ventures in the electronic sector were very rare. The special measure to make foreign licensers promise to license their technologies to all firm at the same rate of royalty payment is very effective for enhancing competition between the domestic firms. The tax incentives and financial assistance are also desirable and useful measures to influence, encourage and promote the development of the electronics industry. Among them, the aggressive depreciation, tax free reserves and tax credits were the forms mostly used by the Japanese government.

Based on its extensive and constructive consultations with major firms and leading research institutions, the government has been able to give financial support to many important research programmes effectively and efficiently. However, the specified research projects have been designed and carried out mainly by private firms themselves. When some technology inventions and innovations became available, it was up to individual firms to decide whether they were economically feasible. The duties of the government were to create a favourable investment environment for investment for R&D, invention and innovation and to make and co-ordinate science and technology promotion policies at the national level. The government of Japan, like its counterparts in many developed and also developing countries, has widely used purchasing policy to promote the domestic electronics industry. However, the military purchasing has never played an important role in the development of the Japanese electronics industry.

To some huge and strategically important research projects, especially in the areas of basic and applied research, effective and efficient co-ordination at the national level by government agencies, leading firms and key research institutions appears to have many advantages. This could avoid the possible duplication research by different private firms, reduce their budget constraints and uncertainty about the projects which might not be economically feasible from the individual firm's point of view. Some evidence have shown that Japan has done very well in this area. The VLSI research programme is one of the examples. Moreover, Japanese government has also played a significant role in developing and co-ordinating a coherent education policy, which has served the country's electronics industry well over the past three decades. The fact that Japan had almost three times as many electrical and electronic engineers as the United States for per million of population in 1977 had already shown this.

Rapid expansion of both production and export of Japanese electronics industry over the past two decades is closely related to the quick technological advance. Behind this lies the firm commitment to and huge financial inputs for technology transfer, innovations and inventions. Many new technologies have been created by Japanese firms since mid-1970s. Continuous and sharp rise in R&D spending and vigorous pursuit of research projects by leading domestic firms seem to be paid off. New technologies have helped Japanese not only reduce their production costs and improve quality but also create many new and attractive products. This has also greatly enhanced the competitive edge of Japanese firms over their competitors, especially Americans, in both international and U. S. markets.

Chapter Seven

The Experience of Technology Transfer and Development in South Korea with Particular Reference to the Petrochemical Industry

Introduction

The first section of the chapter will briefly discuss the technology transfer in South Korea over the past three decades. The effort will be made to examine the scope and the general pattern of the transfer. However, the main purpose of the chapter is to explore technology transfer and development in the Korean petrochemical industry. It is found that modifying and improving the existing foreign technologies instead of creating new ones was the major Korean approach toward to the development of the domestic petrochemical industry. This is perhaps the appropriate and practicable way to achieve quick technical progress for most developing countries. The government of South Korea had played a very active role in the whole process of the technology transfer. It did not only act as a guardian of the domestic firms and implement a closely co-ordinated education policy, but also keep watchful eye on both domestic firms and foreign suppliers in the whole process of the technology transfer. On the one hand, the Korean government took a tough position and imposed low rate of royalty payment on foreigners. On the other hand, it disciplined the domestic firms and demanded a high standard of performance.

Since the 1960s the Korean economy has undergone a dramatic change. Korea was a poor, small and technologically backward country. Although its agriculture was relatively developed, compared with other developing countries, its industrial sector was crude, characterised, for the most past, by labour-intensive techniques.

Agriculture began to lose its prominent position in the economy since mid-1960s. Industry has played a commanding role since then. During the 1970s Korea's industry experienced structural adjustment. Steel, shipbuilding and petrochemical industries became internationally competitive and replaced light industries as the backbone of the Korean economy. Coming into 1980s, Some technology-intensive industries, such as semiconductor industry, especially chips manufacturing industry started emerging, promising, to lead the Korean economy into next century.

The successful development of last three decades has made Korea one of the leading developing countries in the world. Now it has become an upper-middle income and newly industrialised country. Its gross national product ranks eighteenth in the world. It is no exaggeration to say that at its present rate of economic growth South Korea will become an economic power in twenty years time. Through the application of effective system of economic management Korea transformed itself from a poor, backward agrarian economy to a semi-industrial country, from a small and unnoticed primary products exporter to a significant world-class competitor in the international textile & clothing, steel, shipbuilding, and electronic products market. During the transformation period, many foreign technologies had been imported into South Korea. Technology transfer and development have played a crucial role for the Korean economic 'miracle'.

From 1962 to 1984, of total of 3,073 technology contracts had been approved by the Korean government:

33	in	1962-1966
285	in	1967-1971
434	in	1972-1976
168	in	1977
296	in	1978
288	in	1979
222	in	1980
247	in	1981
308	in	1982
360	in	1983
432	in	1984

Annual technology contracts rose from 6.5 during 1962- 1966 to the 57 during 1972-1976, to 168 in 1977 and 296 in 1978.

The total number of technology contracts under different categories of industry at different time periods can be seen from Table 7-1.

Table 7-1 The technology imports into South Korea (1962-1984)

Year Industry	FFP	SFP	TFP	77	78	79	80	81	82	83	84	Total
Agriculture &heretical	0	6		0	1	2	1	1	3	5	5	24
Food	2	6	7	0	1	9	5	15	21	20	24	110
Pulp & Paper	0	4	3	3	2	0	0	2	2	0	1	17
Fabrics	5	2	10	2	2	1	4	4	4	3	2	39
Chemical fibres	2	5	14	1	6	12	3	6	23	27	29	128
Cement	1	11	9	3	10	7	9	5	9	6	10	80
Oil refinery& chemicals	5	59	85	25	42	54	36	38	44	50	64	502
Pharmac-euticals	2	17	8	1	4	0	5	17	12	6	20	92
Metals	1	28	45	17	24	29	19	19	24	22	21	246
Electrical & electronics	5	65	84	32	51	42	47	33	60	80	77	578
Machinery	6	58	116	56	115	102	59	70	62	82	123	849
Shipbuilding	0	1	10	6	12	3	5	19	14	21	17	108
Communication	3	13	10	0	4	8	6	3	12	7	0	66
Electric power	0	2	7	8	11	6	4	8	8	4	4	62
Construction	1	3	4	3	4	2	8	4	6	9	7	51
Others	0	5	22	11	7	14	11	3	4	18	28	123
Total	33	285	434	168	296	288	222	247	308	360	432	3073

Source: Government of Korea, Ministry of Science and Technology, 'Technology Imports Annual', 1984.

Notes: FFP, SFP and TFP represent First Five-year Plan, Second Five-year Plan and Third Five-year Plan, respectively.

The process of technology transfer to South Korea has accelerated over the last two decades. We can see that nearly two-thirds of the technologies obtained from abroad during the twenty-three year period (1962-1984) were imported over the last five years (1980-1984). The rapid transfer, adaptation and diffusion of foreign technologies had helped South Korea to achieve a high rate of economic growth. Accordingly, the royalty payment to foreign technology licensers also rose dramatically.

US$	0.8	million	in 1962-1966
US$	16.3	million	in 1967-1971
US$	96.5	million	in 1972-1976
US$	451.9	million	in 1977-1981
US$	115.7	million	in 1982
US$	149.5	million	in 1983
US$	213.2	million	in 1984

Japan and the United States have been the two most important technology suppliers to South Korea. This can be seen from the fact of that almost five-sixths of technology imported during 1962 to 1984 in South Korea came from United States and Japan. It is also true that more than half of the total export during the same period in South Korea went to these two countries. The easy access to these two huge markets (they were guaranteed in the 1950s and 1960s) was extremely important for Korea to carry out its ambitious programme of technology transfer and development.

Japan was the leading supplier of technology to South Korea. It provided nearly three-fifths of Korea's technologies imports during 1962 to 1984. The total number of technology agreements was 1,700. America signed a total of 708 technology agreements with South Korea for technology transfer. This accounted over one-third of the total foreign technology transfer to South Korea.

There are four Korean laws controlling the foreign technology imports into South Korea. They are:

The foreign capital inducement law (1966);
The foreign exchange control law;
The law concerning establishment of Free Export Districts;
The science and technology promotion law;

Among them, the foreign capital inducement law can be regarded as the major policy instrument which played a very important role in the transfer of capital and technology to South Korea over the last twenty years. The criteria, priority and procedures for importing foreign technology are all listed in this law. The variety of the financial and administrative advantages granted to foreign suppliers by Korean Government are also specified by the law.

According to the government policy, the import of following foreign technologies would be encouraged.

1. technology with high potential to export markets;

2. technology for manufacturing components and developing new process for the capital goods industry;

3. technology which would be costly to develop domestically in time and expenses;

4. technology whose spill-over has the potential for cost reductions and productivity increase;

Thus, any technologies with the potential of increasing export capacity and employment opportunity would be imported.

The Korean government deliberately discouraged domestic firms from developing the technologies which were very costly both in terms of time and expenses. While the governments in most other developing countries had done the opposite thing.

The foreign technologies which had the great potential for cost production and productivity enhancement had been given top priority to import.

Koreans imported not only capital goods but also the know-how that could enable them to effectively apply the imported technologies. This made South Korea remarkably different from other developing countries, especially China. If we regard the capital goods as 'hardware', the know-how is just like software. Both of them are interdependent. Without software, one cannot operate the hardware properly and efficiently. Usually software is very expensive, even more than hardware itself. To most kinds of advanced technologies, know-how is extremely important. Generally speaking, the imported technologies without adequate know-how cannot be mastered and diffused effectively and efficiently. According to one survey conducted by the Economic Planning Board of South Korea, between 1962 and 1980, 50.2 percent of 1,720 contracts approved by the government covered the provision of know- how only, and another 23.8 percent included licences and know-how together; only 21.1 percent granted licences and 4 percent only permitted the use of trademarks. This was matched again by another research done by Korea Industrial Research Institute. In its research report, the result was given that from 1980 to 1983, 48.4 percent of total 603 contracts approved by Korean government was only know-how; 37.2 percent was licences and know-how together; 5.8 percent licences only and 8.6 percent was of trade marks. So most contracts signed by the Koreans have not only covered licence but also blueprints, basic design, operating manuals, construction, training and supervision.

Table 7-2 The growth of output, inputs, and total factor productivity

Economies	Year	Growth of value-added	TFP growth rate	TFP share	Total Factor input growth rate	Total Factor input Share
Korea, Rep.	1955-60	4.22	2.00	47.4	2.22	52.6
	1960-73	9.70	4.20	42.3	5.50	57.7
Japan	1960-73	10.90	4.50	41.3	6.40	58.7
Hong Kong	1955-60	8.25	2.40	29.1	5.85	70.9
	1960-70	9.10	4.28	47.0	4.82	53.0
Taiwan	1955-60	5.24	3.12	59.5	2.12	40.5

Source: Hollis Chenery, 'Growth and Transformation', in 'Industrialisation and Growth- a comparative study'; Hollis Chenery, Sherman Robinson, and Moshe Syrguin; A World Bank Research Publication; Oxford University Press, 1986. pp 20-22, table 2-2.

According to Chenery (1986), the TFP of the Korean economy grew at 2 percent annually during 1955-1960. This was responsible for 47.4 percent of total economic growth in South Korea during the same period. Between 1960 and 1973, TFP grew at 4.20 percent per annual accounting for 42.3 percent of the aggregate annual growth rate of the economy. The annual growth rate of TFP for the Japanese economy from 1960 to 1973 was 4.5 percent and this accounted for 41.3 percent of total economic growth.

Technological progress may take place in any firm, any industry or any country either through technological inventions and innovations, which could be accomplished by basic research and development, or/and through the transfer, adaptation and diffusion of the existing technologies. It is generally agreed that transferring and adopting existing technologies instead of creating new technologies is the more appropriate and more efficient way of leading to technological progress and economic growth in developing countries. This is vindicated by the experiences over the past decades from Japan, Taiwan, Hong Kong and South Korea.

7.1 Petrochemical Industry

The petrochemical industry is that part of the chemical industry which deals with the processing of liquid hydrocarbons (oil and gas). Petrochemical is derived from petroleum or natural gas. Crude oil is a mixture of many substances, mostly hydrocarbons, which are compounds of hydrogen and carbon, and such other compounds as sulphur, oxygen and nitrogen.

Petrochemical products can be classified in five groups: industrial chemicals; speciality chemicals; polymers; agrochemicals and consumer products. The main uses of petrochemical products are briefly described in Appendix One at the end of the chapter.

Among the polymers are polyethylene (PE); polypropylene (PP); polyvinyl chloride (PVC); polybutylene (PB); polystyrene (PS); epoxy resins; styrene butadiene rubber (SBR); butadiene rubber (BR); isoprene rubber (IR); and thermoplastic rubber (TR).

Plastic materials and synthetic resins are long chain polymers formed by the polymerization of chemical intermediates. They are built up by the chemical combination of low-molecular-weight units termed 'monomer' such as ethylene, propylene, styrene, vinyl chloride, and acrylic compounds. The growth of plastics has been through the replacement of natural materials: wood, glass, paper, and metals.

The major outlet of plastics is in packaging: flexible bags and wraps, blow-moulded bottles, containers, closures and collapsible tubes. The second outlet is in construction products: panels and siding, flooring, pipe, fittings, conduit and plywood; electric and electronic applications, insulation of wire and cable, is the third major market. The other markets are surface coating, housewares, automobiles, toys, furniture and appliances. The textile and clothing industry is the major market for man-made fibres.

In the following sections, the focus will be on the Korean petrochemical industry. First, the background of the industry, including how and why the Koreans started it in the late 1960s and what they learned from their first modern chemical plant, will be reviewed. Second, two specific technology transter, namely low density polyethylene (LDPE) and vinyl chloride monomer (VCM) at Ulsan petrochemical complex, will be examined. The efforts will be made to explore the following areas: What technologies Koreans imported; From whom? Under what terms? What they had done to adapt the foreign technologies to their own conditions; What improvements they had made.

7.2 The Economic Context

Industrial production expanded markedly during the first and the second five year plans (1962- 1971). The textile and other labour-intensive industries then dominated the export sector. Thus by as late as 1970 textiles and garments, plywood, and wigs were still the largest, second largest and third largest export, respectively. By 1975, although the plywood dropped to fourth position, textiles and garments still sat at the top. Indeed they continued to lead exports until 1985. During this period, footwear emerged as the fifth largest export.

By the beginning of the 1970s, the Korean government had believed that the country's interests might be better served by the heavy and chemical industries. The situation then seemed to be favourable to South Korea. After nearly two decades of technology transfer and development, Koreans had accumulated valuable experience in dealing with foreign technologies, and so were ready to receive more advanced processes. Korean engineers, technicians, and workers had become more skillful than their counterparts in many other developing countries. However, and even more importantly, the external environment began to change quickly. In 1971 Japan announced a new policy. This was to reorientate the economy away from natural resource-consuming, heavy and chemical industries to 'clean' and 'brain-intensive' industries. And a similar strategy was being adopted in other industrial countries also. Thus, this seemed to be a very good opportunity for Koreans to transfer technologies from these countries, especially from its neighbour- Japan. Since then, Korea has continuously sought to attract Japanese fading industries such as metal castings, bicycles, sewing machine, leather products. In addition, the Korean government launched on a most ambitious plan to industrialize. The priority of national investment was consequently shifted to the chemical, petrochemical, iron and steel, shipbuilding, machinery and automobile industries.

7.3 The Development of Korean Petrochemical Industry

The promotion of large scale heavy and chemical industry began in the mid-1970s. But the setting up of a petrochemical industry had begun even earlier. In fact, the

Korean government had made great efforts to stimulate this industry from the late 1960s, and these efforts had been intensified in the early 1970s. The petrochemical industry is capital- and natural resource-intensive, and it uses very sophisticated technology. These features represent a severe challenge to the reality which most developing countries face- a scarcity of capital, technology and natural resources. So how the Koreans overcame these chellenges and mastered the advanced technologies in a relatively short time period is very important to explore.

The technologies used in petrochemical industries were foreign to South Korea. Before 1970 almost all petrochemical products were imported from Japan and the United States, even though the first modern chemical plant- the Chungji Fertilizer Plant had been set up as early as 1960. This plant was assisted by the U.S. Agency for International Development and was staffed by most of Korea's university-trained chemical engineers. Chungji signalled the beginning of the modern chemical industry. Seven years later, the first oil refinery (the Korean Oil Corporation) was established, as a joint venture of the Korean government and the Gulf Oil Company. This in turn was the first step toward the development of the petrochemical industry. Between them, the fertilizer company and the oil refinery corporation educated many Korean chemical engineers and workers, and so helped Koreans to become familiar with sophisticated chemical technologies. It is no exaggeration to say that the way was thus paved for Koreans later to transfer and adapt foreign, advanced petrochemical technologies.

Korea's petrochemical industry was heavily dependent on the supply of foreign capital. Almost all technical knowledge and equipment had to be imported from Western countries, and all the processes involved were very capital-intensive. In addition, the petrochemical industrialization programme was very ambitious. This forced the government to use foreign capital to finance the project. As a result, all but one of the petrochemical plants were built as joint ventures of a Korean firm and a major foreign petrochemical company in the U.S. or in Japan. According to the terms of the joint venture agreement, foreigners invested half of the equity capital and provided the technology. Foreign firms also provided long-term loans to secure the capital for plant construction, and they also supplied the design for plant construction. Meanwhile, local firms provided the other half of equity capital, and were responsible for acquiring plant sites and supplying the personnel. All but one of the plants were designed by the foreign firms, using modern processes that had been well proven abroad.

A look at the production of the Ulsan Petrochemical Complex, the first and also the largest one by now, in South Korea in 1977 gives a general idea of the scale and variety of production in Korea at that time.

