PROGRAMMING THE INVISIBLE HAND: THE COMPUTERIZATION OF KOREA AND TAIWAN

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Executive Summary

. Korea and Taiwan are following industrial strategies that make high technology a fundamental part of all economic activity. Their first objective -- entry into the world's computer industry -- has been achieved. Their domestic computerization may not be realized until the 1990s, but their capacities for high tech trade are making them major market forces much sooner.

Their manufacturers are already respected competitors in semiconductors, auxiliary equipment, components and parts, and finished computers. Production is solely for microcomputers and is bought as much for high quality as low cost. Projections suggest that by 1990 Korea and Taiwan will have a 5% share of the world's computer business. These are realistic expectations.

Supporting the production successes are solid infrastructures, especially important for education, science training, and research. The foundations of high technology have been laid in university and research centers over three decades. Many universities have computer science departments that graduate competent professionals in growing numbers. New research centers abound, such as Taiwan's Institute for Information Industry and its Electronics Research and Service Organization, and Korea's Software Development Center and its Institute for Electronics Technology.

The energizers of the computer industry are private companies. In Korea these tend to be subsidiaries of large conglomerates that are producing an integrated range of computer products. In Taiwan they tend to be mid-sized firms, often specializing in relatively narrow product areas. There are exceptions in both countries.

Corporate strategies in both nations aimed at exports and rely mainly on U.S. technology. Complex networks of licensing and purchasing agreements, joint ventures, co-production, marketing, and R&D agreements, and software training tie the Korean and Taiwan producers to American firms. Production is mostly for American and Japanese original equipment manufacturers. Very little is sold as a brand name product, a pattern that may change radically by 1990.

The major channel of technology transfer for both countries has been licensing under supplier contracts, though Japanese contractors have grown wary about making technology available. Corporate R&D is growing rapidly. It is commonly centered more on solving production problems than on product development, another pattern that may soon be changed. Several companies have set up R&D units in the U.S. for performing research and procuring needed technology. Korea's are subsidiaries of conglomerates; Taiwan's are joint ventures between U.S. and Taiwanese firms. The R&D units are also centers for recruiting computer professionals of Korean or Chinese descent.

. In their entry into computer trade, Korean and Taiwanese companies are feeling the pinch of inherent information-age problems. Their dependence on exports makes them vulnerable to the frequent changes in

computer trade. Numerous firms failed when games demand dived in the early 1980s. More went under in the 1985 recession. Two Korean semiconductor manufacturers, misjudging Japan's ability to get 256K microchips in production, were stuck with excess capacity for 64K products. After two years of expensive research, five Taiwanese firms had 5 and 10MB hard disks for a market flooded with 20MB disks.

An unsolved problem for both countries is developing software in the Korean and Chinese languages. Widespread usage is impossible without easily understood programs in native languages. Theoretical software answers are available, based on methods developed in Japan. But three crucial impediments block their practical application.

One is the lack of an accepted standard for operating systems; application software must be written for specific equipment. Another is the export orientation of computer firms; programming and systems development is in English while end user software must be in Chinese or Hangul. A third impediment is weak legal defenses against piracy; software writers have little hope of being rewarded for their work.

Corrective actions are underway that many industry experts say will end the software impasse and lead to an upsurge of investments in computer systems. This scenario is likely to require a four- to five-year period before significant change is evident.

Korea and Taiwan also face difficulties in making the internal adjustments necessary for knowledge-based economic efficiency. Their banking and financial structures, in particular, are sorely strained by the requirements of high tech industry and computerization. But change is unsettling to worker, executive, and bureaucrat alike, who need time to adjust. By opening up an economy, it exposes sheltered groups to world trade. Thus, restructuring is stubbornly resisted.

. The consequence in each nation is a policy battle over the pace and intensity of economic liberalization and institutional modernization. If restructuring is held up, computerizing and high tech will be retarded, and discord with the U.S. and other nations over market access intensified. On the other hand, restructuring could aggravate smoldering political tensions in each country.

Thus, both nations are debating the new planning and regulatory controls they need in a high tech world. It is in their national interest, as well as in the U.S. interest, for Korea and Taiwan to follow policies that will integrate their industry more closely with the world community.

The internationalization of Taiwan and Korea could be enhanced by effecting their closer involvement in OECD consultations on economic policy and in GATT negotiations on trade in services. Much greater appreciation -- on both sides of the Pacific -- of the international consequences of information age trade also might help.