Table 7-3 Production of Ulsan Petrochemical Complex, 1977. (Metric tonne/year)

Item	Quantities	Producer
LDPE	50,000	Korea Pacific Chemical Co.
HDPE	35,000	Korea Petrochemical Ind. Co., ltd
VCM	60,000	Korea Pacific Chemical Co.
Ethanol	30,000	Korea Ethanol Co., ltd
Acetaldehyde	24,000	Korea Ethanol Co., ltd
Styrene monomer	60,000	Ulsan Petrochemical Ind. Co., ltd
Polystyrene	50,000	Hannam Chemical Ind. Co.
Polypropylene	45,000	Korea Petrochemical Ind. Co., ltd
Acrylnitrile	27,000	Tony Suh Petrochemical Co.
SBR	37,000	Korea Synthetic Rubber Ind.Co.,ltd
Petroleum resin	5,000	Kolon Petrochemical Co., ltd.
Cyclolrexne	36,000	Korea Oil Co.
Caprolactam	33,000	Hankook Caprolactam Co.
Alkyl benzene	13,000	Esso Chemical Co., ltd.
Maleic anhydride	10,000	Dae Nong Petrochemical Ind. Co,. Ltd.
Phthalic anhydride	8,400	Samkyung Chemical Co,. ltd
TPA	100,000	Samsung Petrochemical Co.
Carbon black	10,000	Korea Continental Carbon Co., ltd.
Methonol	45,000	Tae Sung Lumber Ind. Co.

Source: Ten year history of petrochemical industry in Korea, 1967-1976; Seoul, Korea Petrochemical Industry Association, 1977.

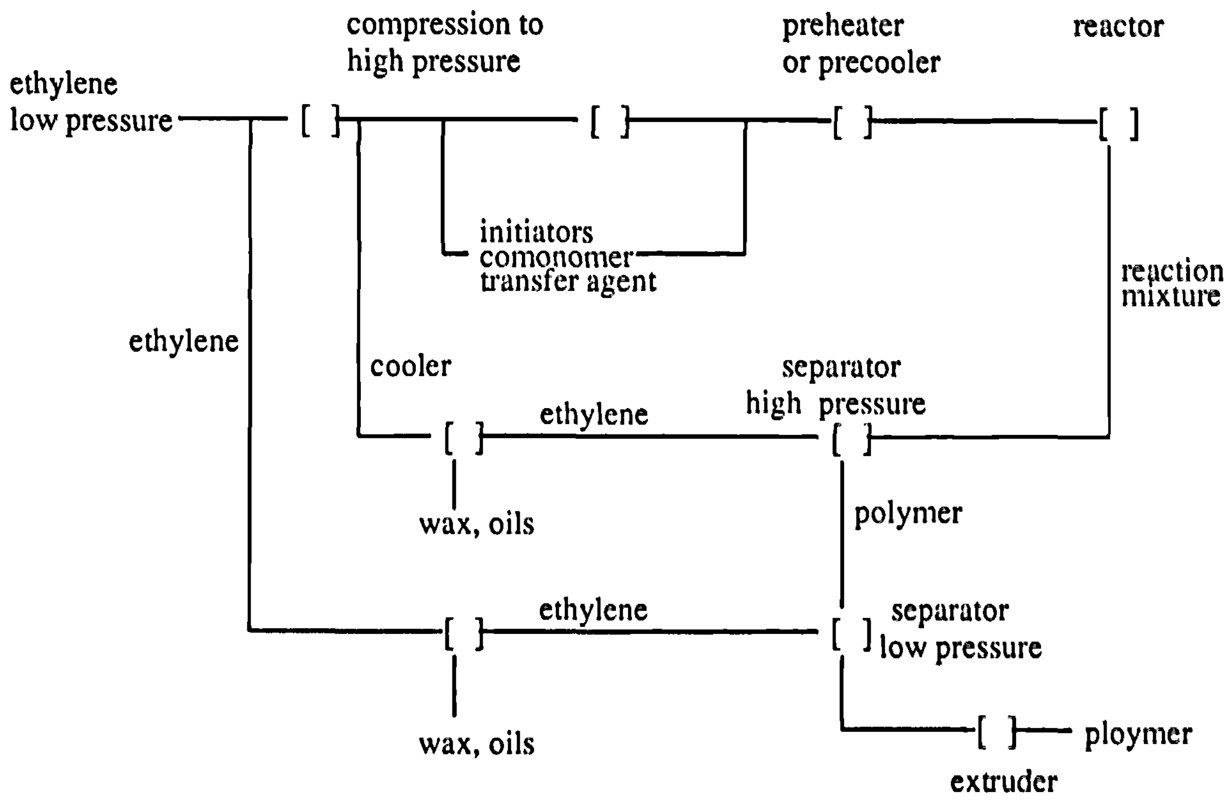
From the figures given above, we can see that the production capacity at Ulsan complex was quite impressive. Within a considerably short period of time, South Korea had established this big petrochemical complex and run it very successefully. Therefore an interesting question needs to be asked here: What had helped the Koreans to absorb imported technologies successfully? Among the contributing factors is the relentless effort to make many modifications, which led to considerable reduction in raw material and energy consumption. For want of data, two imported technologies at Ulasan complex have been chosen for detailed analysis. They are production processes for producing low density polyethylene (LDPE), and vinyl chloride monomer (VCM). Both LDPE and VCM are produced from ethylene, one kind of olefins.

7.4 Major Modifications at the LDPE Plant

Low density polyethylene is one kind of ethylene polymers. The insulating properties of polyethylene (PE) compare favourably with those of any known dielectric material. The outstanding electrical properties of LDPE were the basis for its initial commercialization. These special properties had been explored and used as radar insulation during World War Two. Today, various types of PE are the principal materials used for power and communications cable insulation. Resins for many types of film and sheet account for over half of the consumption of LDPE.

The process of LDPE production is shown in Figure 7-1. The Ulsan LDPE plant imported the technology, which was very sophisticated, from the Dow Chemical Co. in the United States. However, the Koreans had tried very successfully to make many modifications. Some of them are listed below:

Figure 7-1 Generalized flow diagram for high pressure polymerization processes



Recovery of ethylene

According to original design, when the system is shut down, repaired and/or replaced, the ethylene gas remaining in the process lines and equipment must be blown off. This made the ratio of ethylene input to polyethylene output very high, over 1.5 : 1. Several experiments were made and finally the process was revised to recover the ethylene gas for reuse as raw material. As a result, the ratio was reduced steadily from 1.541 in 1973 to 1.011 in 1978. This was really a big achievement. The net effect was cost reduction of US$ 600,000 per year in terms of 1976 prices, or 1.29 percent of the total manufacturing cost.

Process change in the compressor system

An additional pipeline had been constructed to connect the ethylene to another primary compressor in case of another primary compressor being shut down. See the figure above. Shutting down one primary compressor according to the original design would lead to the break- down of the whole production system. This modification resulted in saving ethylene about US$ 55,000 per year.

Development of new products

Several experiments were made by Koreans at higher temperature and lower pressure than that of the original design. The products produced under the new conditions were confirmed to have the same characteristics as the original ones. But the power and steam consumption were reduced by the virtue of the lower pressure.

Figure 7-2 Partial production line of LDPE production

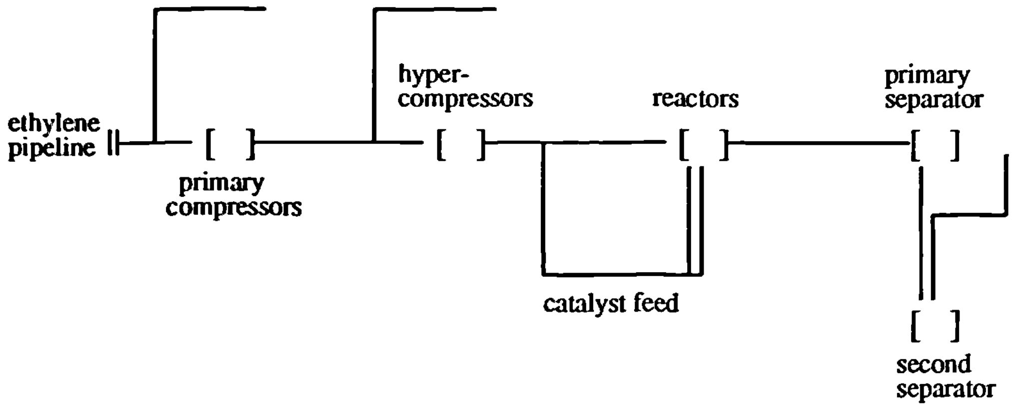
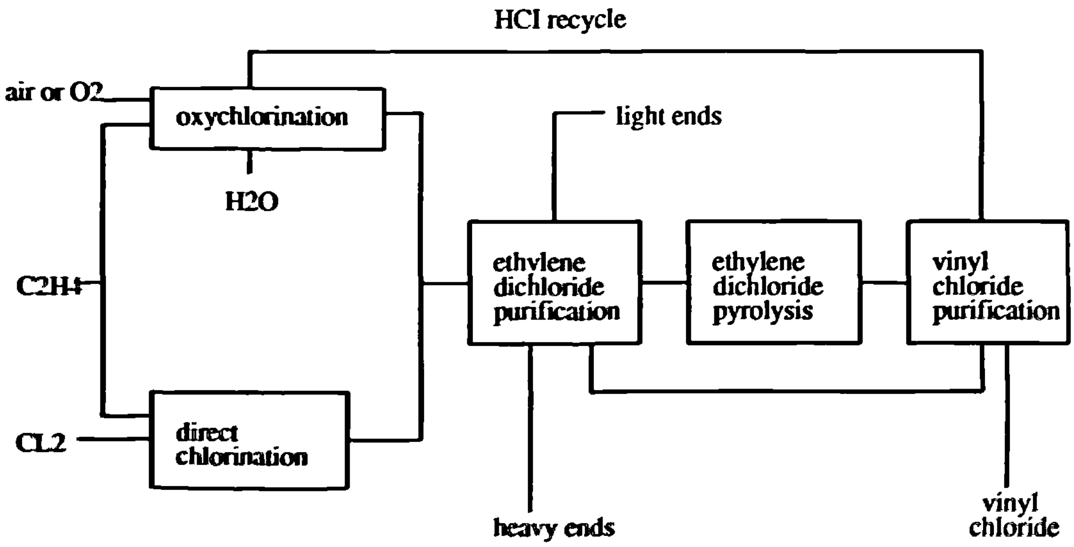


Figure 7-3 The main flowchart of VCM production



7.5 Major Modifications at the VCM Plant

Vinyl chloride monomer (VCM) is a highly demanding petrochemical with a growing market. Rigid poly (vinyl chloride)-PVC is one of the most energy-efficient construction materials available.

Most VCM producers in the world are using the balanced process based on ethylene and chloride, as does the VCM Plant at the Ulsan Complex. The principal steps in a balanced vinyl chloride process can be seen from Figure 7-3.

Major modifications at the Ulsan VCM plant are listed below.

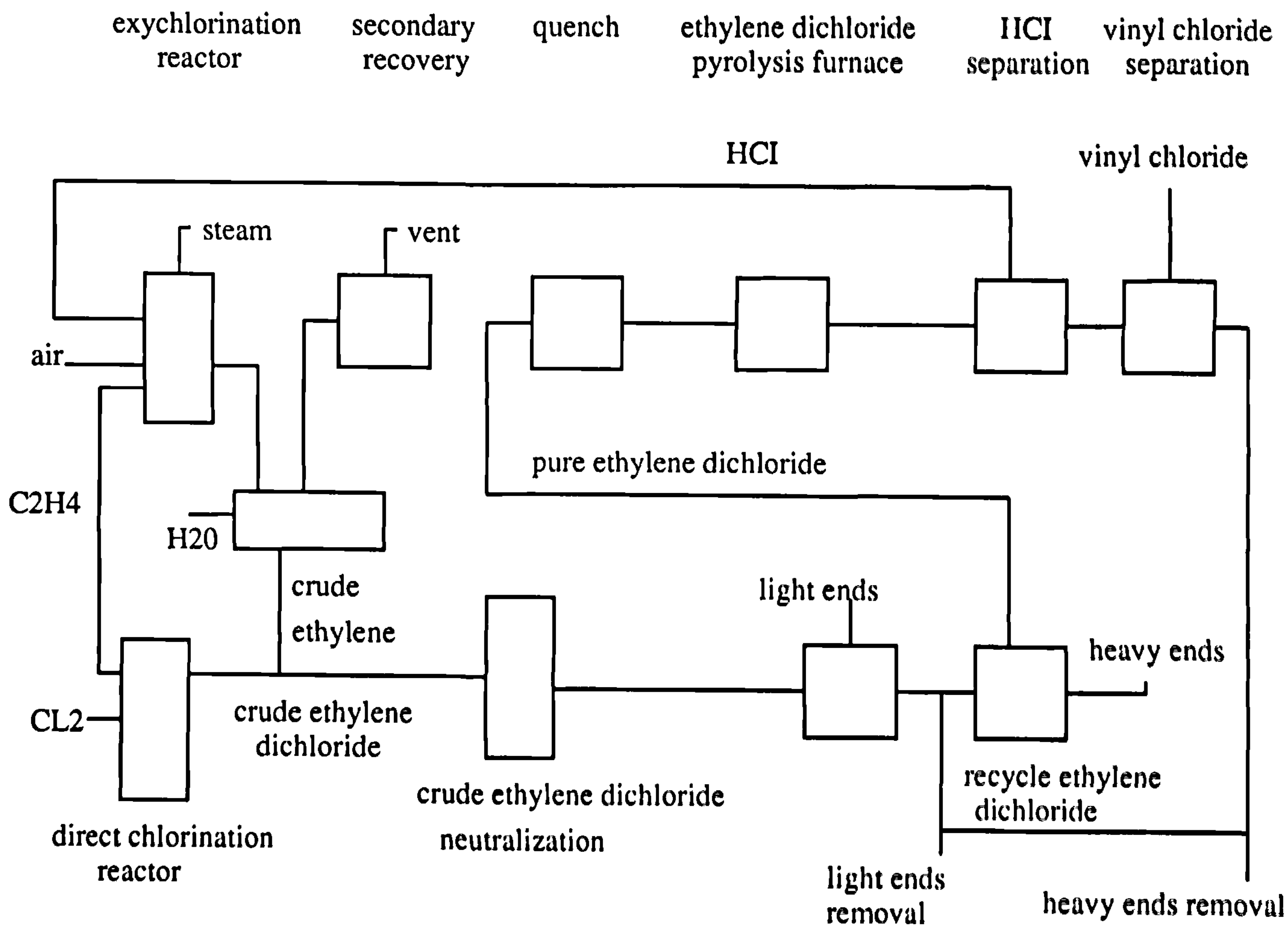
Materials recovery

As mentioned above, before pyrolysis process EDC should be purified. But the original foreign design (also a normal practice) allowed for some amount of EDC to be dissolved in water and drawn off during the purification process. This might have been unnoticed by managers or engineers in other countries, but the Koreans took it very seriously, especially after the oil price shock. A special team was set up to deal with the 'problem'. They were really very keen on trying to save the EDC from the waste water. Finally a recovery system for the EDC was designed and installed in 1974, the EDC-dissolved water was treated, and the EDC was recovered and reused as new material. The amount saved was worth US$ 350,000 per year, in 1976 prices, or 0.75 percent of the total manufacturing cost.

Energy-saving modifications

One modification took place in the condensate line, which resulted in saving steam 1,900 metric tonnes per year. The cost reduction was US$ 20,650 per year.

Figure 7-4 Flow diagram of VCM production



Another modification was made by using low-pressure steam in EDC distillation tower in summer time (see the right bottom corner in Figure 7-4 above). This saved steam 1,382 metric tonnes/year, and had a cost reduction of US$ 15,000 per year.

Energy saving in the EDC purification system

EDC was purified through two separation stages (see also the right corner at the bottom in the Figure 7-4 above), light ends were first removed, then heavy ends removed. This was the most energy-consuming process, which acounted for more than half of the total steam required in the VCM plant. The modifying experiment had been carried out to measure the steam reflux rates required by the boilers. Finally the optimum steam reflux rates had been obtained. As a result, the 50% reduction of the steam supply for the first distillation tower and 30% for the second tower had been achieved, and saved a total US$ 156,000 a year.

Another energy-saving modification took place in the EDC recycle process. At the beginning of the recycle, unreacted EDC was separated from vinyl chloride through a distillation tower (see right top corner in the Figure 7-4 above). The mothod used here was as same as the modification mentioned above in the purification system, which reduced the reflux rate from original 2,558 kg/h to 2,184 kg/h, the total cost reduction from this modification was US$ 5,300 a year.

Energy- saving modification in vinyl chloride separation system

Purified EDC was sent to ethylene dichloride pyrolysis furnace for cracking (see top centre in the Figure 7-4 above). The vinyl chloride was formed through the cracking process, but before pure vinyl chloride is transferred to the storage tank, HCI and other lighter components must be removed successively by passing through two different distillation towers (see top right corner in the Figure 7-4 above). Carrying out this separation process needs a considerable amount of steam. Some modification and innovation work had been done in the first tower, this subsequently enabled the second tower to save a significant steam consumption.

Another modification for energy recovery had been made in the EDC recycle line. As mentioned above, vinyl chloride was purified through two successive towers. At the second tower, HCI was removed. Then unreacted EDC was separated from the VCM and sent to EDC recycle line. A modification was made to recover the waste heat of the unreacted EDC. This was channelled by a heat exchanger to the next tower in the system. Total cost reduction was US$ 50,800 per year.

The technologies used at the LDPE and VCM plants at the Ulsan Complex were imported from the Dow Chemical Co. (USA). They were very sophisticated and advanced. But after a series of successful modifications and improvements, these two plants had entirely mastered the technologies. The considerably low (efficient) energy unit ratio achieved by these two plants strongly demonstrated their success. Some comparisons of the energy unit ratio of some plants in South Korea, Japan and the United States are given below:

'Energy unit ratio' for LDPE plants

Asahi Dow in Japan	1,498 Kcal/kg
US Dow	2,071 Kcal/kg
Ulsan LDPE plant	1,253 Kcal/kg

'Energy unit ratio' for the VCM plants

Toyo Soda (Japan)	3,194 kcal/kg
Ulsan VCM plant	2,912 Kcal/kg

7.6 The Korean Experience of Technology Transfer in Petrochemical Industry

Technology transfer consists of acquiring all knowledge about the design of a process and the principles on which the process works; the procurement of the equipment incorporated in the process; the construction of the plant; the testing and startup of the plant; and its operation and improvement. Generally speaking, Koreans did very well in all stages of the technology transfer.

The evidence for the rapid operational absorption of the imported technologies is overwhelming. For instance, the production records of the two plants, namely LDPE and VCM, reveal quick attainment of the 'capacity' rate of output of polyethylene and the steady approach of that rate of VCM. Since March 1973, the LDPE production has continued to run at high levels, consistently exceeding the iinitial design capacity-as has VCM production since 1976. The whole process of the technology transfer in these two Korean petrochemical plants was quick, efficient and effective. Acquiring the knowledge about the design of the production process is one of the most difficult areas in technology transfer, since this embodies much R&D However, Koreans did not do badly at all at this stage. Although almost no Korean participated in the basic design after the negotiation, a lot was learnt from the foreign design. Thus the Koreans succeeded in understanding the principles of the basic design and all the functions of the entire system. By the time they came to construct the second, third and subsequent plants they had made considerable progress.

Construction in South Korea was incredibly quick. We know that delay in plant construction for the use of imported technologies is common in many countries, and is especially so in the developing countries. Half-a-year's delay is routine, one-year delay is not unusual, and even a two-year delay is still not rare. But in South Korea, delay of plant construction was rare.

At the stage of absorption and modification, the Koreans were very impressive. They made lots of improvements in the design of the production system and in the construction of the equipment. It was through these modifications and improvements that output was increased, the quality of the products upgraded, and the cost of production reduced. Low cost and high quality provided a sound basis for successful technology transfer in the Korean petrochemical sector.

From the Korean experience, we can see that to the developing countries, putting great emphasis on modifying and improving imported technologies is perhaps the most appropriate, practicable, and efficient way to achieve technical progress quickly. Modifying, not creating technologies, can help the developing nations to improve the quality of their products, and to increase their competitiveness in the world market, and so to generate quick and high returns on their investment. In the Korean case the cost of modifications was reatively small, but the savings in raw materials and energy were very impressive. The Koreans made no exciting research breakthroughs as they upgraded their imported technologies. But their small and simple modifications helped them to make very competitive products.

Several years after the Koreans imported the Dow Chemical techniques, some technological advances began to take place outside Korea. Thus, for example, work was done on reducing the huge amount of energy used for heating the raw material to a very high temperature at the first stage of VCM production, and for purifying the EDC and VCM at later stages in the respective processes. The new techniques uses liquid-boiling reactors in a direct chlorination process. This brand new design offered energy savings and also reduced product purification requirements. The energy savings arise essentially because the reactor is used as a reboiler for the conventional EDC purification system. This results in lower steam and cooling-water usage requirements than those of the conventional process.

Another new techniques was introduced for use in the EDC cracking process. Cracking is the process for dehydroclorisation of EDC leading to the formation of vinyl chloride. Since the conventional cracking techniques limits EDC conversion to 50-60 percent, considerable energy and cost saving could be achieved through increasing conversion levels without concurrent losses of EDC to undesirable side reactions and cooling problems. And in 1982, laser-induced EDC cracking was excitingly reported to have been invented at the Max Planck Institute (Gottingen, FRG). At temperatures comparable to those used in existing commercial production, it is claimed that this laser-induced process increases conversion while concurrently decreasing the formation of unwanted by-products.

Korea was probably unable and so, sensibly, never tried to achieve major breakthroughs in the production of petrochemicals. Among the questions that thus arise is whether the new techniques threaten Korea's comparative position. A full answer to that question would take this enquiry too far afield. The extent to which Korea was to be kept abreast of new technology is discussed below. Here, however, it may be noted that Korean production does not yet seem to have been threatened by foreign competition. In this regard it has helped that the new technigues call for a complete redesign of the existing system and very large capital investment, with the cost of the latter rising sharply following the oil crisis. However, the cumulative impact of the many 'minor' technical modifications made by the Koreans afforded them some protection.

Extensive collection of information from as many accessible sources as possible helped the Koreans to know which techniques were available and which were the appropriate ones for them to import. By contacting all major petrochemical producers world-wide, Korean's bargaining position was strengthened. The involvement of the nation's capable chemical engineers and responsible bureaucrats in the relevant negotiations enabled Korea to sign an agreement with their foreign partner quickly. And establishing the new petrochemical plants as joint ventures with foreign technology suppliers accelerated the trasfer process. Moerover, detailed agreement and the clear definition of the term 'know-how' gave the Koreans the right to import everything relating to the new techniques-from basic design and blueprints to details of construction and all operational know-how.

When the Korean government announced its ambitious petrochemical plan and prepared to set up the big complex at Ulsan, foreign firms began to apply for permits to participate. The three foreign firms that offered to supply the technology to manufacture polyethylene were the Union Carbide Company, the Gulf Oil Corporation and the Dow Chemical Co. And four foreign firms which offered the technology to make VCM were the Gulf Oil Co., the Dow Chemical Co., the Skell Oil Co. and the Union Oil Co. of California.

Rather than choosing from these limited numbers, the Korean government decided to approach all possible owners of polyethylene and VCM manufacturing processes. They thus expanded their options in the case of low-density polyethylene to thirteen and in the case of VCM to six. The foreign firms were asked to submit their processing schemes and financing proposals, on the basis of sharing the equity ownership of the joint venture 50-50 with the Korean government. Finally, the Dow Chemical Co., which had expressed interest in both processes, and its technology had been chosen.

It may not be the original intention of the Korean government to set up 50-50 joint venture with foreign partners. The reality of the scarcity of foreign capital may push the government to take that road. However, because they had a stake in the joint-venture plant, the foreign partners were more willing to transfer know-how than they would otherwise have been, and they were also willing to help Korean engineers to master the imported techniques quickly.

The Korean government has played a very important role in technology transfer to and the economic development of the country during the last thirty years. Without exaggeration it may be said that technology transfer would have failed- or at least would have been much less successful than it was- without the positive participation of the Korean government. The directing and influential role of the government may be seen in at least three areas.

(a) Government and the Transfer of Technology

Through its guarantee of the foreign return on investment, the Korean government successfully imposed a limit on royalty payments. This, at no more than 3 percent of the value of production, was low compared to the norminal terms available to foreign investors elsewhere, particularly in Latin America. The bargain, however, was not a bad one for the foreign investors. Because the Koreans were serious, and because the government did not hesitate to 'impose' performance standard on domestic firms. As a result, many Korean firms had reached the capacity level of production very quickly. The real value of royalty payments thus was as attractive as that elsewhere. Many Korean firms had felt that the government had not only supported and protected them from being abused by foreign monopolies, but also demanded good performance from them. They knew very clearly that the government would accept nothing less than their proficiency. Dedicated, hard-working, incorruptible (comparatively) as they were, the Korean bureaucrats expected identical behaviour from their private citizens. It is commonly believed that the overall performance of technology transfer of a country is positively correlated with the performance of its government in the developing countries.

At early stages of technology transfer and development, the Korean firms were relatively small, and their technological and financial capability was limited. It consequently was prudent for the Korean government to be an active party in negotiations. In this way the bargaining position of the domestic firms was strengthened and curbs were put on the monopoly power of the giant foreign firms. And in the event, the final terms of most agreements signed between Korean and foreign firms were relatively favourable to the Koreans. Thus in the case of Hanyang, the agreement provided inter alia that: the foreign partner, Dow Chemical, should reveal all of its own designs and 'know-how' to its Korean employees; Korean engineers would be trained by Dow in the application of all the aspects of its current technology-basic process design, detailed equipment design and procurement, construction, testing, start-up, operation and maintainence; Korean engineers would participate in each of these activities as quickly as possible, and in sufficient number to replace Dow's expatriate engineers; and with some qualifications, Dow would automatically inform Hanyang of improvements to the imported technology made by itself or any of its licensees. One of the most important term included in the agreement was to give Korean firms the right to access all new improvements and innovations from its foreign supplier. The rapid technology advance in developed countries makes a large scale technology transfer in a developing country very difficult to become successful. It takes years to absorb and adopt such a technology. Sometimes even within the period of plant construction and start-up operation, the major improvements and innovations in the developed world might make it obsolete. Successfully gaining the guarantee of being informed immediately about the latest technological improvements and innovations by the Koreans, and more importantly, with the least cost was quite important.

(b) Education

The education policy of the Korean government was closely co-ordinated with its technology and economic policies. Thus making the necessary human resources available to every industry sector was the major purpose of the Korean education policy. And this purpose was accomplished mainly through stressing engineering education and training. Education has long been regarded as one of the top priorities in South Korea, and the investment in it has been more rapidly-growing and reached a higher level than in most developing countries. The percentage of the relevant age group entering higher education in South Korea was much higher (nearly ten times higher) than that of most other developing countries, and reached a par par with developed countries. The percentage of the relevant age group entering primary and secondary schools was even remarkable. The Korean educational policy has provided qualified and skilled labour to Korean industry. This in turn has resulted in rapid increases in productivity associated with subsantial and quick learning-by-doing, so that where Korea has had a wage advantage its international competitiveness has increased. In addition to the remarkable spread and efficiency of general education, the Korean government has made particular effort in special areas. This has included engineering education and training designed to benefit the textile, iron and steel, ship-building, petrochemical and automobile industries, and more recently the electronic industry. This targeting of educational effort increased the technological capability of selected major industries and economized on educational resources. Such purposeful concentration contrasts sharply with, say, China and India where limited resources were spread thinly.

(c) Policies to Accelerate Successful Transfer

The Korean government implemented a series of policies to accelerate the process of technology transfer and development. Anti-monopolistic profit-making was one of those. Most technologies imported into South Korea were very advanced and large-scale. Consequently, in most areas of production, only one innovating firm was permitted to import the technology, so that a natural monopoly was created. To prevent abuse of the monopoly power, the government kept its eyes open on the operations of the innovating firm. Government policy was designed to encourage firms to obtain high profit and a high rate of output, so that the normal monopolistic trick of boosting profit by restricting output and raising prices was not allowed. High rates of output (at first stage as a result of equal or excessive design capacity; at the second stage as a result of expansion of production capacity) were initially achieved mainly through the quick and effective absorption and adoption of the imported technologies. This meant that capacity output could quickly be reached. Quality improvement and cost reduction could then stimulate a further growth in output by expanding demand, and so laying the foundation for capacity expansion. Under the watchful eye of the government, Korean firms were forced to select technologies very carefully, and to make every effort to transfer them quickly and efficiently. Firms also knew that without impressive quality improvement and cost reduction of their products, they could not compete abroad. The effect of the government policy proved to be very positive. As production facilities were expanded, more employment opportunities were provided, and the national economy became stronger. And the growing strength of the economy- associated it with a growing capital stock and an increasingly skilled labour force- encouraged and facilitated more technology transfer.

The Korean government could have behaved in different ways, as the governments of some other developing countries often do. It could have been passive, accepting whatever terms the foreign supplier offered; or it could have negotiated just as firmly but for different terms which might have enriched a small fraction of its citizens while leaving the remainder no better off. It is obvious that in either of these cases the adoption of the imported technology would have been less successful, and the benefit to the entire economy less substantial. It is also believed that the two cases usually resulted from the incompetent, and corruptible governments. The Korean government, staffed by competent, enthusiastic, responsible and incorruptible (relatively) bureaucrats, has done a marvellous job for the last thirty years. From the experience of government intervention in South Korea, we can see that a major determinant of the ability of a developing country to absorb an imported technology is the preference of its government, as reflected in the terms that it imposed on the foreign suppliers. If these terms were output- and employment- oriented, the country's ability to absorb the technology would be enhanced-not, however,if these terms were short term profit- and publicity- oriented.

What the Korean government had generally done was: to monitor the progress of the absorption of the technology; to assure that all the different branches of the government- those issuing import licences, those granting permit, those training individuals, etc.- to synchronize their activities; to establish a system of incentives and penalties and to instill in all the non-government bodies the same sense of purpose that provided the driving force for government itself.

The most important thing the Korean government had done was to keep its eyes open on the whole process of the implementing the contract by foreign and domestic firms. All too often, governments in the developing countries tend to pay much more attention on signing and pronouncement than the subsequent implimentation of contracts of technology transfer. In fact, the implementation is far more difficult than reaching an agreement. This work is very hard and tedious. If it is left to technology supplier and innovating firm to carry out alone, it will fail sometimes, or it is most likely that the undesirable result will happen. Because the foreigner and domestic firms may not be able to mobilize all resources necessary to implement the project, or because their objectives are not consistent with the country's interest, these two non-government agencies may not secure the desired outcome. Korean government has been keeping pressure on both foreigner and domestic firms to fulfil their promises on the contract, setting very high standards of performance, and demanding compliance to terms agreed upon. All of these have accelerated the process of absorption and adoption of imported technology.

7.7 Some Other Contributing Factors for the Successful Technology Transfer in Korean Petrochemical Industry

The relatively strong and sufficient demand for petrochemical products was one of key factors for the success of technology transfer in the Korean case. It is obvious that the existence of sufficient demand can help an importing firm to reach the 'design capacity' production as soon as possible, and to sustain a high rate production as long as desirable. The existence of sufficient demand is also a very strong stimulant for a technology importing firm to make great effort on production increase and construction, which can ensure the firm to make profit and share a bigger market. The firm's profit is mainly derived from the quickest fulfilment of the production. The big problem usually accompanying the technology transfer in most developing countries is that importing firms often fail to reach the 'design capacity' production before too long. The reasons accounting for this are various, the commonest one being the unrealistic prediction of future demand. Ambitious programmes carried out or influenced by government are usually responsible for this.

In the case of Korean petrochemical industry, the output targeted and real demand seemed well matched. We know that the major products of petrochemical industry, such as plastics, synthetic fibres, rubber are vital inputs to the textile and clothing industry, footwear industry and tyre industry. These were major exporting industries in South Korea, which were internationally very competitive. From the ten exports in South Korea during 1960s and 1970s, we can see that a very strong demand market for petrochemical products did exist. In addition, the production costs of synthetic fibres and resins were becoming cheaper and cheaper, compared with that of natural fibres. More and more firms thus shifted to the production based on synthetic fibres. Korean export industries did benefit from the good quality, low price and great variety of products from domestic petrochemical producers.

To estimate the future market of demand, Korean government took a very different view from its foreign consulting company. The result testified that the Korean government made a right decision, although it seemed too ambitious. In 1964, the Korean government invited an American consulting firm, Arthur. D. Little Co., and the Fluor Corporation to make marketing and engineering feasibility studies for a petrochemical industry in Korea. The first report, submitted in 1966, indicated that only a moderate increase in the demand for petrochemical products existed in the early 1970s and concluded that the domestic market was far too small to support plants capable of producing at low unit cost, relative to plants abroad.

However, the Korean government had made different forecasts, yielding higher estimates of demand for petrochemicals, high enough to make new plants economically feasible. These demand estimates suggested that a petrochemical complex changing 66,000 metric tonnes per year of ethylene would be appropriate.

To exploit economies of large-scale production, the Korean government chose an even more ambitious programme in the Second Five-Year Economic Development Plan (1967-1971), which resulted in setting up of a petrochemical plant at Ulsan changing 150,000 metric tonnes of ethylene per year.

The decision to go for large-scale plant was another important contributing factor for the success of the technology transfer at the LDPE and VCM plants. The petrochemical industry was one of the fastest growing and among the most profitable industries from the 1950s through the early 1970s. During the period, production of plastic materials experienced a dramatic increase. It was predicted that by the end of the century the production of the plasic will match, even outstrip that of steel. From bank cards to shopping bags, from hospital to office, from car to airplane, we can see that more and more plastic materials are being used widely through the whole economy. It is believed that the car industry and building industry will be the most promising markets in the future.

The bulk petrochemical products are consumed in the form of intermediates for the production of plastic, synthetic rubber and synthetic fibres, fertilizers, detergents and pesticides. the production of these materials has increased rapidly from about 3 million tonnes in 1950 to over 70 million tonnes by the mid-1970s, with plastic accounting for over half of this production. In Western Europe, the petrochemical industry grew at about 3 times the rate of the growth of the GDP.

Unfortunately the high growth of the petrochemical sector began to slowdown after the early 1970s. The oil crisis in 1973 reinforced the trend and almost brought the expansion of the industry to a standstill. The future of one of the most promising industries yesterday suddenly became uncertain and gloomy. What happened in the early 1970s seemed to echo the forecast of the future market slowdown by the Little company (USA) in the late 1960s, which in the circumstances recommended investment towards the setting up the plants with moderate scale of production in Korea.

Table 7-4 The economy of scale of petrochemical production

	condition prevailing in 1972		condition prevailing in 1977	
	naphtha steam cracking	naphtha steam cracking	naphtha steam cracking	naphtha steam cracking
capacity tonne/yr				
ethylene	300,000	150,000	300,000	150,000
fixed capital cost US$Mn	104	67	184.3	118
production cost US$ 'ooo				
raw materials	21,150 (42.2)	10,570 (36.1)	129,600 (71.6)	64,800 (66.4)
utilities	1,080	540	2,200	1,100
catalysts-chemicals	620	310	1,000	500
manpower	700	700	1,100	1,100
other charges	6,750	4,350	12,000	7,700
amortization& return	19,800 (39.5)	12,750 (43.6)	35,000 (19.3)	22,400 (22.9)
Total	50,100 (100)	29,200 (100)	180,900 (100)	97,600 (100)
production prices US$/tonne				
ethylene	90	108	320	340
propylene	55	66	220	230
butadiene	150	186	370	390
LPG	32	32	130	130
gasoline	45	45	168	158

Source: United Nations Industrial Development Organisation, ICIS, 83, December 1978.