1

THE COMPUTERIZATION OF KOREA AND TAIWAN

> As every individual endeavours as much as he can both to employ his capital in the support of domestic industry, and so to direct that industry that its produce may be of the greatest value; every individual necessarily labours to render the annual revenue of the society as great as he can.
>
> Adam Smith, The Wealth of Nations[1]

Korea and Taiwan have been remarkably successful in establishing production and trading sectors in the computer industry. They have done less well in recasting legal and regulatory structures for computerization. Their governments are looking for ways to speed up liberalizing measures at home and to reframe economic ties abroad. They are encountering resistance, however, from business and bureaucratic interests that are not yet ready for the structural transition to an international high technology environment.[2]

For three decades Korea and Taiwan have been models of Asian enterprise and front runners in Third World development. Incomes have increased more than fourfold. Both nations have revitalized tired agricultural systems and have established commercial and industrial enterprises that are world competitors in electronics, steel, textiles, shipbuilding, and heavy construction.

Expectations have risen with incomes. Korea's plans project "an advanced economy during the 1980s," and Taiwan's Ten Year Plan forecasts "a developed country within the 1980-90 period."[3] High tech and computerization are the heart of planning that is intended to inject new growth and to counter depressive tendencies. Both countries are out-

growing labor-intensive strategies as well as many administrative and managerial habits; they are trying to correct weak spots in heavy capital sectors and develop economic environments befitting more advanced societies.

Both nations have adopted computerization programs that are intended: (1) to overcome limitations in R&D and professional personnel; (2) to help their computer companies get started; (3) to modernize and enlarge telecommunications systems; (4) to facilitate greater computer-communications usage in industry and commerce; and (5) to make economic and legal structures more compatible with high technology.

The programs have many similarities and have already led to significant improvement in production and capacity. Both countries are increasing staffs of qualified computer professionals. Both are investing heavily in manufacturing facilities and in telecommunications and are expanding output of assemblies and components, primarily for export. Both are looking to American technology, trade, and markets to make computerization possible. Networks of licensing and purchasing contracts, software training, co-production and marketing agreements, joint ventures, and R&D arrangements link suppliers in Taiwan and Korea to U.S. information technology firms.

Yet Taiwan and Korea are computerizing along lines that show the unique and diverse style in their enterprise systems. Korean manufacturing is dominated by subsidiaries of conglomerates that are investing in integrated, large-scale factories. Production in Taiwan is primarily in medium-sized, independent firms that have relatively low

capital investment. Both countries have formed branch R&D units in the U.S. that feed laboratories and factories at home -- but do it in different ways.

The Asian newcomers have not always outsmarted competitors. When Korea's semiconductor makers misjudged the market, they were hit by Japanese price cutting and mass sales of the 256 K memory chip earlier than anticipated. Taiwan's hard disk producers were blindsided when U.S. firms preempted the 10-megabit market with advanced disk drives having far greater capacities.

Firms in both countries suffered badly from the collapse in the computer market in 1985. Moreover, a software lag is holding up usage of computers, the result of a bottleneck that is mainly in producing acceptable software in the Korean and Chinese languages.

The greatest difficulties for Korea and Taiwan are internal adjustments needed for knowledge-based economic efficiency. Such changes would open their economies to outsiders and stimulate wider and more efficient computer usage. They would also expose sheltered domestic groups to global markets. The adjustments would be hard to deal with in the best of circumstances and have been stubbornly resisted.

Both governments are moving ahead on many fronts: proprietary rights, trade and communication regulations, and bank and finance structures. But restructuring is an uphill battle, too painful for industrialists, bureaucrats, and bankers who would have to alter traditional ways and work in changed environments. The needed consensus is slow in forming.

The consequence for each country is a major policy dilemma over the pace and intensity of economic liberalization and institutional modernization. If restructuring is held up unduly, computerization and growth are likely to be retarded. Discord with the U.S. and other advanced countries over high tech trade and market access is likely to be intensified. On the other hand, aggressive restructuring could be internally disruptive.

What is at issue for Korea and Taiwan is finding a new governmental formula for guiding high technology economies. Programming the invisible hand for a computerized world requires more flexible planning and regulatory controls. Both countries are trying to work out and implement economic policy machinery that will assure their competitiveness in a high tech world.

This study is an effort to provide a clearer perception of what these issues are and how they might be addressed. It begins with a review and assessment of industrial policy in Korea and Taiwan since their liberation after World War II. In later parts, computerization in each country is described and analyzed in the context of the enterprise systems that have evolved since the 1940s. The final section looks into the international implications of high technology in East Asia, and at the trade and policy questions that are emerging.