Whether or not the petrochemical industry should be set up in South Korea at the beginning of the 1970s was purely a matter of economic judgement. But when the decision was made to set up a plant, the economy of scale should be immediately taken into account. The choice of large scale plants was one of the important factors contributing to the successful transfer of technology in the Korean petrochemical sector. Table 7-4 has shown the effect which the scale economy could make on petrochemical production.

Raw materials and energy strategy adopted by the Koreans proved to be crucial for the success of the technology transfer. Even before the crude oil crisis, the Korean petrochemical industry had already had many extremely difficult tasks to deal with. The technologies imported were very advanced and highly sophisticated, so that it would take many years to absorb and diffuse the technologies even within these countries with relevant production experience. The petrochemical was a brand new industry sector to the Koreans. Lack of production experience and technical expertise made it most likely that the Koreans would have to spend more years to walk through along their learning-by-doing curve. Unfortunately, the early 1970s saw the dramatic oil price increase in decades. This immediately doubled or tripled the prices of raw materials rfor petrochemical production. The demand for petrochemicals (which even began to grow sluggishly at the early 1970s) seemed facing a further decline. Driven into a corner, Koreans petrochemical producers tried extremely hard to survive. The emergency measures were taken immediately after the oil price increase was confirmed. Raw material saving council and energy saving council were set up to tackle the disastrous problem. A series of modifications and improvements (as listed in the previous sections) were mainly designed to save the energy and raw materials and alleviate the catastrophic effect of the oil crisis as much as possible. The very low unit cost of Korean petrochemical products had proved that they had accomplished the tasks very successfully and impressively. This was another important factor which helped to save the Korean petrochemical industry from a seemingly unavoidably disastrous dead end. They had chosen a right strategy. They had carefully timed and successfully tackled the core area of the petrochemical production- raw materials and energy.

During 1950s and 1960s, economies of scale had been effectively exploited by building up more and more large scale plants in the petrochemical industry all over the world. In addition, the prices of crude oil had steadily declined during the same period in real terms. These two factors led to the fall in the wholesale prices of most petrochemical products. For example, for plastics and synthetic resins there was price drop of more than 15 percent in the United States and about 6 percent in Japan. The price of bulk petrochemical products fell more heavily: 35 percent for ethylene and methanol and about 50 percent for ammonia, ethylene oxide, polystyrene, styrene and vinyl chloride. For PVC and polyethylene the drop was 60-65 percent.

However, the golden age of the petrochemical industry quickly passed away at the beginning of 1970s. On average, 1974 saw the product prices increase of most petrochemicals at 200-300 percent. This was mainly because that the oil crisis led to the sharp increase in the prices of the raw materials and source of energy for petrochemical production. In addition, the rush to raise their stocks by many petrochemical producers at a time when supplies were inadequate and price levels were uncertain had pushed the price increase even further. The following table shows the price changes of some petrochemicals.

Table 7-5 Trends of export prices for specific chemical products, oil, naphtha and gas (US $ per ton)

production	1970	1972	1974	1975	1976	1977	1978	1979	1980
ethylene	70-90	80-90	260-285	260-330	240-330	295-315	286-370	310-590	410-740
ammonia	35-50	38-45	135-150	150-230	105-123	100-120	95-110	120-160	140-200
methanol	60-90	50-70	100-250	100-150	100-130	90-135	120-130	150-175	200-240
high-density polyethylene	290-370	270-340	700-790	615-660	620-680	630-660	580-700	770-1000	950-1200
low-density polyethylene	230-300	250-300	680-740	550-600	550-600	500-560	515-560	840-950	980-1150
polyvinyl chloride	290-330	220-380	650-760	510-570	520-610	510-580	580-700	840-950	810-1100
oil	13.31	18.19	85.41	85.01	91.25	100.72	100.72	102.80	
naphtha	16.08	20.02	123.25	109.73	130.69	125.12	146.14		
natural gas (for 1000m3)	9.37	10.81	18.31	39.20	60.39	64.80	76.79	87.16	159

Source: UNIDO, ID / WG, 336 / 3. May 1981, P. 84

Raw material, energy supply, fuel, capital investment, wages and salaries are major components of the cost for petrochemical production. But they take a very different share in total cost. One significant character of petrochemical industry is that the raw material takes the lion's share in total cost. Even before the 1973 sharp increase in oil price, a large proportion of the production cost of the monomers and intermediate products for synthetic resins, plastics and fertilizers was accounted by the raw materials. The crude oil price shock strengthened the cost structure further. This meant that the raw material costs will account for a even larger share of the production cost than before. This was strongly supported by the following figures. A 300,00 tonne per year ethylene cracker plant built in 1977, the cost of raw materials was 6.13 times that of an equivalent one operating in 1972, while capital costs increased by 1.76 times only. This led to a dramatic increase in the raw materials cost share in ethylene production, rising from 42 percent in 1972 to 71.6 percent in 1977. Although capital investment costs rose over this period, their share of the total production costs had declined in relative terms from 39.5 percent to 19.3 percent. Manpower cost (wage, salaries, etc.) had also declined from 1 percent to 0.6 percent. This was just a example for ethylene production.

The effect of the oil crisis on the production cost of other petrochemical products, however, varied, depending their own material intensiveness and energy intensiveness. All in all, material cost share for the products like methanol, vinyl chloride, PVC, LDPE will be substantially increased following the sharp rising of the oil price. Two products being producd by Hanyang at Ulsan were among the group.

It seems very true now that if the strategy adopted by the Koreans (using emergency measures to save energy and raw material) had not been in the petrochemical sector, or if it had been the sector but a few year earlier, the final results could not have been so impressive. The right strategy taken at the right time in a right industry enhanced very effectively the technology transfer.

The successful technology transfer had helped not only the Korean petrochemical industry but also many other industries, which have strong backward linkage with the petrochemical sector, to compete effectively on the international market.

Petrochemical industry has very strong forward linkage with many industrial sectors. Because many hundreds of different petrochemicals could be used in thousands of areas, it is extremely difficult to trace back all linkages and give a clear description of the relationship between the petrochemical industry at one hand and the economy as a whole at the other. However, by using some available data, we can explain at least some contributions of petrochemical industry to the Korean economy.

First let us have a look at the textile & clothing and footwear industries. We know that both of them have very strong backward linkages with petrochemical industry. The textile and clothing industry had certainly been the major driving force of Korean industrialisation at least before the mid-1980s. The textiles and clothing industry had sat at the top position among the major Korean exporting industries before 1988 and accounted for an average of 40 percent of total Korean export in the early 1970s. The corresponding figures were 29.5 percent in 1981, 23.1 percent in 1985 and 24.3 percent in 1988. Given the US$ 60,000 millions of Korean export in 1988, the 24.3 percent share is certainly very impressive.

Footwear exports were not as significant as textiles exports in 1970. However, footwear export reached the top 5 position in 1975, and stayed there firmly through 1975 to 1987. In 1988, footwear exports reached the number three position, overpassing the export of steel products and automobiles exports. It accounted for 6.7 percent of total Korean export in that year. The excellent performance of Korean footwear industry can be seen from the following figures.

South Koreans have made many kinds of shoes (especially sports shoes) for many famous shoe makers in the world. Reebok and Nike, the two most famous sports shoe makers in the world began to order directly from Korean manufacturers long time ago. The peak shipments reached to 4 million pairs monthly average for each company. Since 1986, the appreciation of the Won and rising labour costs had already reduced South Korea's attractiveness for foreign footwear giants. Even then, in October 1988, Reebok and Nike ordered 1.7 million and 2.2 million pairs, respectively. Korean technological excellence of footwear manufacturing has been a key factor behind the quick expansion of the footwear export but the raw material for footwear industry certainly played a very important role as well.

Table 7-6 Korean exports of footwear, 1976-1988 (US $ million at current prices)

1976	1977	1978	1979	1980	1981	1982
398.5	487.6	686.2	728.9	904.2	1049.4	1181.8

1983	1984	1985	1986	1987	1988
1269.6	1398.4	1571.2	2109.3	2824.1	3800.8

Source: Economic Handbook of Asia and the Pacific.

As stated above, textile and clothing industry has been extremely important for the fast growing Korean economy. If we have a further look of the driving forces behind the success, it is easy to find that petrochemical industry is a very important contributor. This is shown in the table 7-7.

From the table 7-7 we can see that during the twenty-year period (1968-1987), the synthetic fibre products outstripped other major materials for textiles and clothing industry. Through 1968 to 1987, the production of synthetic fibre fabrics increased 37 times, the corresponding figure for cotton fabrics was only 4.76. Another interesting comparison was that the total production of cotton fabrics was 60 percent larger than that of synthetic fabrics production. But in 1987, the latter was 387 percent larger than the former. Although pure silk fabrics has increased also impressively (nearly nine times) during the same period, its total production was only 1.18 percent of that of synthetic fabrics production. So it is no exaggeration

Table 7-7 Output of principal products of the South Korean textile & apparel industry, 1968-1987

year	woollen yarn (tons)	cotton fabrics (1000 m2)	pure silk fabrics (1000 m2)	synthetic fabrics (1000 m2)	kintted underwear (1000 iterms)
1968	2,315	113,293	3,182	71,000	
1969	1,847	191,820	4,704	96,479	
1970	1,927	192,634	6,923	175,498	
1971	1,402	233,782	8,134	222,914	
1972	3,231	201,189	12,032	338,123	
1973	3,145	264,400	15,538	519,576	
1974	2,747	261,446	13,887	479,070	
1975	3,229	254,779	14,789	726,959	
1976	5,271	294,770	14,458	942,227	
1977	9,889	287,740	11,290	963,144	
1978	9,744	273,391	17,050	1,101,196	134,713
1979	11,559	317,160	13,846	1,223,803	165,271
1980	12,325	366,019	11,317	1,461,249	179,187
1981	13,643	353,654	18,649	1,801,872	168,848
1982	16,433	446,882	21,379	1,753,977	187,150
1983	20,708	442,263	19,619	1,801,645	219,440
1984	23,417	395,310	18,404	1,936,129	217,400
1985	25,736	470,129	19,651	2,101,099	208,377
1986	29,246	536,415	25,860	2,357,801	268,288
1987	33,582	539,134	31,044	2,624,355	340,200

Source: Economic Planning Board of South Korea.

to say that the synthetic fabrics product was mainly responsible for the rapid expansion of the Korean textiles and clothing industry, and the petrochemical industry was the final supplier.

Petrochemical products are not only important to textile and clothing industry, but also to other sectors. This can be seen from the case of most Korean giant conglomerates. Among them, Sunkyong Group is a very typical case.

Sunkyong is one of the largest giants in South Korea, it consists of many companies, such as Sunkyong fibres Ltd., Sunkyong Chemical Ltd., Yukong Ltd., Yukong Line Ltd., Sunkyong Industries Ltd., SKC Ltd., ... etc. One company of the Group -- Sunkyong Fibres Ltd., is one of the major South Korean textile and apparel firms, with 3,598 employees and total sales was 211.8 billion Won in 1987. Its overseas

Figure 7-5 A part of Sunkyong Group's Vertically integrated business system

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Yukong Ltd.
                                        [overseas oil exploration and development
energy source development               [coal business
                                        [petroleum refinery and marketing
     ______________________________I
       I                                            [ethylene ... LDPE, HDPE
       I          [naphtha cracking unit             [propylene ... PP, PO
       I          [                                  [butadiene
petroleum-------- [
chemicals         [                                  [benzene
                  [aromatic extraction unit- --------- [toluene
                                                     [xylene- paraxylene(PX)
                                                            I
I____________________________________________________________
I                 Sunkyong fibers ltd. (Clothing & apperals)----------------------I
I ---------------------------------------------------------------------------------I------
I I  Sunkyong industries ltd.                                                     I
I I               [synthetic fibres (a vast variety of polyester and acetate textiles &products)
I-IDMT/TAP------[polyester  adhesives / PET bottles, microchip & engineering plastic
 I                [fine chemical-life science products
 I                [new industrial materials
 I----------------[------------------------------------------------------------------------
                  [
                  [polyester film   -video tapes
  SKC Ltd.        [                 -a variety of film; stapping foil, packaging
                  [                 -floppy discs
                  [                 -DAT (digital audio tapes)
                  [                 -audio tapes (Sunkyong magnetic Ltd.)
                  [
                  [optical memory media compact discs, holograms
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Source: Business Korea, December 1988.

export accounted for 76 percent of the total sales. The following figure shows the importance of petrochemicals and related products for the Group's business.

Exports of some direct petrochemical products have also grown very rapidly over the last twenty years. The Korean petrochemical exports was only 221 million US dollars in 1977, but reached to 1,321 million US dollars in 1987. The figures in Tables 7-8 and 7-9 tell this.

Table 7-8 Korean petrochemical exports (in million US$)

1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
221	329	504	755	644	670	677	845	936	1,068	1,321

Table 7-9 Production of tires, inner tubes and rubber

items	1972	1973	1974	1975	1976	1977	1978	1979
tires for road vehicles ('000)	1,088	1,575	2,048	2,658	3,491	4,767	6,905	10,019
inner tubes, rubber for motor vehicles ('000)						5,025	8,797	13,535

items	1980	1981	1982	1983	1984	1985	1986	1987
tires for road vehicles ('000)	12,327	9,101	7,855	12,033	15,126	15,207	18,214	20,060
inner tubes, rubber for motor vehicles ('000)	17,535	16,201	16,073	21,833	32,298	26,480	34,762	46,738

Source: Statistical Yearbook for Asia and the Pacific 1988.

The experience of Korean industrialisation over the last three decades shows that manufacturing sector is the real engine of the rapid growth of the economy. Behind the sector, there are many driving forces, such as textile and clothing industry in the 1960s and 1970s (even before the mid-1980s), footwear industry in the 1970s and 1980s, HCI in the 1970s and 1980s, which include petrochemicals, ship building, steel, automobile industries, the electronic industry since the mid-1980s. They together are responsible for the economic success in South Korea. At the constant price of 1980, Korean gross national product was 32,408 billion Won in 1977, and it reached to 66,320 billion Won in 1987, a total 104.6 percent increase in the ten years time. During the same period, the output of Korean manufacturing industries increased from 8,090 billion Won to 22,964 billion Won, a 184 percent increase. The share of the manufacturing industries in GDP was 25 percent in 1977, but 34.6 percent in 1987. Among manufacturing sector, the progress of petrochemical industry is certainly impressive. This industry has made a great contribution not only to textile and clothing industry but also the Korean economy as a whole. However, the successful technology transfer is the most important factor reponsible for the growing competitiveness of the Korean Petrochemical products.

Appendix 7-1

Some Main Petrochemicals and Their Uses

Olefins are used in the production of a number of plastics and resins (such as polyethylene, PVC, polystyrene, polyurethane), synthetic rubbers, industrial alcohols, polyester and acrylic fibres.

Butadiene and isoprene are used for the manufacture of synthetic rubber, thermoplastics and polyamide fibres.

Benzene is most widely used for the manufacturing of intermediate chemicals-- styrene. The major use of toluene is in the production of benzene, but it is also used for solvents and plastics (polyurethane). Xylenes are used for solvents, plasticisers, resins and the production of intermediate chemical in fibre manufacture.

Methane is used as a fuel and in the synthesis of other chemicals, notably methanol and ammonia.

A cetylene is used in the manufacture of vinyl plastics and rubber. Ammonia is one of the most important inorganic base chemicals, providing a source of nitrogen for fertilizers and industrial chemicals.

Among the industrial chemicals are hydrocarbon and oxygenated solvents; phenol; ethyelene oxide and derivatives; propane- based resins; higher olefins; synthetic detergent intermediates; alcohols; and organic acids.

Automobile tires are major outlet for styrene- butadiene- rubber (SBR), 65-70 percent of the SBR is used here.

The synthetic fibres are man-made fibres and are polymerized by petrochemical molecules. Their washability, durability, strenth and resistance to shrinking and soiling have allowed them to replace cotton, wool and silk in many applications.

Crude oil can be decomposed into many products each with many applications. The first stage in the manufacture of petroleum products is the separation of crude oil into different fractions by distillation. This is a physical process that uses the different boiling points of various oil fractions to split up the crude oil into a number of homogeneous products. The distillation produces gas, dry gas, propane, butane, light gasoline, cyde oil, wax and sulphur.

The subsequent conversion process fulfils two functions. It sometimes improves the quality of the products that result from the first treatment. And it converts products for which demand is weak into products for which demand is strong. Because the conversion process is a chemical one, it changes the structure of various oil fractions.

The two important conversion processes are cracking and reforming.

Feedstocks of petrochemical industry

The petrochemical industry has main feedstocks--natural gas and the by-products of the oil refining process. The availability and prevailing price of each feedstock will determine the final choice of the petrochemical manufacturers. In Western Europe naphtha is used most frequently as a feedstock for ethylene crackers, and it accounts for almost 80 percent of total input. It is even higher in Japan. But in the United States, naphtha is only responsible for 10 percent of the feedstock.

Base chemical products

Because crude oil comprises mainly hydrocarbons, its downstream products (base chemicals) have been formed mainly by hydrocarbon compounds. These base chemicals can be divided into two groups according to their different structure.

1. Open-chain structure aliphatic compounds
   --araffins such as methane, ethane, propane and butane; and

   --olefins such as ethylene, propylene, butylene; and

2. Close chain structure cyclic compounds
   --aromatics such as benzene, toluene and xylene (BTX).

In terms of quantities produced olefins and aromatics are by far the most important products in Western Europe. And ethyelene is by far the most important single product among the olefins. The production of aromatics is carried out by reforming of naphtha. As mentioned above, cracking naphtha produces ethylene, which is the major material for producing LDPE and VCM, the two very useful petrochemical products that will be given a special place in the discussion of the Korean petrochemical industry later in this chapter.

Appendix 7-2

Main Steps of Manufacturing Process of LDPE and VCM

Manufacture of LDPE

Staged compression, with interstage cooling, of purified ethylene, usually from a pipeline, and introduction into the reactor.

Introduction of a free-radical initiator, for example, oxgen or peroxides, and a chain transfer agent to ethylene at some stage of compression, or into the reactor.

Partial conversion of ethylene to PE, usually between 15 and 30 percent.

Extrusion of molten polymer, followed by pelletizing and cooling.

Cooling of ethylene from separators, removal of wax and oil in separators, and return to compressor.

Characteristics and end-uses of LDPE.

LDPE has an unique combination of properties: toughness, high impact strength, low brittleness temperature, flexibility, processibility, film transparency, chemical resistance (especially to polar compounds), low permeability to water, stability, and outstanding electrical properties.

VCM is mainly used to produce PVC (polyvinyl chloride) through polymerization. PVC is one of the few synthetic polymers that have wide application in commerce. This is because of its high degree of chemical resistance and a truly unique ability to be mixed with additives to give a large number of reproducible PVC compounds, which can be used as wire insulation, rigid pipe, or housing siding. Rigid PVC compounds can also be used in the manufacture of bottles, pipe and siding. Flexible PVC compounds are used in wire insulation and wall covering.

Manufacture of VCM

Although the commerical production of VCM began as early as in 1930s, it was not until the 1950s, when ethylene became plentiful, that new processes were developed-- based on the combination of ethylene chloride. However, since the EDC cracking process also produced HCI as co- product, the industry did not expand immediately. During the late 1950s, a new technology -- oxychlorination was discovered that stimulated the growth in the vinyl chloride industry.

Using the process based on the new technology, ethylene reacts with HCI and oxygen to produce ethylene dichloride. Combining the component processes of direct chlorination, EDC pyrolysis, and oxychlorination provided the so-called balanced process for production of vinyl chloride from ethylene and chloride with no net consumption or production of HCI.

Direct chlorination

Direct chlorination of ethylene to ethylene dichloride is conducted by mixing ethylene and chloride in liquid EDC. Ferric chloride is a highly selective and efficient catalyst for this reaction and is used in most commercial processes.

Oxychlorination of ethylene

The oxychlorination process needs higher capital investment than direct chlorination process, and has higher operating costs and a less pure EDC product. However, it is an unavoidable process needed to consume the HCI generated in EDC pyrolysis.

In the oxychlorination process, ethylene reacts with dry hydrogen chloride and either air or pure oxygen to produce EDC and water.

Cracking

Cracking, i.e. dehydrochlorination of EDC results in the formation of vinyl chloride.

Purification of ethylene dichloride for pyrolysis

By-products contained in EDC from the three main processes must be removed; these include by-products in EDC from direct chlorination, and oxychlorination and recovered EDC from the cracking process.

Ethylene dichloride from the oxychlorination process is generally less pure than direct-chlorination EDC and, thus, is usually washed with other water-extractable impurities. Low boiling impurities and water are taken overhead in the first (light-ends) distillation tower and then pure dry EDC is taken overhead in the second (heavy-ends) distillation tower.

Ethylene dichloride recovered from the cracking process contains an appreciable number of impurities. Two of these, trichloroethylene and chloroprene, are not readily removable by distillation and necessitate the use of other treatment.

Ethylene dichloride pyrolysis to vinyl chloride

Thermal cracking of EDC produces vinyl chloride and hydrogen chloride. The endothermic cracking of ethylene dichloride at gauge pressures up to 2.5-3.0 MPa (360-435 Psig) and the temperature of 500-550 C degrees can provide better heat transfer, reduce equipment size and relatively easily separate HCI from vinyl chloride by fractional distillation.

Chapter Eight

The Implications of the Korean and Japanese Experience for the Chinese Petrochemical and Electronics Industries

8.1 Introduction

As shown in chapters six and seven, both South Korea and Japan achieved remarkable success in technology transfer and development over the last three decades. In the case of the Korean petrochemical industry, many factors explain success. Among them are scale economies, government policy, realistic market prediction, successive and minor modifications and improvements to imported foreign technologies, special measures for reducing consumption of raw materials and energy, quality improvements and strong forward linkage between the petrochemical and other sectors, particularly textile & clothing, footwear and car industries. In the case of the Japanese electronics industry, scale economy and government policy have also been very important. Moreover, the particular structure of firms in the industry also to have been a crucial contributing factor to its rapid growth. Massive and continuous investment over the last thirty years has also been vital for the dramatic technological advance of the sector in Japan. Effective and efficient co-operation at the national level among most leading firms in research and development is certainly a big advantage for the Japanese electronics industry. Furthermore, the fierce competition in the international market has most effectively disciplined the Japanese electronics producers.

To what extent are these above factors relevant to the future development of Chinese petrochemical and electronics industries? This chapter is set to make some comparisons in these two sectors. Moreover, the relevance of Korean and Japanese experience to the Chinese economy as a whole will be discussed in the following chapter.

8.2 Petrochemical Industry and production in China, South Korea and Japan

China started to produce petrochemical products in the early 1960s. However, the Chinese petrochemical industry had achieved very moderate growth before 1975. This can be seen from the production growth of the some most important intermediate products of the petrochemical industry, namely ethylene and chemical fibres and synthetic fibres (see table 8-1 below).

Table 8-1 Production of some petrochemical products in China, 1952-1990
(Unit: '000 tons)

Year	1957	1965	1970	1975	1977	1978	1979	1980	1982
Ethylene	0	3	15	65	303	380	435	490	565
C.Fibers	0.2	50.1	101	160	190	285	326	450	517
S.Fibers								314	385

Year	1983	1984	1985	1986	1987	1988	1989	1990	1992
Ethylene	654	648	652	695	973	1232	1396	1572	1950
C.Fibers	541	735	948	1017	1175	1301			
S.Fibers		441	771	831	982	1125			

Source: State Economic Commission of China, State Statistical Bureau of China, China Statistical Yearbook, various issues.

Notes: for the data in 1992: China Petrochemical Corporation

From Table 8-1 we can see that the ethylene production jumped from annual 15,100 tons in 1970 to 65,000 tons in 1975 and to 303,000 tons in 1977. However, the growth had been quite moderate between 1978 to 1986, at an average annual rate of 9 percent.

Unlike South Korea and Japan, China started its petrochemical industry based on indigenous know-how and technology. The establishment of the oil industry in the late 1950s and early 1960s and the great importance of petrochemical products for both military and civilian use induced China to develop the industry in early 1960s. Most petrochemical plants in the 1960s and 1970s were using domestic technologies, characterised by small and medium-scale and low level technologies. However, China started to import foreign technology as early as in the mid-1960s. In the 1980s and early 1990s many petrochemical complexes were constructed with foreign technology, but many units are still run on the old domestic know-how and technologies.

On the contrary, Korea developed its petrochemical industry based on the imported foreign technology. Although South Korea started late (in early 1970s), it imported the most sophisticated and also the most efficient technologies and set up the very large-scale plants to exploit the scale economies from the very beginning. Moreover, they had successively enlarged the existing scale successfully on many occasions The production of main petrochemical products has experienced rapid expansion over the last twenty years. Table 8-2 lists the production of main petrochemical products in South Korea between 1983 to 1992.

Table 8-2 Production of some main petrochemical products in South Korea ('000 tons)

	1983	1984	1985	1986	1987	1988	1989	1990	1992
Ethylene	491	526	562	534	576	609	663	1054	3000
Polyethylene	279	317	353	376	469	572	637	841	
Polypropylene	195	219	259	263	348	518	530	574	
Polystyrene	123	132	134	253	304	340	434	592	
PVC Resin	323	344	411	472	451	455	464	526	
SBR	92	100	99	111	136	148	140	184	
Propylene	273	298	318	307	328	351	375	608	
VCM	179	188	202	189	198	209	195	374	

Source: Korea Statistical Yearbook, 1991.

Notes: For the data in 1992: Japan Petrochemical Industrial Association.

The petrochemical sector in Japan came into being in late 1950s when a pioneer, Mitsui Petrochemical Industries Ltd. finished construction and started up a complex, including an ethylene plant at Iwakuni in 1958 (see Japan Economic Almanac 1986). The Japanese petrochemical sector has been much bigger than that of South Korea and China. The following table lists the production of some main petrochemical products in Japan.

Table 8-3 Production of some petrochemical products, Japan ('000 metric tons)

Year	1977	1978	1979	1980	1981	1982	1983	1984	1985	1987	1988	1989	1990	1991
Ethylene			4780				3700	4383	4200	4580	5060	5600	5810	6140
PVC	1125@	1204	1592	1429	1129	1218	1420	1504	1550			1973	2048	2055
Polyethylene	1295@	1767	2165	1860	1671	1674	1773	2251	2027			2712	2887	2982
Polypropylene					959	941	1062	1272	1304			1719	1942	1955
Synth. Rubber	971	1028	1107	1094	1010	931	1003	1161	1158			1352	1425	1377

Source: Japan Petrochemical Industry Association; Japan Economic Almanac, 1986, 1993 editions; Japan Statistical Yearbook, 1986.

Notes: @ refers to the output in 1975.

8.3 Production Scale and Competitiveness in Petrochemical Sector

One of the major factors affecting the efficiency of petrochemical sector in China is closely related to the production scale. When China started its petrochemical industry, the country was totally isolated from the outside world. The technologies adopted by the Chinese petrochemical sector were almost entirely indigenous. Given the very low level of technological capability at that time, these technologies were, therefore, characterised as small scale and less sophisticated. Unlike South Korea, which imported large-scale and advanced foreign technologies from the very beginning, China built many petrochemical plants on a quite moderate scale. For example, 140 enterprises were producing synthetic fibres in 1980 in China, with a total output of 314,000 tons a year. When advanced foreign technologies and financial resources became available, China started to import whole plants with large scale production in the late 1970s. Although some large scale plants went on stream in the early 1980s, on average, the production scale of petrochemical plants in China has been smaller than that of South Korea, and much smaller than that of Japan. To take the production of ethylene, the most important basic petrochemical product, as an example, Koreans started their first ever ethylene plant at Ulsan in 1976, with an annual capacity of 150,000 metric tons. The production capacity of the subsequent ethylene plants in South Korea has been extended to 200,000 metric tons per year in the early 1980s. Furthermore, the Korean ethylene producers set up even larger plants, often with the range of 300,000 to 350,000 metric tons per year. For example, Smasung General Chemicals Co. established a petrochemical complex in July 1992 in Sosan, with a capacity to produce 350,000 metric tons of ethylene annually. In the meantime, the Hyundai Business Group was also constructing another complex, with the same production capacity of 350,000 metric tons of ethylene a year, on a nearby site (see Korea Business World, September 1992).

The production scale of petrochemical plants in Japan is even more impressive. For example, In 1983, there were twelve ethylene producers in Japan, with 14 ethylene plants between them. Of these, nine had annual production capacity of 300,000 metric tons and over (see Japan Economic Almanac, 1985). Even with an annual domestic demand of 6 million tons of ethylene, the Japanese Petrochemical Association and MITI still thought the number (12) of ethylene producers were too many (see Japan

Table 8-4 lists production scale of many plants at the Ulsan Petrochemical Complex, which is the first one in the South Korea.

Table 8-4 Production Scale of Petrochemical Plants in Ulsan Complex, South Korea (Mt/year)

	1976	1982	1985	1992
Ethylene	150,000		200,000	350,000
LDPE	50,000	70,000	100,000	
HDPE	35,000			
VCM	60,000	150,000		
Ethanol	30,000			
Acetaldehyde	24,000			
Styrene monomer	60,000			
polystyrene	50,000	100,000		
Propylene	81,000			
Polypropylene	45,000	80,000		
Acrylnitrile	27,000			
Butadiene	20,000			
SBR	37,000	50,000	50,000	
Benzene	74,000			
Caprolactam	33,000	100,000		

Source: Korea Petrochemical Industry Association.
Notes: For the data in 1992: Korea Business Reviews, November 1992.

Economic Almanac 1986). While in China, more than twenty plants were producing only 982,000 tons of ethylene in 1987.

Scale economies play an more important role in petrochemical industry than in most other industries, including many capital-intensive ones. The technical coefficients are very much fixed for many petrochemical technologies, one cannot do much to change them, for example, by substituting capital with labour. In some other industries, on the other hand, such as textile and clothing, capital could be substituted by more labour inputs, with a result of unchanged unit production cost. The optimum combination of production factors will surely depend on their relative prices in an economy. For most petrochemical production, labour cost only accounts a tiny part of the total cost. For example, in 1972, the cost of labour accounted for just 1.4

percent of total production cost for a ethylene plant with an annual 300,000 tons. While the share of the labour in the total production cost for a plant with a same production scale dropped to 0.6 percent in 1977 (see Table 7-4). The production scale is one of the key factors to decide unit production cost and, subsequently, the competitiveness of most petrochemical products. It is obvious that the small scale production put Chinese petrochemical producers at a very disadvantageous position from the very beginning.

Table 8-5 Total unit investment costs for selected petrochemicals and intermediates

	small plants		large scale	
Intermediate/ products	Individual plant US$/ton/yr.	Total investment US$/ton/yr.	Individual plant US$/ton/yr.	Total @ investment US$/ton/yr
Ethylene	802	--	611	--
HDPE	636	1,450	448	1,094
LDPE	1,000	1,850	692	1,340
LLDPE	634	1,377	461	1,027
Ethylene oxide	1,005	1,773	701	1,286
Ethylene glycol	234	1,556	153	1,112
Ethyl benezene	112	328	77	242
Styrene	282	658	215	493
Polystyrene	487	1,158	352	855
SBR	1,331	1,478	856	966
DMT	1,181	--	883	--
PET	1,178	2,919	828	2,150
TAP	1,170	--	865	--
PET	1,116	2,632	694	1,835
Chloride	661	--	451	--
VCM	414	1,195	312	875
PVC	998	2,000	645	1,514

Source: UNIDO, ID/WG, 336/3, May 1981, P.105.

Notes: @ including upstream investment

Plant size also has a very strong effect on the investment costs for the production of many petrochemical products, not only ethylene. The extent of the effect will depend on the type of the product, its level of maturing, its production cost structure and the complexity of the production process. Table 8-5 shows the different unit investment costs with different plant sizes for some major petrochemical products.

From the table above we can see that the unit investment cost of different products varies significantly, from the highest unit investment cost of PET at US$ 2,150 to the lowest US$ 242 for ethyl benzene (all in large scale plants). But the most important point is that of the unit investment cost difference between the same product with different production scale. The unit investment cost of the products in the table above for small scale (all for individual plant) is much higher than that of large scale production. The results are given below:

Products	Percentage (higher)
Ethylene	31.3
HDPE	42
LDPE	44.5
LLDPE	37.5
Ethylene oxide	43.4
Ethylene glycol	53
Ethyl benzene	45.5
Styrene	31.2
Polystyrene	38.4
SBR	55.5
DMT	33.7
PET	42.3
TAP	35.3
PET	60.8
Chloride	46.6
VCM	32.3
PVC	54.7

Large scale plants also have big advantage over the small ones in unit cost reduction. One research reported (Source: UNIDO, ID/WG, 336/2, May 1982) that increasing plant scale from small to large can reduce the unit cost: 4 percent for ethyl benezene and styrene; 7-10 percent for PVC, VCM, PS, LlDPE and HDPE; around 13-16 percent for methanol, PP, ethylene, LDPE and ethylene oxide; and about 18 percent for SBR.

8.4 Major Factors Affecting the Performance of the Chinese Petrochemical Producers

The present survey shows that many factors have accounted for the failure to effectively exploit the economies of scale in the Chinese petrochemical industry. Before the late 1960s, it was the absence of foreign technology and know-how, and the lack of technical experts which prevented China from exploiting scale economies in the sector. Sedition from the Eastern block led by the Soviet Union and embargo by the Western allies led by the United States isolated China entirely. Being denied to access to any foreign technologies, China started to develop its petrochemical sector by using indigenous technologies in the late 1950s and early 1960s. However, given its low level of technological capability, China only managed to build a small number of petrochemical plants with very small production scale before the early 1970s. For example, the first ethylene production plant, with an annual capability of 5,000 tons, was built by the Lanzhou Chemical Company in 1961, which used the gas generated from its oil refinery. The technologies used in the plant were very primitive, with a low technical efficiency and high consumption of raw material and energy. The unit production cost was consequently very high. Even though on such a small scale, the plant only managed to reach its design capacity (5,000 tons a year) in late 1960s. While in 1965, the average annual ethylene production in the world already reached to 180,000 tons. In the same year, China only produced 3,000 tons ethylene. Between 1961 and 1970, Chinese petrochemical industry grew at an incredibly slow pace. This can be seen from that the annual production of ethylene, which is the most important basic petrochemicals and also the symbol of a country's petrochemical industry development, in China only reached 15,000 tons in 1970.

Although China started to develop petrochemical industry several years earlier than South Korea, it began large scale production as late as in 1977 (three to four years behind the South Korea). First foreign technology for ethylene production was imported from Germany in the late 1960s, with an annual capacity of 36,000 tons. The whole project was initially approved by the state council in 1964. However, the plant construction and equipment installation took five years (1965- 1970) to complete.

As mentioned earlier, the average annual production scale in the world already reached 180,000 tons in 1965, it increased again to 237,000 tons between 1966 and 1978. Why did China import foreign ethylene production technology with a small capacity- 36,000 tons a year? The survey revealed that neither technical nor economic feasibility studies had been taken before the technology import. Why the company imported ethylene production technology from Germany other than from other countries, and why the imported technology had such a small scale tended to base on random choice. However, the selection of such a small scale foreign technology did reflect, to some extent, the reality that there was acute short supply of both technical and managerial manpower in China at the time. An annual capacity of 36,000 tons was indeed very small by the international standard, it however represented a seven time-fold of the production capacity of the company's ethylene plant, which was also the only ethylene plant of that time in china. Besides, the imported foreign technologies were very advanced. To import, adapt and master such a small-scale foreign technology already presented a big challenge to China at that time.