2

INDUSTRIALIZATION AND DEVELOPMENT IN KOREA AND TAIWAN

> Some labor with their minds and some labor with their strength. Those who labor with their minds govern others; those who labor with their strength are governed by others.
>
> Mencius, Writings[1]

Korea and Taiwan are nations of limited natural endowment. They have few mineral resources, poor agricultural lands, and densely populated territories. Their one resource is their people. They must rely on "those who labor with their minds" to industrialize -- and to computerize.

Individual abilities were effectively restrained during the colonial years of the Japanese Empire. Japan annexed Taiwan in 1895 and Korea in 1910, though it had practical control over them before annexing them. When Japan surrendered in 1945, its Empire fell apart and the people of Korea and Taiwan could reclaim their freedom once again.

The Cairo Declaration of 1943 assured their autonomy. In it the U.S. and the U.K. agreed to Korea's independence and accepted China's claim to Taiwan. Events ran according to the script in Taiwan. The Chiang Kai-Shek government sent its troops from the mainland in 1945, replacing Japanese forces with its own and reasserting Chinese authority over Taiwan.[2]

The plans for Korea did not work out as anticipated. The Yalta Conference in 1945 provided for an international trustee for all of Korea; it did not specify, however, the details for its administration. After Soviet forces occupied the northern areas, U.S. troops moved into the south. Korea became a divided nation. When the Republic

of Korea was proclaimed an independent state in 1948, its authority covered only the southern portions of historic Korea.[3]

The first years were politically turbulent in both countries. The 10 million Chinese who were already living in Taiwan developed grievances against the Kuomintang military regime and against the 2 million newcomers from the mainland. Dissension smoldered, even erupting in demonstrations against Kuomintang rule, armed clashes, and several hundred casualties.

The political scene in Korea was also disorderly. The North Korean invasion in 1950, besides destroying most of the nation's industrial capacity, disrupted political and economic activity in every part of the country. For several years the parliamentary process was in shambles. President Rhee's inept treatment of his political opposition brought the nation close to rebellion.[4]

Taiwan and Korea weathered these stormy beginnings. Both found workable answers to their political problems, reconciling their need for strong military forces with the requirements of a representative government. A division of power evolved between military authorities and their civil compatriots, political compromises that enabled the governments to function by consensus and to take decisive economic actions. Although the political environment in both countries is subject to severe internal and external tensions, governments are able to operate efficiently and provide the institutional structures needed for business and industry to prosper.

Sources of Economic Strength

Actually Korea and Taiwan were beginning to exhibit economic strength even during the difficult early years of independence. Despite severe dislocations from the northern invasion, the Korean economy recovered readily. By the mid-1950s overall production was growing more than 5% and industrial production more than 14% a year. Taiwan showed equal resiliency. In the trauma of massive migration and military defeat on the mainland, economic growth hit 6% a year and industrial production 9% by the mid-1950s.[5]

The reconstruction and early accomplishments in Taiwan and Korea have been overshadowed by the glittering achievements of later years. The early advances underscore, however, the important underlying strengths in both cultures, particularly their work habits, the entrepreneurial vigor of their people, and their high regard for education and learning. These strengths are evidenced by the individual initiative and drive of the Koreans and Taiwanese, by their work schedules of 55 to 60 hours a week, and by annual national savings of 25 to 30% of GNP. Both countries have compulsory education, Korea through the sixth grade and Taiwan through the ninth; literacy rates are above 95%, and college and university attendance rates are approaching those in Europe and North America.

These traits are customarily associated with cultural and family traditions of the Korean and Chinese people -- especially the Confucian tradition. Their effect on economic recovery was magnified by migrations of Chinese and Koreans from other parts of Asia and the U.S., often skilled or educated and sometimes bringing capital with them.

The economic accomplishments are the product of the Korean and Chinese people, and the energetic leadership of political and business management. Their successes came when native economic potential was eventually woven into coherent and powerful development strategies. In this process, their encounters with the U.S. and Japan were powerful influences.

U.S. aid had a strategic place in the transition to independence. The security shield provided by U.S. forces in the area was immensely important for domestic enterprise and foreign investment. Security assistance eased pressures on domestic resources, and economic aid added materially to supplies. Economic aid to Taiwan amounted to $1.7 billion over the 1949-65 period and to $3 billion for Korea during 1953-68. Although modest in absolute amounts, the combined impact of assistance plus local procurement of U.S. forces accounted for as much as 15 to 20% of overall economic activity in the years of most severe deprivation.