Since 1973, almost a decade later after the Lanzhou Chemical Company started the first foreign technology import in the petrochemical sector, China embarked on second round production expansion and technology upgrading. The first very large scale (300,000 tons/year) ethylene plant was imported by Yanshan Petrochemical Company in late 1970s. However, it is not yet clear whether the Chinese decision makers and economists had realised and taken the factor of scale economies into account when they planned to import these foreign technologies. The three ethylene production plants imported during the period varied greatly in terms of production capacity, with Yanshan Ethylene Plant (The construction started in August 1973) having an annual capacity of 300,000 tons/year, while Shanghai Ethylene Plant (The construction started in January 1974) only 115,000 tons/year, and Liaoyang Ethylene Plant (The construction started in October 1974) just 73,000 tons/year. There were no good reasons to explain why the plants with such huge difference in terms of production scale could coexist. In fact, the small-scale Liaoyang Ethylene Plant should not be constructed at the first place. Moreover, there was also no strong rational economic argument to support the decision that the biggest ethylene production plant should be located in Beijing, which had relative disadvantages to the other two cities both in upstream and downstream production facilities. Shanghai is the biggest city in China and has been the industrial and commercial centre for more than one hundred year. It has much bigger and stronger industrial base and downstream production facilities than Beijing. Liaoyang is not only an industrial city but more importantly is very near to the biggest oil field and refinery facility in China, while Beijing is more than two thousand kilometres away. The biggest ethylene plant was located in Beijing probably because the city is the country's capital and also because such a huge project would have a very strong 'snow-ball' effect for setting up more big downstream production plants and facilities. This would mean hundred of thousands of new jobs would be generated for the urban population in Beijing. The social and political impact for having such a big project would be much stronger and favourable to the decision makers in the capital than in other cities.

Many petrochemical projects which were constructed in the 1980s and are being proposed in the 1990s have also revealed their political and social orientation. The average annual ethylene production in the world reached to 450,000 tons in late 1980s and early 1990s. The production capacity of some largest plants in the world now goes well beyond 450,000 tons and even reaches 720,000 tons. While in China many economists and engineers have estimated that the optimum plants size for ethylene production would be within the range of 300,000 tons to 450,000 tons a year, if all relevant factors, such as location, transport and downstream production facilities in the nearby region, water, raw material and energy supply, and also the composition and quality of the raw material are taken into account. It is true that since early 1980s, four more large scale ethylene plants have come to operation, however, many more small scale plants have also been built and are being proposed. For example, in 1992, thirteen small-scale ethylene plants in China produced only 43,000 tons and another six middle size plants produced 580,000 tons between them. Moreover, more and more local governments are trying extremely hard to set up ethylene plants in their own regions. Among the newly approved ethylene production projects, at least five are below the annual capacity of 140,000 tons, they are Guangzhou Plant (The contract was signed in January 1992) with annual production capacity of 115,000 tons; Xinjiang, Beijing, and Zhongyuan plants (all these three plants signed their contracts in 1991, while only Beijing plant started construction first in June 1992) with 110,000 tons a year each; and Tianjin Plant with an annual capacity of 140,000 tons (The construct was signed in June 1992, and planned to start operation in August 1995). Some economists have pointed out that the economy as a whole and the petrochemical industry in particular would benefit considerably if these approved mid-scale ethylene projects (within range between 110,000 to 150,000 tons a year) could be replaced by a small number of big plants (with an annual production capacity of 450,000 tons a year).

If the lack of qualified technical and managerial personnel and the lack of experience of operating large scale plant were among the key factors for the failure to exploit economies of scale in the Chinese petrochemical sector in the 1960s and early 1970s, they are no longer true in the 1980s and particular the early 1990s. The experience of one of the companies covered by the survey, the Lanzhou Petrochemical Company, has already revealed this. The company was the first one in the petrochemical sector and was also the first one to import foreign technology. Over the period of 1962-1992, the company accumulated vast experience in the areas of production, management and labour training. It had trained 15,000 managerial and technical personnel for more than 300 enterprises and government departments. In 1992, the company had 6,740 technical personnel, of which 566 were senior engineers, 1,978 were engineers and 4,196 were technicians. However, with decades production and management experience, the company's ethylene plant just reached 80,000 tons a year as late as in 1988. It is obvious that some things else other than lack of technical and managerial personnel and production experience have prevented the company from reaching a large-scale operation. The survey shows that lack of investment funds and very limited autonomy concerning the company's economic matters are the key constraints for the company's necessary expansion and technical upgrading.

Lack of competition and existing ineffective market mechanism are mainly responsible for the irrational coexist of both large-scale plants and small ones, efficient and inefficient producers in the Chinese petrochemical industry. Many important raw materials and final products are still priced by the state. This would, without doubt, lead to irrational price system and greatly hamper competition.

The survey shows that unit production cost of ethylene varies greatly between producers. For example, it is 931 yuans per ton for Beijing Ethylene Plant, one of the biggest and perhaps the most efficient plants in China, 1,419 yuans for Shanghai Ethylene Plant, but 2,345 yuans for Lanzhou Ethylene Plant, which is the first ethylene producer in China. The different unit production costs seem to be closely linked to different production scale among the plants, while Beijing plant has an annual production capacity of 300,000 tons, Shanghai plant 115,000 tons, and Lanzhou plant just 36,000 tons. The Lanzhou Petrochemical Company was the first to import foreign ethylene production technology in 1964. However, the company's ethylene plant had operated, with a mere 36,000 tons/ a year, for nine years (December 1969- November 1978). Although the plant doubled its production capacity to 72,000 tons a year in November 1978, the expanded capacity was achieved by introducing another set of production system, which was designed by the company itself. The new production system was more or less a copy of the existing one. This was not the efficient way to increase the company's production scale.

Moreover, the initial operation also revealed some major design flaw and structural problems.

The small scale production, among others, may be also responsible for the technical inefficiency for the Lanzhou Ethylene Plant. Consumptions of both raw materials and energy for per ton of ethylene production at Lanzhou Ethylene Plant were considerably higher than that of Beijing and Shanghai plants. This was particularly true before 1989, when an entirely new ethylene production system, with an annual capacity of 80,000 tons a year was introduced.

Comparison of raw materials consumption in Lanzhou, Beijing and Shanghai plants (tons of light diesel oil/ton ethylene)

1984					1985				
A Lanzhou	B Beijing	C Shanghai	A as % of B	A as % of C	A Lanzhou	B Beijing	C Shanghai	A as % of B	A as % of C
7.693	3.676	3.78	209.3	203.5	7.58	3.63	3.72	208.8	203.8

Comparison of energy consumption in Lanzhou, Beijing and Shanghai plants (10 Kcal/ton)

1984					1985				
A Lanzhou	B Beijing	C Shanghai	A as % of B	A as % of C	A Lanzhou	B Beijing	C Shanghai	A as % of B	A as % of C
2423.5	988.6	1156.4	245.1	209.6	2685.1	948.8	1153.9	283	232.7

It is certainly true that small scale is only one of the reasons for Lanzhou plant's low technical efficiency. The survey also shows that lack of necessary financial resources and consequently failure to timely replace old equipment are also two key factors responsible. For example, in 1992, among the total 41 sets of production systems in the Lanzhou Company, 33 were out of replacement date. And among the 22,500 units of production equipment, 62 percent were beyond replacement date and 40 percent (9,193 units) of the total units have been 10 years beyond their replacement date.

In the past, all investment funds came from the state budget, and the Lanzhou Ethylene Plant had long been denied of further funds for expansion and upgrading, which were very necessary and economically desirable. Over the past fifteen years, especially past eight years, many economic reform schemes had been introduced. State- run companies began to be given some leeways to borrow money for technical upgrading and production expansion. However, many companies, particularly the companies like Lanzhou Petrochemical Company (LPC), has found that it is still very difficult to obtain a substantial amount of money to finance a large capital project. Many factors accounted for this. In the case of LPC, the exceptionally low depreciation rate is one of the main factors. In China, depreciation rates are often assigned on company basis. It was 2.8 percent for the LPC in the 1960s and 1970s, and 3.2 percent for the 1980s and 5 percent since 1988. Many 30 years old equipment and machineries are still to be depreciated. While Beijing Petrochemical Company (BPC) and Shanghai Petrochemical Company (SPC) have an annual depreciation rate of 6 percent.

Low profit rate has also weaken the financial capability of most companies. The deliberate high prices for inputs and low prices for outputs, both are still decided by the state have squeezed the profit margin of Chinese petrochemical producers to an extremely low level. In addition, the state has also imposed a very high taxation on profit. This has led to a very low ratio of retained profit- below 5 percent (It is currently 4.75 percent for the BPC and 4.6 percent for the SPC).

Lack of necessary financial resource has been one of the key factors responsible for the extremely low technical efficiency of the LPC. It is difficult to expect a company, with majority of its production facilities obsolete, to operate efficiently. More importantly, the great difficulty for obtaining funds has induced many companies to make rash investment decisions whenever an opportunity becomes available. For example, after having lobbied very hard for nearly ten years, the LPC luckily got a significant amount of investment funds in 1987. The funds, however, only enabled the company to import a new generation of cracker tower with an annual production capacity of 80,000 tons. There was still a quite big financial gap for the company to upgrade other production facilities simultaneously. The upgrading of some other existing facilities was very important and necessary to have the new cracker tower operated efficiently. Among them, a new separation system was thought crucial and cost 160 million yuans. In a normal circumstance, such a huge capital investment project should not be started before a satisfactory financial solution for upgrading other main facilities can be found first. However, the LPC still made the deal to import the new cracker tower without thinking the potentially disastrous economic consequences seriously. In 1988 the company installed the new cracker tower and expanded the annual production capacity to 80,000 tons. However, the continuous use of the existing separation system, which had been obsolete for several years at the time, meant that only 70 percent of the design capacity of the new cracker tower could be realised. In addition, the serious leakage from the old separation system also cost the company very badly. These together incurred an annual 26 million yuans to the company, which was almost 20 percent of the total cost for purchasing a new separation system.

Delay in construction and particularly delay in reaching 'design capacity' are another two key factors for the low efficiency of many Chinese petrochemical producers. The survey shows that the average time period from starting construction to startup of operation for the 17 plants which gave their answers for this question was 59.1 months. Of the 17 plants, five are between 30 to 34 months, two for 37 months, one for 48 months, one for 59 months, two for 64 months, one for 72 months, two for 84 months, the rest three are 89, 96 and 108 months, respectively. The schedule time for construction of a petrochemical plant in China varies from 30 to 45 months depending on their sizes, locations, transport facilities and supply conditions of key materials. For example, the schedule time for the construction of Yangzi Ethylene Plant (with an annual capacity of 300,000 tons) was 44 months. It took 108 months (9 years) for the Sichuan Petrochemical Fibre Plant (with an annual production capacity of 91,000 tons) to complete the construction. The construction of Liao Yang Petrochemical Fibre Plant (with an annual production capacity of 175,000 tons) lasted for 96 months (8 years). This certainly incurred a huge economic loss to the companies and also to the Chinese economy as a whole. Many reasons were responsible for the delay. Among them were sudden change of government policy (either because of political or financial reasons), lack of raw material either for plant construction itself or for production, mismanagement of construction process, short supply of water and electricity, and poor transport facilities, selection of an inappropriate site, lack of skill and experience of building very large scale plant, inadequate number of qualified engineers and technical personnel. Moreover, seven out of eight plants which lasted for over 64 months started construction before 1977. It is also quite encouraging to find that four of the largest plants (they each have an annual production capacity of 300,000 tons) completed their construction within 37 months. And the Shanghai Second Ethylene Plant completed its construction within 31 months.

Slow to reach 'design capacity' is another key factor for the low efficiency of many Chinese petrochemical producers. For example, it took the BPC seven and a half years to reach the 'design capacity' in its ethylene plant. While the LPC just managed to operate at less than 70 percent of the production capacity after seven years it enlarged its previous ethylene plant. Both Qilu and Yangzi ethylene plants reached their 'design capacity' after five and a half years of startup operation. Among the major factors for the delay are short operation cycles, frequent breakdown, lack of technical and managerial skill, poor quality of raw materials, low capacity of downstream production facilities, poor transport facilities, short supply of raw materials (from time to time), the time spent on inspection and maintenance being too long, inadequate technical feasibility study, and almost absence of economic feasibility study before technology importing.

Failure to keep operating at full capacity after reaching 'design capacity' is another reason for the low technical efficiency of many producers. For example, the Beijing Ethylene Plant dropped below the 'design capacity' level again in 1984, 1985 and 1986 after it reached that level in 1983. While the Shanghai Ethylene Plant just managed to run at 18 percent of its full capacity in 1991, which resulted in a 55 percent increase in energy consumption, from about 10,200 Kcal/ton in 1990 to 15,820 Kcal/ton in 1991. The main reasons for the sudden drop in operation rate are lack of raw materials supply, frequent breakdown, and inadequate capacity of downstream production facilities, the last one was the key reason responsible for the sudden drop of the production of the Shanghai Ethylene Plant in 1991.

Very encouragingly, the present survey also shows that the performance of the Chinese petrochemical sector has improved since the late 1980s. This can be seen from table 8-11. The beginning of the 1990s shows an encouraging sign of continuous improvement for the Chinese petrochemical industries. For example, in 1991 and 1992, all major Chinese ethylene producers have successfully reduced the unit consumption of both raw materials and energy. The highest level of unit consumption of raw materials for the major ethylene producers except the chemical plant of Gaoqiao Company, which did not operate normally, in the 1991 and 1992 was 3.757.

For example, Beijing Ethylene Plant had a quite stable unit consumption level of 3.475 and 3.488 for 1991 and 1992, respectively. The corresponding figures were 3.82 and 3.757 for Qilu Company; 3.696 and 3.552 for Yangzi Company; 3.678 and 3.65 for Shanghai Company; 3.957 and 3.950 for Liaohu Company. Even the Lanzhou Petrochemical Company achieved an impressive unit consumption of raw materials 3.797 (for 1991) and 3.689 (for 1992), while it had a very high unit consumption of raw materials in the mid-1980s, 7.963 in 1984 and 7.58 in 1985. The unit consumption of energy had also been reduced considerably. Four of the five largest ethylene plants had brought the unit consumption of energy below 9,360 Kcal in 1992. Although the LPC had the highest level of unit consumption of energy in 1992- 12,520 Kcal, which still represented a more than 100 percent reduction of its 1985 level (26,450 Kcal). The economic benefits gained from these reduction were huge. The unit consumptions of energy for 1991 and 1992 were 8,250 and 8,520 for Beijing Petrochemical Company; 9,620 and 8,790 for Qilu Company; 9,380 and

9,360 for Yangzi Company; 13,090 and 11,140 for Shanghai Company; 12,900 and 10,090 for Liaohua Company; 14,570 and 12,520 for Lanzhou Company; and 10,370 and 10,280 for Jihua Company.

High operation rate is one of the key factors for the reduction in unit consumption level of both raw material and energy in 1992. In fact, all major ethylene products have over-fulfilled their planned production in 1992. Four of the five largest plants (with 300,000 tons/per year each) have operated above their 'design capacity', with annual production of 328,268 tons for Beijing Company, 324,449 tons for Daqing Company, 301,200 tons for Qilu Company and 320,033 tons for Yangzi Company.

Strong market demand is certainly one of the important factors for the high operation rate. However, given the fact that the supply had been lagging behind the demand for ethylene product in China for the whole 1980s and the early 1990s, it seems that some other factors might have played the key role. The survey shows that technical modifications, innovations and continuous training (especially on the job training) may have helped the producers to achieve a better management and a more efficient production over the past decade, although any statistical correlation is extremely difficult to be established.

Given the price distortions and strange taxation policy, it is difficult to judge the economic efficiency of the petrochemical producers in China, and even more difficult to compare the economic efficiency between producers in South Korea and China.

8.5 Some Implications of Korean and Japanese Experience

As shown in the survey, failure to reach 'design capacity' quickly is one of the major reasons for the poor performance of many Chinese petrochemical producers. Many petrochemical plants in Japan and South Korea also suffered from the low capacity operation in the early 1980s, but that was because the sudden drop in demand and world-wide economic recession. It was never the same case in China. Chinese petrochemical producers have never met the strong domestic demand over the last two decades. China has continuously imported huge amount of petrochemical products over the last two decades (see the tables below).

Table 8-6 Imports of some petrochemical products by China, 1971-1980

Products	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Polyvinyl chloride tn	13651	53351	61669	64521	31576	45267	59609	79938	66033	67497
LDPE tn	650	747	2282	24246	18128	17792	8978	12853	7517	6630
HDPE tn	154	--	280	20950	20237	29403	33913	26887	16211	45742
Polyamide fibre tn	5400	7900	9000	13200	8000	12900	10900	12500	14500	27100
Polyster fibre(000'tn)	10.5	18.4	28.0	48.1	67.3	94.2	141.7	179.7	125.8	251.0

Source: China Statistical Yearbook, 1981.

Table 8-7 Imports of some petrochemical products by China
(Volume: 000' Tons; Value: US$ Mns)

	1985		1986		1987		1988		1989		1990	
	Vol	Valu	Vol	Value	Vol	Valu	Vol	Value	Vol	Valu	Vol	Value
Polyethylene in primary forms	741	470	680	420	669	501	1018	1294	534	573	359	299
Polypropylene in primary form	411	302	348	256	291	281	562	766	260	287	218	186
Polystyrene in primary form	130	107	154	116	85	104	401	638	190	268	143	166
PVC in primary form	61	44	87	63	84	71	104	123	84	99	78	76
Synthetic fibre for spinning	490	710	301	421	241	370	451	787	392	691	376	554
Synthetic fibre continuous filament and yarn	300	711	200	454	86	217	112	330	128	404	116	293
Synthetic rubber	72	80	84	90	47	51	41	59	40	57	44	67

Source: China Statistical Yearbook, 1992.

On the contrary, Korean and Japanese petrochemical producers have been continuously running at a very high rate of operation. For example, both the VCM and LDPE plants at Ulsan quickly reached the 'design capacity' and have continuously maintained that high level since then (see Table 8-8). These two plants had a small setback between 1981 to 1983, when output dropped below 'design capacity' because of a world-wide recession, which sharply reduced the demand for petrochemical products.

However, the reasons for the low capacity operation of many Chinese petrochemical plants, as shown in the survey, have been slow adaptation and diffusion of imported advanced technologies, lack of locally supplied supplementary parts, insufficient inspections and maintenance, frequent breakdown and unguaranteed supply of energy and raw materials.

Korean experience shows that effective measures of reducing raw material, energy and fuel consumption proved to be crucial to a lower unit production cost and an increase in the competitiveness of petrochemical products.

Table 8-8 The outputs of LDPE and VCM plants at Ulsan (1973-1985)

Year	Low density polyethylene (metric tons per year)		VCM (metric tons per year)	
	Design Capacity	Actual Production	Design Capacity	Actual Production
	50,000		60,000	
1973		56,431		56,183
1974		69,799		55,263
1975		60,945		57,309
1976		63,767		60,680
1977		65,460		61,804
1978		71,925		65,344
1979		67,902		60,008
1980		63,391@		48,869@
1981		57,332@		56,401@
1982		48,863@		51,695@
1983		57,806		59,440
1984		67,282		59,936
1985 (6 months)		29,330		26,858

Source: Korea Petrochemical Industry Association, 1988.
Notes: @: insufficient market for output.

The petrochemical industry is unique in the sense that the share of raw material in the total production cost has bee very high. For example, the raw material accounted 42.2 percent of total production cost in a large ethylene plant with capacity of 300,000 tons a year. However, the first oil crises in 1973 pushed the share to a very high level of 71.6 percent in 1977. It is very obvious that any considerable progress in raw material conservation would make a great impact on reduction of unit production cost.

Table 8-9 Material consumption indicators of key petrochemical enterprises in China. (1980-1990)

	1980	1981	1985	1987	1988	1989	1990
Ethylene consumption for LDPE (kg/tn)	1059	1068	1052	1065	1042	1050	1054
Calcium carbide cos-umption for PVC(kg/tn)	1464	1464	1449	1468	1409	1409	1443
Propylene consumption for polypropylene (kg/tn)	1170	1166	1162	1176	1134	1142	1149
Butadiene consumption for butadiene rubber (kg/tn)	1046	1040	1035	1032	1030	1029	1029
Calcium carbide cons-umption for chloropr-ene rubber (kg/tn)	3193	3263	3024	3027	3020	3013	3007
Crude Benzene consum-ption for pure benzene (kg/tn)	1484	1497	1498	1440	1502	1500	1479

Source: China Petrochemical Industry Association, 1992.

From the table above we can see that some progress has been made in reducing the raw material consumption in the Chinese petrochemical sector. For example, the consumption of calcium carbide for chloroprene rubber production has been reduced from 3,193 to 3,007 kg/ton over the ten years period, a 5.8 percent reduction. The corresponding figures are: 0.47 percent reduction of ethylene consumption for LDPE, 1.4 percent reduction of calcium carbide consumption for PVC, 1.8 percent reduction of propylene consumption for polypropylene, 1.6 percent reduction of butadiene consumption for butadiene rubber and 0.3 percent reduction of crude benzene consumption for pure benzene, respectively. Except the calcium carbide consumption, which recorded a 5.8 percent reduction over the ten years period, all others have not achieved big progress. To make a comparison with Korean producers, the raw material consumptions at the LDPE and VCM plants at Ulsan are listed below.

Table 8-10 Raw material consumption at the LDPE and VCM plants at Ulsan, (1973-1984)

Year	Ethylene Consumption for LDPE (kg/ton)	Ethylene Consumption for VCM (kg/ton)	EDC Consumption for VCM (kg/ton)
1973	1054	242	900
1974	1030	237	885
1975	1035	229	869
1976	1024	231	876
1977	1020	230	875
1978	1011	227	886
1979	1022	223	904
1980	1027	221	923
1981	1021	222	884
1982	1017	223	891
1983	1015	224	869
1984	1013	222	892

Source: Korea Petrochemical Industry Association, 1988.

If we take a look at the ethylene input for the production of LDPE in the two tables above, we can see that the level of use in the Korean plant in 1973 was very similar to that of Chinese producers in 1980. However, ten years later, Koreans had successfully reduced the consumption level from 1,054 to 1,013 kg/ton. While Chinese producers had only managed to reduced it to 1,054 kg/ton in 1990, which was exactly the same as that of Koreans in 1973. With the annual production of polyethylene of 1,500,000 tons a year, China could save 61,500 tons of ethylene a year if it can reach the consumption level of Koreans. Given the international price of US$ 730 for per ton of ethylene in 1989 (see Korea Business World, 1989), this means that China can save 44,895,000 US dollars a year just for polyethylene production alone. To put it into another way, China could realise a reduction of US$ 30 for per ton of polyethylene production. This would considerably increase the competitiveness of the Chinese polyethylene products in the world market if China wished to export them. The impact on cost reduction and on competitiveness would be high if we took all other petrochemical products and a fast expansion rate in the Chinese petrochemical sector as a whole (for example, the total consumption of ethylene would hit 5 millions tons a year before the end of the decade) into account.

The Korean experience also shows that the competitiveness of many petrochemical products can be obtained by efficient transfer, modification and diffusion of imported foreign technologies. In regard to the very nature of the big share of raw material and energy in the total cost of production of most petrochemical products, measures leading their reduction should be given top priority in application process of imported technologies. As has been demonstrated by the Koreans, such measures are crucial for the competitiveness of a country's petrochemical producers.

Korean petrochemical producers aimed to become internationally competitive from the very beginning. The major portion of the Korean petrochemical products have gone to meet the growing demand from other exporting industries, including textiles and clothing, footwear, automobiles and toys, since the early 1970s. However, the direct export of petrochemical products has expanded rapidly over the last fifteen years or so. This can be seen from Table 8-11.

Table 8-11 Imports and exports of some main petrochemical products by South Korea and Japan, 1976-1990 (in '000 US dollars)

	1976	1977	1978	1979	1980	1981	1982	1983	1984
Polyethylene									
Korea Imp.	25522	56851	71204	130124	40779	42583	49548	57240	64948
Exp.	16	165	710	4825	32930	20914	33280	23147	26814
Japan Imp.	--	4334	11473	18856	30416	63806	78478	51587	45361
Exp.	242764	276595	283839	345112	389826	322075	315508	302847	353641
Polypropylene									
Korea Imp.	2305	7247	31506	51640	12113	12299	20377	30423	29216
Exp.	2548	489	186	4364	12047	16580	22233	30121	24445
Japan Imp.	519	832	1879	12751	17870	17580	10861	9955	8602
Exp.	87382	111055	126974	130013	128523	176030	169180	167687	183482
Polystyrene									
Korea Imp.	8386	10230	15240	43976	22643	11763	8049	13589	16940
Exp.	516	1074	1780	846	15446	14301	15278	20904	27081
Japan Imp.	3256	5995	11398	34502	45638	45499	38101	32698	37161
Exp.	88473	116739	147583	171448	177660	196033	194638	235237	297909
PVC									
Korea Imp.	7310	16735	11127	22432	8978	10208	9559	8600	14743
Exp.	1409	2531	7473	11052	45841	47251	57056	48642	65530
Japan Imp.	20548	18204	40271	45926	60159	73042	90902	65085	72275
Exp.	188246	188032	182317	232045	242999	204994	179196	209037	219281

	1985	1986	1987	1988	1989	1990
Polyethylene						
Korea Imp.	56752	81885	135098	143533	161760	120527
Exp.	22209	6758	6318	16473	35004	121856
Japan Imp.	57409	95975	95042	112359	129810	104450
Exp.	275716	322930	352445	337758	337157	348093
Polypropylene						
Korea Imp.	21200	30446	54985	28290	27241	28536
Exp.	42803	24786	44681	80705	127095	98942
Japan Imp.	16394	27732	30923	27980	164325	36813
Exp.	186804	230870	311388	295765	231447	300932
Polystyrene						
Korea Imp.	21545	22343	41321	37692	32469	28844
Exp.	49279	74269	102560	131245	213166	223014
Japan Imp.	35004	52405	51385	76399	79073	82410
Exp.	258104	314169	463954	514718	462088	515453
PVC						
Korea Imp.	14216	16721	31294	70314	66958	105828
Exp.	78581	118654	119090	107455	76069	85857
Japan Imp.	80960	138134	152404	112451	93894	100496
Exp.	218192	264578	313078	258039	221120	210533

Source: International Trade Statistics, various issues.

Lack of competition is another important factor for the poor performance of Chinese petrochemical producers. On the domestic market, there was little competition between the Chinese producers at least before the mid-1980s. Low supply capacity

(China has been a big net importer of many main petrochemical products over the last twenty-two years) has further reduced the chance for competition. Moreover, the domestic petrochemical sector has been tightly protected from foreign competition. Given all these factors, the Chinese petrochemical producers certainly had no incentive and need to compete in the international market. The government policy should be formulated to encourage competition between the domestic petrochemical producers. To open the domestic market to foreign competitors will force the Chinese petrochemical producers to adopt most efficient technologies and improve management techniques.

8.6 Growth and Future Development of the Chinese Electronics Industry

8.6.1 Production and Exports Since 1978

The Chinese electronics industry has 17,000 firms with 1.8 million workers. In 1992, the industry achieved a new annual growth record of 47.4 percent, with the value of output exceeding 100 billion yuans (US$ 17.5 billion). The industry is expected to grow at an annual rate of 20 percent between 1993 and 1995, hitting 200 billion yuan (US$35 billions) by the end of 1995 (see China Daily, July 3 and July 13, 1993).

The share of the developing countries in China's total electronics exports declined from 93.9 percent in 1980 to 67.4 percent in 1987, while the share of the United States rose from 1 percent to 18.3 percent during the same period. And the EEC took 10.3 percent of China's total electronic exports in 1987 (see Hongkong Trade Statistics, 1980-1987; OECD, Trade by Commodities, 1980-1987).

Chinese electronics industry achieved an average annual growth rate of 20 percent between 1979 and 1987 and its exports grew at an annual average rate of 35 percent in real terms during the same period, much faster than the 18 percent rate registered

Table 8-12 Exports of Electronics Industry, China (1978-1987, 1992)

Year	Total Value (US$ Mn)	Value Index (1978=100)	Percentage of China's Manuf. Exp.	percentage of China's Total Exp.
1978	96	100.0	1.93	0.95
1979	131	136.5	1.93	0.96
1980	203	211.5	2.17	1.07
1981	260	270.8	2.37	1.21
1982	258	268.8	2.34	1.13
1983	339	353.1	2.88	1.42
1984	473	492.7	3.4	1.71
1985	528	550.0	3.53	1.72
1986	996	1034.5	4.80	2.82
1987	2043	2128.1	6.73	4.29
1992	6870	7156.3	--	8.47

Source: USCIA: International Trade Annual Statistical Supplement (1984-1989).

Notes: For the data in 1992: Ministry of Electronics Industry, China, 1993.

Table 8-13 Commodity composition of Electronic Exports, China, 1979-1987 (in US$ millions)

	1979	1980	1981	1982	1983	1984	1985	1986	1987
Telecommunications equipment	10.0	16.8	19.5	15.1	35.9	47.3	59.3	145.1	299.5
Consumer products	15.0	42.7	57.1	74.7	104.4	200.5	245.4	506.7	1134.7
of which, TV sets	1.1	5.5	6.4	7.2	9.0	10.3	35.7	78.4	201.2
radios	12.7	31.2	44.4	59.0	79.8	144.9	167.6	333.9	767.4
Electronic parts	97.5	132.6	172.0	151.9	182.1	202.3	186.5	268.6	471.8
Business electronics	8.3	10.6	11.6	16.8	16.3	22.9	36.4	75.8	136.6
Total electronics	130.8	202.6	260.1	258.5	338.5	473.0	527.6	996.1	2042.6

Source: USCIA: China: International Trade Annual Statistics Supplement 1984-1989.

between 1970 and 1978. In 1992, China exported five million colour TV sets and 120 million recording devices. Chinese-exported black-and-white TV sets accounted for 30 percent of total world exports.

Although China's electronic exports increased rapidly between 1979 and 1987, its share in world electronic exports was only 1 percent. World electronic exports rose from US$ 84.1 billions in 1979 to US$ 234.7 billions in 1987 (see International Trade Statistics Year-book, various issues).

8.6.2 Problems and Strategies

The Chinese electronics industry is facing some extremely difficult problems. Of these, the technology gap between China and Japan is very important. It will slow down production and, particularly, export of the Chinese electronics in the near future.

To take the production of memory chips, which has been the most dynamic area of world electronic production and export over the last twenty years, China has so far only reached the technology level of Japan in 1981 or 1982. No Chinese producer is capable of making RAM chips beyond the capacity of 64 K, while the Japanese producers are making 16M and 64M RAM chips. It is not only the low level of technology but also, and more importantly, the incredibly slow progress in this area which reveal the weakest area of the Chinese electronic sector. In 1985, Wuxi Microelectronic Company, with financial support and technological assistance, acquired the production capability of 64K RAM ICs partially by importing some key technologies and partially by pooling domestic expertise. However, eight years later, the technology level of RAM ICs production in China stays at a similar position as in 1985. During the period, neither were there any domestic technological breakthroughs, nor were any advanced foreign technologies imported.

Second, the production scale of many electronic products is quite moderate. A simple comparison between China and Japan can reveal the problem vividly. For example, 17,000 firms with nearly two million workers in China produced US$ 17.5 billion worth of goods in 1992, while each of the top ten Japanese electronic producers has the turnover of over US$ 20 billion. The production of ICs in China rose from 1.684 million in 1980 to 5.313 million units in 1985, while Hitachi, NEC and Fujitsu each were producing 64K DRAMs at a monthly rate of more than 10 million units and Mitsubishi Electric 8 million a month (see Japanese Electronic Almanac, 1988). In 1989, the production of ICs in China (including all types) only reached the level of 100 million units a year.

Third, lack of close co-operation between the producers and research institutions and between the latter themselves is another key factor for the slow technological progress in the Chinese electronic sector. The survey shows that the government had been actively involved in the development of the industry between 1981 and 1985. However, the government has failed to show its enthusiasm and vigour to support the technological advance in the electronic sector since 1986. No effective policy has been formulated and no concrete action has been taken over the last several years to close the huge technological gap with the advanced countries.

Lack of financial resource has been another major obstacle for the Chinese electronic producers to close their technological gap with Japan and other advanced countries. Chinese producers are small and financially very weak. The foreign exchange earning of major Chinese producers are still far too low to enable them to import 1M RAM ICs production technology in the feasible future, whose cost goes well beyond 50 million US dollars.

Fourth, inappropriate or inactive government policies should also be responsible for the slow technological advance in the sector over the last six years or so. The government has failed to provide any substantial financial assistance to any promising research institution or major producers to import existing advanced foreign technologies or carry out domestic R&D themselves. And more importantly, the government has also failed to conduct an effective nation-wide co-operation in R&D. Given the growing competitiveness of many other electronic products, especially TV sets, radios, satellite receiving equipment both at home and abroad, the effective demand for ICs from other electronic sectors grew dramatically over the last eight years or so. For instance, the domestic demand for ICs in China reached 500 million units a year in 1989, while the Chinese producers only delivered about 100 million units a year, with a gap of 80 percent of domestic demand being filled by imports. The total cost of ICs Imports came close to US$ 900 millions. With only 20 percent of the total expenditure being spent on technology importing, the Chinese ICs producers may be able to close their technological gap considerably.

To learn from the Japanese experience, China needs first to set up nation-wide research project. The valuable human resource should be pooled to tackle the key problems effectively. The government should formulate an active policy to encourage domestic R&D on the one hand and foreign technology importing on the other. At the present stage, the provision of necessary financial resource from the central government is very desirable. Moreover, preferential tax treatment for all electronic producers generally and electronic exporters particularly will be beneficial economically. In the meantime, various forms of domestic market protection are also necessary in order to facilitate the domestic producers of some key products.

From what has been discussed in chapter six, we can see that Japanese electronic producers had acquired foreign technologies mainly through licensing. Direct foreign investment in the electronic sector and direct production in Japan were prohibited until the late 1970s. In the meantime, imports substitution was also adopted in this area by Japanese government. It was believed that these measures reserved the domestic market for Japanese producers and allowed them to reach the required volume threshold to take advantage of learning economies later. It is believed that the means of licensing alone is not sufficient to help China to catch up with the technology leaders quickly in electronic sector.

Moreover, Japanese were able to transfer, imitate, adapt, and diffuse the American technologies very quickly, because they had adequate supply of highly qualified managers and engineers, which are still scarce in China now. Therefore, to acquire advanced foreign technologies mainly via licensing may not be the best way for China to catch up quickly. All forms of technology transfer, including licensing, foreign direct investment, joint venture, and even purchasing existing research establishments and recruiting expertise in the advanced countries should be explored. However, some forms of domestic market protection should also be maintained for some years to come. This certainly presents a delicate challenge to the Chinese decision makers.

The high degree of vertical integration enabled Japanese manufacturers to carry out huge investment on basic research and also on new plants and equipment. Without the huge amount of R&D funds and quick reinvestment a firm cannot get the technology leadership or even just follow up the new technological advance in this sector. To learn from Japan, China also needs to set up large vertically integrated firms. The existing Chinese electronic producers should be able to find the most efficient way to merge. However, the effective government policies should be implemented to facilitate and accelerate the process.

To promote competition among the Chinese electronic producers both at home and abroad is certainly the most effective and efficient way to assure the long-term success of the Chinese electronics industry. The Japanese experience has also shown this. With growing and deeper engagement in the international market, the production efficiency should be improved quickly. Furthermore, every Chinese electronic producer needs to realise that domestic market protection should be temporary and specifically targeted, and it should not be taken as a shelter for inefficiency.

Chapter Nine

Summaries and Conclusions

Technological progress has played a crucial role in the rapid economic growth in Japan and South Korea. Many factors together have contributed to the successful adaptation and diffusion of foreign technologies in these two countries.