U.S. aid, consisting of commodities for supplementing production of local suppliers, plus project aid for restoring infrastructure in power, transport, education, health, and water, often filled a critical role in revitalizing economic activity.[6] Cotton from America, for instance, supplied Korean and Taiwan textile mills in their startup years, and U.S. funds for technical training provided a boost for manpower needs. American aid was timely in restoring weakened economies.[7]

The impact of the U.S. in the reconstruction years was not limited to its material aid. American companies quickly set up trading ties in both countries and began buying supplies as soon as production could be restored. They hired local employees, many of whom were given extensive

training, sometimes in the U.S., and they sometimes placed them in managerial or professional positions.

American economic advisors provided institutional guidance as well as technical help in getting infrastructures rebuilt, of particular relevance for fiscal, monetary, agricultural, and planning systems. Of great importance also were education exchanges that brought large numbers of students from Korea and Taiwan to universities in the U.S. The result was a prolonged period of intensive exposure to American economic institutions for a large part of the rising leadership and professional groups in both countries.

Moreover, looking to American institutions as norms in the modern world and going to the U.S. for higher education became habits that continued beyond reconstruction. The postwar encounter with the U.S. left a lasting imprint on the social and economic organization of Korea and Taiwan.

Japan has also been a major influence on economic development of Korea and Taiwan. The extensive economic relationships of the postwar era are well-known -- and will be explicitly dealt with later. Less evident are the legacies from pre-independence. The many decades as Japanese colonies left a complex economic imprint on Korea and Taiwan. Japan's system dealt with colonies as suppliers and markets for the homeland. Its intent was Japanization. Its method frequently overrode indigenous rights and customs and left hostility and distrust that are still strong impulses.[8]

But the encounter also brought the first touch of Westernism to Taiwan and Korea. They entered the industrial age, it has been said,

through Japan's "Open Door." The Japanese introduced new methods of education and agriculture. They built the first communications links, rail lines, and roadways. They brought in new medical services that greatly improved health standards.[9]

Their firms established processing and manufacturing plants where Koreans and Chinese worked as unskilled laborers or in nonmanagerial positions. Japanese trading companies hired them, as did communications, finance, transport and service firms. The exposure was a colonial exercise in technology transfer. On an elementary level, it was valuable experience for enterprising Koreans and Taiwanese.[10]

Many of these workers proved able to operate the plants and factories that were taken over after World War II.

In Taiwan, the Japanese properties were seized by Kuomintang military forces and operated initially as government enterprises. The public corporations angered the Taiwanese, who resented managers from the mainland as much as they had resented the Japanese. They agitated, along with some of the new arrivals, for a more active private sector.

As the companies were badly managed, they were an increasing drain on public funds, so many of them were sold to private entrepreneurs. The new owners were often Taiwanese; others were Chinese businessmen from other parts of the world, or family members living in Taiwan. Several of these firms are today's major producers of wood products, textiles, cement, and paper.[11]

Korean experience was similar. Most of the Japanese plants were destroyed in the Korean War. But production in several was restored by their Korean employees. An impressive number of the country's greatest

industrial successes have been in industries that were first formed during the Japanese occupation, and later redeveloped with indigenous technology and management resources. Production of tires, cement, electrical equipment, leather goods, shoes, plywood, and textiles, it has been pointed out, began on this basis in the 1950s.[12]

Charting Growth Paths

Despite the early signs, Taiwan and Korea did not become growth leaders until their planners and businessmen had more experience. Success came when government policies were aligned to reinforce entrepreneurial and production talents of their business activists.

The belief that industrialization could be speeded up took hold in the late 1950s and was greatly influenced by Japan's success, an irresistible lure in other East Asian nations. Japan emerged as an industrial power on their doorsteps, in circumstances comparable to their own. The experience looked repeatable, and a consensus soon formed around making an intensified effort to speed up development.

What Korea and Taiwan adopted from Japanese experience was more a principle of action than a model for development. Indeed, two Japanese economists, Miyohei Shinohara and Toru Yanagihara, claim that there is no Japanese model; there is only a vision and a will

> to create an atmosphere of consensus around the government's views, which are often presented as "visions". Visions thus authorized serve as a guiding principle in the formulation of economic policy and also serve as a frame of reference in consultations between government and the private sector.[13]

Although there are many conceptions of the Japanese development strategy, the comments of Shinohara and Yanaghira seem to describe most accurately what Korea and Taiwan have adapted to their particular

circumstances: an industrial strategy, first, based on principles and goals derived from business-government consultations and, second, pursued intensively by the government. The strategy relies on the invisible hand of individual enterprise but makes sure that it moves along at a smart clip toward widely accepted goals.