To create the policy environment and mechanism necessary for improving economic efficiency is extremely important for China to emulate Japan and Korea. This amounts to adherence to the market mechanism of economic management, albeit without ruling out the active role of government as in the case of both Japan and South Korea.

Both governments in Japan and South Korea have played a very important role in their countries' economic success. Their firm commitment to economic growth is believed crucial to the high and sustained economic growth in these countries. On the contrary, the state intervention in China before 1978 failed to deliver concrete economic result, because most development policies and plans were drawn by political rather than rational economic objectives. In China today, to promote and to stick to market-oriented reform would be the true indication of commitment to economic growth.

To provide financial assistance to and at the same time to impose economic discipline upon domestic firms is perhaps one of the most important areas which China needs to learn from Japan and South Korea. Moreover, it should also be stressed that not all but competent and efficient governments in the developing world may achieve what have been accomplished by the governments in South Korea and Japan. Very broadly, such a government should have the wise and honest political leaders, a well-educated, highly competent and incorrupt bureaucracy class, and well-designed economic policies aiming to promote growth and reward enterprises and achievement. Such a government should also be capable of promoting communication, mutual understanding, trust and co-operation between itself, the business community and labour force.

The Japanese and Korean experience also shows that although a 'national environment' at a certain point is shaped by historical development in the country and influenced by the government's policies, it can be reshaped or radically reconstructed by the changing perception and attitudes of its people and perhaps particularly its business community.

The Japanese and Korean experience has also shown that the very existence of strong economic discipline has been a key factor for economic success in Japan and South Korea much as its absence has been the main cause for the economic failure in many other developing countries. Economic discipline can be imposed upon domestic firms by applying policies aimed at fostering market competition. One such policy is to set the real interest sufficiently high. This will not only balance the supply of and demand for investment funds but also keep inflation under control. At high real interest rates, few firms would use their loans for unproductive purposes. This would certainly enhance the allocation by making both government officials and businessmen conscious of the opportunity cost of investment funds. To link financial assistance to export promotion is another very effective way of improving the competitive efficiency of Chinese firms. New and better ideas, management practices and production techniques could be introduced more quickly and enthusiastically by making assistance conditional on export promotion.

Firms with monopolistic or oligopolistic powers should be regulated by the government. The research results from public laboratories, institutions and from joint-venture or private facilities but with public funding should be made available to all domestic companies. This could lead to increased competition between all firms, especially between the well-established ones and newly emerging ones in new and rapidly expanding industries. Policy should also aim to persuade or bring pressure to bear on foreign firms, especially the powerful transnational corporations, to accept the principle and practice of charging a uniform loyalty fee for transferring the same technology, to all domestic firms no matter how different these domestic firms are in terms of size, production scale, market share and financial capability. This has proved to be very effective to promote competition between firms within high-tech industries, especially in Japan. Given the East Asian culture, some events, such as 'Top-Quality Award' and 'Leading Exporter Award' ceremonies, and high profile 'problem-solving' meetings with the attendance of the president, ministers and representatives of leading business groups are also very effective means of promoting competitive efficiency. Given the wide coverage of TV, radio and newspaper, these ceremonies and meetings are bound to make significant impact on most firms and their employees.

No matter how well such disciplinary policies are formulated and executed, they are just external factors. Whether they can achieve the expected effect will, largely, depend on some internal factors- self-discipline and economic motivation (including market expansion and profit increase).

The Chinese economy has undergone a dramatic change over the last fifteen years and is moving towards a market economy. However, there is still an irrational price system in China now. The profitability of investment under a regime of price distortion as in China can hardly reflect its true costs and benefits to the economy. In the absence of the performance criterion (real profitability in this case), it will be difficult for banks to formulate appropriate lending policies. It is also impossible for the state to impose any economic discipline upon domestic firms.

To solve the above problems, the Chinese government needs to carry out price and taxation reform. The prices of most commodities should be set free gradually. The price signals based on supply and demand condition can help firms to make appropriate investment decisions and also help the banks to formulate appropriate lending policies. A fundamental taxation reform should make all state enterprises independent, so they can make their own decisions on all matters concerning their respective activities.

Failure to exploit economies of scale and specialisation has denied China a very important source of productivity growth and production improvement for a quite long time. It is widely believed that even without the introduction of sophisticated machines and other automated production techniques, consolidation of production could have a major impact on cost reduction and quality improvement of production through standardisation of parts and use of more specialised machine tools.

The minimum efficient scale for automobiles production in 1980 was around 500,000 million units a year. While in China, each of the four major auto producers only managed to produce 25,000 automobiles a year. Given the unit production cost rising 6 percent at 50 percent of MES level (see Table 5-4), the unit production cost at 2.5 percent of MES level would be high enough to make all Chinese producers uncompetitive. In 1982, China produced 190,000 refrigerators in 103 factories, while the MES level of refrigerators was 300,000 a year. Of one hundred and forty enterprises in the bicycle industry in 1982, only eleven had reached the break-even point of about 300,000-500,000 units a year. It is also noted that the cost of production for most small watch producers would fall 25 percent with each doubling of production scale.

Inefficient transport and communication system is one of the major factors for the failure to fully exploit the scale economies in China. Lack of modern management techniques and the unfamiliarity with the structure and organisation of giant corporations is also responsible. Modern enterprises, especially the transnational corporations, can only be run efficiently by using modern management techniques. This would certainly require a large number of highly qualified personnel, including managers, technicians, accountants, engineers, marketing and financial experts. These are the people who have been in short supply in China even today. Furthermore, policy emphasis on self-reliance and trade barriers between the different regions is another factor responsible.

It is clear that the scale problem is not only the production scale itself. It requires raising the nation's education level, significantly upgrading its transport and communication systems and the introduction of modern management techniques. Above all, moving to market economy system is perhaps the most important precondition for the Chinese economy to fully and effectively exploit the benefits of the scale economy.

To promote private sector will be a very effective way of increasing competition and improving efficiency. However, in the meantime to help the best-practice state-run enterprises to merge, if economically feasible, with other less efficient ones is also a practical way to improve economic efficiency in China today.

At present, China needs to promote the growth of large- scale domestic companies, just like what Japan and South Korea did before the 1980s. The emerging of such giant companies in China, possibly with their number at hundreds, would be economically desirable. Otherwise, China would never be able to compete with foreign giants, especially foreign transnational corporations from South Korea, Japan, U. S. and West Europe on the same footing.

A high degree of concentration is not necessarily related to inefficiency. Both Japan and South Korea have shown this. The top ten Korean chaebols accounted for almost 70 percent of the country's GNP in 1984. However, there is no doubt at all that these two most concentrated economies are also the most competitive and dynamic ones. According to Amsden (1989), there are two behaviour patterns which can be associated with high concentration in a learning context. First, once growth gets underway, there is little reason for the big business groups to collude and every reason for them to compete in a wide array of industries in order to maintain parity with one another in their overall size. Competition tends to be a consequence of growth, not a cause of it. Second, high concentration permits high rates of investment embodying foreign technology, the realisation of scale economies and learning-by-doing. Growth contains the seeds to increase productivity, and increased productivity raises output further in an upward spiral. However, we should also recognise that the strong financial discipline and self-consciousness have also encouraged domestic firms in Japan and South Korea to compete with each other.

It would be controversial, naive and even absurd to claim one culture is superior to others. Any of such proposition would be untenable, if we try to answer the following questions. Why was Japan so poor just a century ago? Why had Britain dominated the world both economically and politically since 18th century through the early 20th century? Why did the United States become the economic superpower in the early of this century? Although the United States is becoming weaker economically, it is still one of the greatest economic superpowers in the world.

However, to stress the points above does not contradict the proposition that some aspects of East Asian culture have played a very positive role in facilitating and accelerating the process of economic development and growth in these countries and regions. It is plausible that, at some stages, certain aspects of a specific culture may gain some advantages over others. These advantages might be temporary, as they would probably decline gradually and eventually disappear. Or else, they might become disadvantages at another stage of economic and technological development. Japanese education system and practice might be cited here as one of the examples. It is true that the system has served Japanese society and economy very well over the last 100 years, and particularly, over the last four decades. The Japanese education system puts great emphasis on discipline and performance improvement for all. Their curriculum and examinations are set at the national level. Both their teaching and examination methods are inflexible by western standards. They have not provided enough incentives and rooms to encourage students to develop themselves freely. The standards have been set for all, regardless of differences in talent and capability. It is believed that the current Japanese education system is incapable of producing people with strong creativity. Although they have produced plenty of highly-qualified and competent manpower for the rapidly expanding Japanese economy during the catch-up process, their capability of generating a large number of world-class scientists who can pioneer imaginative research and make important discovery and big breakthroughs in the key areas is becoming questionable while the country is moving to the frontier in many key technological sectors.

In the United States individualism has prevailed for centuries and formed the essence of the country's social and cultural value. In Japan and other East Asian countries individualism has been curbed and depressed for centuries. This is suggested to be one of the reasons accounting for lack of scientific and technical discoveries and inventions in these Asian countries over the last two and half centuries, during which individual creativity and invention had played a key role in technological advance in the West. However, over last four decades, group action and co-operation have played an increasingly important role in many areas, including R&D. Team effort is becoming increasingly important as a basis for improved individual performance. Strong group action and co-operation, certainly among others, have made important contributions to the economic success both in Japan and South Korea. This, however, only means that some aspects of East Asian culture have given these countries some comparative advantages exactly at their present stage of economic and technological development. How long these comparative advantages can remain and when they will start to diminish will remain to be seen in the 1990s and the beginning of the next century.

It should be stressed that market economy system is the precondition for China to make any economic gains from its East Asian culture. Without such a system, those cultural factors like trust, loyalty, co-operation, hard working and strong discipline, which are believed to have made great contribution to the economic success in Japan, Taiwan, South Korea and Singapore, would have little or no impact on the process of Chinese economic development. Their application may have here a counter productive impact. The Chinese experience over the periods of 'Great Leap Forward' and the Cultural Revolution has shown this.

Loyalty to the state and to the company one is working for should be stressed. And a mutual understanding and trust should built up between the state and the business community and between the management and employees. With the emergence of large number of private-owned companies in China, both life time employment and seniority wage system need to be considered, at least among the largest ones and those with great potential for rapid expansion. Japanese experience shows that lifetime employment and seniority wage system together can greatly enhance the feeling of loyalty and strengthen the fate-sharing attitude. This in turn can increase production efficiency and improve product quality. Both management and employees in such a fate-sharing company are most likely to work more efficiently and to control product quality more vigorously and enthusiastically.

Lifetime employment and fate-sharing philosophy can certainly provide the Chinese companies with strong incentives to invest heavily on their employees, particularly in the area of labour training and working environment. The labour training is one of the most effective ways to raise productivity. However, as a long- term investment, labour-training not only requires huge amount of financial resources but also the commitment and patience for expecting a return on the investment over a long term period. It has been noticed that extensive training programmes have been widely carried out in Japan. The great potential for a significant economic gain and the extremely strong confidence for having a return back have been the two most important factors encouraging Japanese firms to invest generously on labour training. There is no doubt that China should imitate Japan in this area. To adopt Japanese-style lifetime employment and seniority wage system may help Chinese firms to formulate long-term and systematic investment strategy. This becomes particularly relevant to the development of China's high-tech industries, including electronics, semiconductor and biotechnology. Firms in these industrial sectors often need to take investment projects which may be at the expense of short-term profitability. This tends to make conflict with the company's shareholders and creditors, because most of them would prefer a steady and consistent increase in profits and dividends. The full commitment of both management and workers to the future development and success of a company in question may help to persuade investors and creditors to support an investment strategy aiming for a long-term success rather than a short-term profitability. It is therefore here that the lifetime employment and seniority wage system may play a part in showing investors that the management and workers would dedicate themselves to the company's long-term success.

Japanese and Korean economic success is partially attributable to the highly disciplined labour force and their hard work. Japanese and Korean labour forces have worked longer hours than their counterparts in other countries. The average working hours .per week in the 1950s and 1960s was 52 to 53 for Japan and over 54 for Korean. Most Koreans are still working over 50 hours per week. China needs to double its effort for catching up advanced countries quickly. The practice of long working hours (8 to 9 hours per day) and six working days per week should be encouraged. This is economically desirable and socially and politically acceptable.

Japan and South Korea have never been 'free-market' economies. Their economic success has demonstrated that government can play a very important role in a country's economic development. Some aspects of East Asian culture, such as the willingness to be governed and to follow government guidance, certainly enhance the governments' ability to manage the economies in the two countries. Very often, during the process of policy formulation, extensive consultations would be conducted by the governments in Japan and South Korea. Such consultations aim to build up the mutual understanding between the state and the business community, and between the government officials and intellectuals. However, after national consensus has been built up and an industrial policy has been introduced, almost all companies from all industrial sectors will follow it and give their full support. China certainly needs to learn the Japanese and Korean approaches. Such approaches can greatly enhance the capability of the Chinese government to formulate and implement industrial policies.

Foreign aid (in the form of grants) had played a very important role in the process of economic recovery and reconstruction in South Korea in the 1950s and 1960s. The inflow of massive foreign loans and free access to the western market, especially the American market greatly helped Korea to achieve economic 'take-off' very quickly. Moreover, the external environment then was very favourable for rapid economic growth, such as quick expansion of world trade, high GDP growth in the advanced economies and the prevalence of free trade world-wide.

Unfortunately, such large scale foreign financial aid, particularly the generous grants from the rich countries, could probably never be available to China. Furthermore, the free access to American market like that offered to South Korea in the past is no longer there. The 1980s had witnessed a sharp rise in protectionism world-wide. The United States has retreated back far away from the free- trade regime. The Japanese and Western European markets have become even more difficult to be approached. The continuous and high rate of growth of world GDP and rapidly expansion of world trade, as in the 1960s and early 1970s, have also become a thing of the past. So even if China now has the similar economic and political systems and equivalent level of national educational attainment which South Korea and Taiwan had in the 1960s and 1970s, it would be very difficult for China to achieve such a long-term and hyper economic growth that South Korea and Japan did in the past.

China cannot follow the Korean 'foot path' towards a high economic growth. There are no foreign grants for China to improve its infrastructure and increase its productive capacity. There are no large-scale concessional foreign loans for China to import foreign technologies. The rich countries' markets are no longer 'free' to access. Therefore, to pursue a export-driven growth strategy seems inappropriate for China. In fact, more and more Chinese exports have been barred or severely restricted from entering into foreign markets through numerous foreign quotas over the last decade.

However, China could still achieve a long-term and considerably high economic growth if some appropriate and highly effective strategies are chosen. First, making all possible effort to tap the financial, technical and managerial resources from international financial agencies, especially the IMF, World Bank and Asian Development Bank. As the largest developing country, China is, without any doubt, entitled to receive a large proportional financial assistance from these agencies. It is not only the investment fund but also the skills and expertise which China should seek from these agencies. Second, the financial resources in some rich countries, especially in Japan, should be enthusiastically explored. From a long-term point of view, Japanese and Chinese economies can be complimentary each other. Therefore, through deepening and expanding bilateral trade and investment in mutually-interested projects and industrial sectors, it is very hopeful that China could get an increasingly large financial assistance from Japan. Third, China should create favourable investment environment to attract foreign investment and should encourage these foreign investors to set up either joint- ventures or wholly foreign-owned companies. This will help China to acquire foreign technologies, management skills and marketing expertise. Fourth, effective measures should be introduced to accelerate the process of economic integration among mainland China, HongKong and Taiwan.

The inflow of a huge amount of foreign investment has greatly alleviated the scarcity of foreign capital and may bring China similar benefit to what foreign aid did to Korea and Taiwan in the 1950s and the 1960s. With a total of 56 billion US dollars foreign investment committed in 1992 alone, China has certainly every reason to expect that large scale inflow of foreign capital would continue for some time in the future. China could still achieve a high economic growth in the face of growing world-wide protectionism by mainly relying on its big domestic market. With the help of growing competitiveness of its products (as a result of reduction in production cost and improvement in quality) and the strength of its economy, China, unlike South Korea and Taiwan twenty years ago, has a strong leverage to make bilateral trade deals with most rich countries. The great economic gain from importing cheap and relatively high quality Chinese goods and the bigger share of rapid expanding

Chinese market could very effectively persuade advanced countries to open their markets for China in the 1990s. At the growth rate even slightly below the average for the past decade, China's two-way foreign trade could top 200 billion US dollars by the end of 1995. With an annual import capacity of over 100 billion US dollars, China will be surely at the position to bargain with any major western country for mutual market access.

The sharp rise in world-wide protectionism and rapidly emerging trading blocks, especially the EC in Europe and NAFTA in North America, could become a big threat for long-term high economic growth in China. How to counter these negative effects and increase its market shares within these trading blocks by delicately using its growing economic strength and domestic market is certainly one of the most challenging tasks that Chinese planners will face in the 1990s and beyond.

In summary, the findings of the study seem to echo the new growth and new trade theories in some way. The economies of scale and external economies have become increasingly important for the rapid and successful industrialisation in Japan and South Korea. To some new and high-tech industries, as shown by the Japanese and Korean experience, these factors may be crucial for gaining comparative advantages over the competitors. There is an increasing return not only at the industry level but also at the individual firm level. Rapid and efficient transfer and diffusion of new technologies have a strong learning effect, which could enhance a country's competitiveness significantly. External economies are prevalent in many industrial sectors, particularly in some new industries. Investment in labour training and R&D in high-tech industries, if left to market force alone, is very likely to lead to underprovision. Moreover, most of such new industries are also strategically important for a country's long-term competitiveness. Therefore, appropriate government intervention seems desirable here. However, not all governments have the capacity to intervene effectively and efficiently. Such a government must be competent and with firm commitment to economic growth. Some cultural and socio-economic factors have helped to facilitate the process of economic and industrial policy formulation and implementation both in Japan and South Korea. Strong mutual trust, understanding and co-operation between the government and business community and between the management and labour force have been important for any policy measures to become effective and successful.

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