The results of dedicated effort are evident in the data on gross national product in the 1960-82 period. For comparative purposes Table 1 below charts several other countries as well. The data show Taiwan and Korea sustaining the highest growth rates in the world over a period of nearly 25 years. Compared to other countries in about the same stage of advancement, the Asians have been moving ahead at a substantially faster rate. Brazil and Mexico have similar per capita earnings and have experienced respectable growth; but on average their expansion has been about three to four percentage points slower. Although Japan's growth was comparably higher in the 1950s and 1960s, it has lagged in recent years, as has the United States'. One result is that Taiwan and Korea have narrowed the gap between themselves and more advanced nations. In 1960 U.S. per capita income was about 16 to 17 times that of Taiwan and Korea: In 1984 it was six to seven times, and by the end of the 1980s the ratio may be reduced to three or four times.[14]

Table 1

Growth in Gross National Product
(1960-1982)

	Percentage Increase Per Year	
	1960-70	1970-82
Korea	8.6%	8.6%
Taiwan	9.6	9.6
Japan	10.4	4.6
United States	4.3	2.7
Singapore	8.8	8.5
Brazil	5.4	7.6
Mexico	7.6	6.4

Sources: World Bank, World Development Report, 1984, Table 2, "Growth of Production," Washington, D.C., 1985, pp. 220-221. Data for Taiwan are from Republic of China, Executive Yuan, Annual Review of Government Administration, 1981-82, Taipei, 1983, Chart 16, p. 82.

Reliance on Export Orientation

A principal instrument of growth in Taiwan and Korea has been the policy of export-led advancement, a strategy also successful in Japan. It is often asserted that exports are the engine of growth for Korea and Taiwan. What this means is that external markets are systematically used as outlets for industrial expansion. They generate growth at home when manufacturers investing in new equipment use the returns from external sales to pay their capital costs.

Both governments provide extra incentives for export firms. They are allowed tax exemptions, rebates, and higher priority in importing

equipment, parts, and supplies. Exporting companies are allowed easy access to bank financing for investment capital and for export credits, both at preferential interest rates. But the incentives are not only a matter of export policy. They have an important secondary purpose: their tie to domestic production. Export orientation is a new answer to the old question of what to do for an infant industry.

How can a new producer be helped through the high-cost startup so that he can reach volume production and have low unit costs? The traditional response is to protect him in the home market. The export-oriented reply is to help him reach large-scale output by marketing abroad. Through careful monitoring, markets abroad could be entered readily when production at home made goods available for export. Korea and Taiwan set up export promotion centers, to collect the data needed from markets abroad and spur the producers at home. Even the president of Korea regularly attended the hard-sell meetings held each month in Seoul to whip the trading companies on to better performance.[15]

Export-oriented policies were accompanied by reductions of some import restrictions and, in time, some export subsidies. But the import barriers erected in the 1950s and export support of the 1960s have come down slowly. Protective barriers continue to shield producers in several industries. Trade and investment liberalization is accepted doctrine in both Korea and Taiwan; yet a substantial measure of restriction still exists. The restrictions do not prevent imports from rising as income levels mount, but they seriously deter some areas of imports. Many export supports continue, even though they are no longer justified for competitive reasons.

The predominant impact of export-orientation policy has been a phenomenal rise in international trade.

Table 2

Foreign Trade of Korea and Taiwan
(1965-1982)

	Million U.S. Dollars				
	1965	1970	1975	1980	1982
Korea					
Exports	175	730	4686	17,214	21,853
Imports	463	1984	7274	21,598	24,251
Taiwan					
Exports	488	1428	5308	19,810	22,204
Imports	556	1523	5951	19,733	18,888

Sources: Asian Computer Yearbook, 1984, Far Eastern Economic Review, Hong Kong, 1984; Republic of China, Executive Yuan, Annual Review of Government Administration, 1981-82, Taipei, 1983; World Bank, World Development Report, 1984, Washington, D.C., 1985.

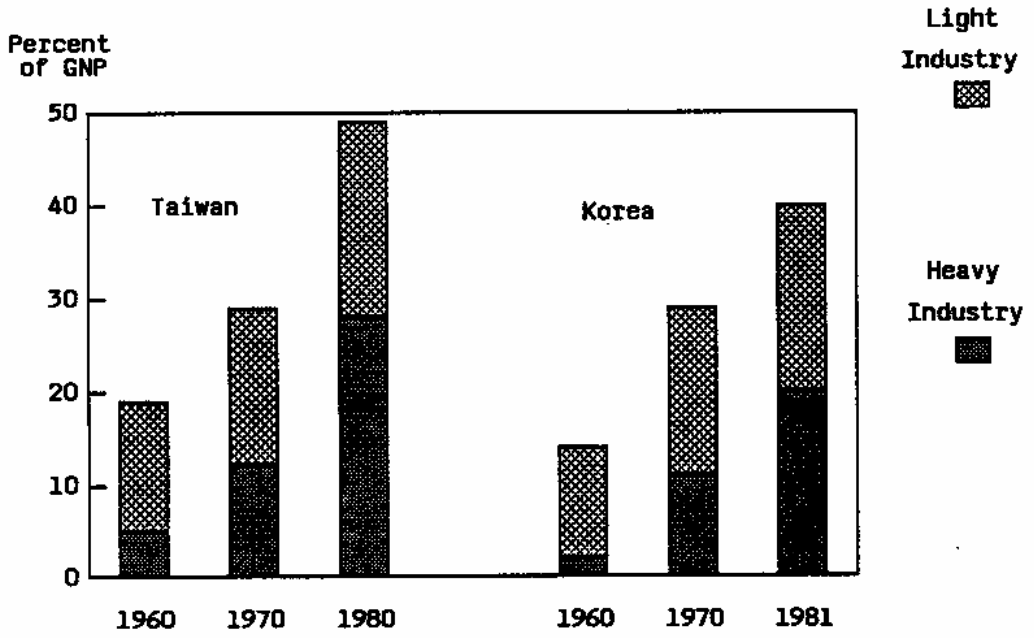
As shown in Table 2, exports have been rising at yearly rates of 30% or more. Taiwan's exports in 1982 were 15 times as high as 12 years earlier; Korea's exports rose more than 30 times in the same period. While price inflation partially accounted for the increases in the 1970s, the increased volume of exports has been the predominant factor in export earnings.

What is also evident in these data is the continued increase even in recent years, when trade had already reached exceedingly high levels. By 1982, Taiwan's exports were 48% of GNP and Korea's 36% of GNP. In

1982 Korea and Taiwan together accounted for 20% of total exports of Third World non-oil producers.

Stages of Industrialization

High growth and export promotion in Korea and Taiwan have been accompanied by structural changes in their economies. In a few short years their productive systems have been dramatically altered, and both countries have changed from predominantly agriculture and service trades to industrial production. The transition has deepened as new heavy industries have been introduced, such as steel, shipbuilding, and machinery. In Taiwan, heavy industry has risen from a small fraction in 1960 to more than half of industrial output in 1980. As Figure 1 shows, Korea's growth in heavy industry has been even more rapid, from insignificant in 1965 to more than half of all industry in 1981.[16]

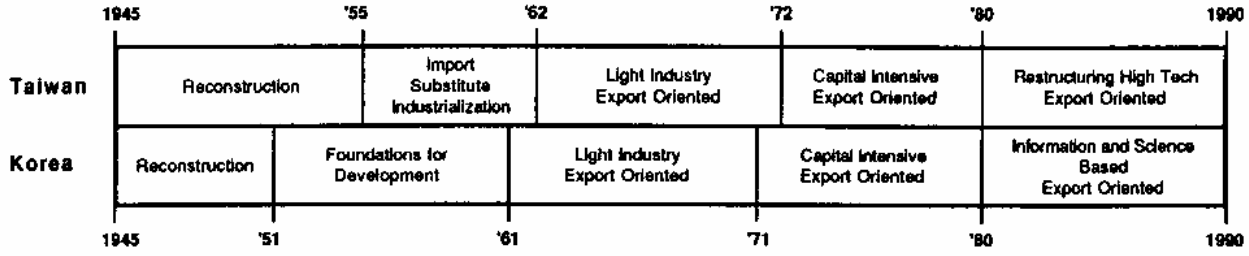


Sources: World Bank, Korea, Policy Issues for Long Term Development, Washington D.C., pp. 254-257; Republic of China, Executive Yuan, Annual Review, 1981-82, pp. 128-132. Industrial production, as measured in this table, includes output in manufacturing, energy, construction, and mining.

Figure 1

Industrial Production in Korea and Taiwan
(Industrial Output as Percent of GNP)

These structural changes are conceptualized in economic reports of Korea and Taiwan as "stages of industrialization." They are akin to similar concepts in a well-known "vision of MITI" that has guided Japanese development for many years. These stages may be traced in Figure 2.[17]



Sources: Republic of Korea, Economic Planning Board, Economic Survey, 1983; World Bank, Korea, Country Economic Report, 1979; Republic of China, Executive Yuan, Annual Review of Government Administration, 1983.

Figure 2

Stages of Industrial Development: Korea and Taiwan

Conceptually, industrialization follows an evolutionary process that goes through four stages, each more advanced than the previous one. As Taiwan and Korea have grown economically, they have acquired capital and managerial resources. They have also deepened entrepreneurial and technological skills. Their educational institutions and research and development centers have gained new authority and competence.[18]

A Development Era Ending

At the same time both Korea and Taiwan have encountered limitations to development along past strategic lines. Domestic wages have risen to the point where it is difficult to stay competitive in several of their most important export industries. Market saturation in steel, ship-building, and textiles adds other limitations on competitiveness with present production methods. The boosting power of an export-oriented strategy is beginning to wane, and dependence on U.S. markets is less stimulating than in earlier eras. The 1960s and 1970s were decades of

expanding world markets, capable of absorbing rising imports without serious disruption. The 1980s are proving to be less accommodating.

Business styles in large segments of both countries have become an anachronism, falling behind in answering managerial demands that are more complicated than those of two decades ago. Closely managed and controlled financial institutions that have been a primary tool of growth for both Korea and Taiwan have become less effective as commerce and industry have become more complex and increasingly international.

Both Korea and Taiwan have outgrown the economic strategies of earlier development. To continue to prosper, they are moving on to more complex and more advanced policies in which information flows, knowledge, computerization, and technology-intensive industry are the primary driving forces.

3

THE COMPUTER AND THE NEXT KOREAN TAKEOFF

> Up to now, we have emphasized manufacturing technology, but we are also encouraging basic studies. Every year we are sending many employees overseas, and by 1990 we will have more than 1,000 Ph.D.s in our organization. By that time, we will be able to create technology for ourselves.
>
> Kim Woo Chong, Chairman, The Daewoo Corporation[1]

Two decades of hyper-growth have enabled Korea to overcome many pressing economic problems. But several new ones have been created that can't be answered in old ways. Planning for the 1980s envisages a period of transition to high technology; it is also a time for correcting obsolete policies. Korea's high tech planning for the 1980s is a mixture of consolidation and preparation, and a "new takeoff" based on a computerized economy.[2]

-- Wage rates have risen more than productivity, which will weaken exports unless labor-intensive industries are modernized.

-- Much of the heavy industry sector is overbuilt, underautomated, and excessively energy consuming.

-- Technologies adopted for production and sale in mass markets are inadequate in quality-conscious markets.

-- Industrial control is in the hands of a few trading conglomerates, some of which are economically inefficient.

-- Global interdependence makes export orientation viable, but is losing ground to protectionism and economic recession.

Korea has huge stakes in computerization and advanced technologies, expecting to energize all economic activity as well as to set up a new high-value-added industry. To make sure their expectations are sound

and will pay off, the Koreans are erecting an elaborate supporting structure. The following is an analytical description of the infrastructure and the computer applications evolving in the Korean economy.

Computer and Components Production

Korea's computer industry has developed from an electronics industry whose exports in 1985 exceeded $6 billion. Although consumer electronics (television, microwave ovens, and the like) are about 80% of the total, computer and peripheral exports are growing much more rapidly. International sales of computers, parts, and components amounted to $467 million in 1985, double the previous year's despite recession in world demand.[3]

The industry is undergoing monumental change. High-capacity semiconductors are becoming a major product, and the microcomputer manufacturers are gearing up for large-scale production of 16-bit systems. Two corporate giants, Samsung and Lucky-Goldstar, which have dominated the industry, are being challenged by new entrants that are equally big, Hyundai and Daewoo. At the same time, many small and medium-sized companies have closed down. The computer industry's profile is shifting rapidly as producers tool up for deepening the technological content of their product.

The change in industrial structure involves major American corporations, through licensing, purchasing contracts, and joint ventures. All of the major Korean manufacturers now have extensive technology arrangements with U.S. multinationals. Some Japanese and European companies are active, on a lesser scale. Japanese firms, concerned about making technology available to potential competitors, have been reticent about

licensing and investment, though they continue to purchase components and supplies.

Production by the mid-1980s consists primarily of assembled systems or components made on order from firms in Japan (40%), the U.S. (50%), and Europe. A small part (about 10%) is marketed under a Korean trade name. Principal among the products are terminals, printers, modems, semiconductors, and monitors. Much of output is at the lower end of present-day technology. A large number of key parts for Korean production must be imported.

A typical product is the CRT monitor that Korean firms make for brand name computer systems, including IBM, ITT, and Apple. Korea's producers are highly cost competitive, and profits are good on monitor sales. Although they are marked down a bit on quality, the Koreans are narrowing this by improvements in production, especially in making printed circuit boards. Some firms are making high-resolution monitors. A few are assembling color monitors; most still produce only monochrome. Color tubes are imported from Japan, as are the highest resolution monochrome tubes. However, domestic manufacturers of tubes are steadily improving, and the domestic content of Korea's monitor production is steadily rising.[4]

According to the Electronic Industries Association of Korea (EIAK), 15 firms are in production and others are preparing to enter the CRT monitor industry. Some, like Samsung and Daewoo's Orion, are giants with production capacities as high as 15,000 units each month. Others are small, producing no more than 1000 per month. According to EIAK, more than 380,000 units were sold in 1983, nearly 90% of them to the U.S.[5]

A component of increasing importance is high-capacity semiconductors. Korea has been a leading maker of semiconductors for consumer goods for many years. Competing seriously in high-capacity microchips is a newer effort for major firms. They have been encouraged by the Semiconductor Industry Fostering Plan, a special loan fund of $33 million, and easy access to bank finance.

Officials in the Economic Planning Board and in other agencies have advocated a more cautious approach in moving into highly competitive semiconductor production, which they feel is highly risky. Some have urged that emphasis be on specialized semiconductor devices, which might be done on a smaller scale and with relatively modest investments. Several have criticized what they regard as excessive reliance on the conglomerates, believing that smaller production units would be more efficient, given the Korean resource base and technological limitations.

In practice, production capacity has grown rapidly, and large amounts of new capital have poured into product development and manufacturing facilities. Korea's semiconductor effort is directed mainly at the commercial end of the market; it is also aimed at mastery of the basic design and technology of the microchip. Korea's program is comparable in purpose to the Japanese semiconductor project in semiconductor R&D in 1976, but differs significantly in its implementation. While MITI managed cooperative research for several Japanese companies, the Korean program is in separate projects run by individual companies.[6]

One is Samsung Semiconductors and Telecommunications, the largest in the industry. Already producing 64 K DRAMs (dynamic random access memory chips) in its factory near Seoul, Samsung began production of

256 K DRAMs in mid-1985.[7] In January 1985 Samsung signed an agreement with INTEL, giving it access to INTEL technology for manufacturing several of that company's microprocessors, microcontrollers, and other products. The agreement is described as "open ended and longer term."

Samsung is expanding its Seoul plant from 30,000 to 150,000 units per month, with a greater mix of higher grade chips. The construction budget is reported at $125 million and the project is scheduled to be completed by 1987.

But Samsung is far from alone in pressing ahead on high-tech microchips. Goldstar Semiconductor, Ltd. (GSS), for instance, has developed the production processes for semiconductor gate arrays used in aeronautics and communications satellites, in high precision weaponry, and in other systems that require a high degree of reliability. The production technology was developed in-house with the GSS team of scientists and technologists. GSS is beginning to mass produce the gate arrays in Korea, anticipating that they will be marketed at home and abroad. In 1985 the company signed a contract for exporting $100 million worth of gate arrays to LSI Logic Corporation.

It is estimated that more than $1 billion is being invested in the semiconductor drive. In addition to Samsung and GSS, both Hyundai and Daewoo are making forays on a lesser scale into the advanced microchip business.[8]

The boldest part of the Korean venture is its novel approach to technology acquisition. All four majors have set up units in the U.S. to support production and operations at home. Samsung's branch office is designing VLSIs and developing end products. Its mission is to solve

pilot production problems. When this is done, the semiconductors are designed in San Jose and produced in Korea. Samsung's 256 K DRAM was developed in this fashion and produced the only serious challenge to Japanese supremacy in marketing this product.

Samsung's objective is not just production and sale; it also has an eye on vertical integration objectives within its empire, supplying future microchip needs for the various manufacturing branches of its corporate family.[9] The other Korean majors in the U.S. -- the Daewoo, Hyundai, and Lucky-Goldstar companies -- have similar expectations from their R&D subsidiaries.

The principal value of the small R&D units in the U.S. is in giving computer manufacturers direct access to scientists and engineers of Korean origin. The subsidiaries spend much of their energy scouting talent and technology. The personnel they hire are highly trained and well educated; they represent years of research and design with such companies as Fairchild, IBM, INTEL, Hewlett-Packard, and National Semiconductor. Several have moved to top positions in Korea. These units will play a critical role in the future of the Korean computer industry.[10]

An important downstream market for Korea's microchips is in micro-computer production. Output has been increasing, rising nine-fold in 1983 when 54,000 units were exported and another 67,000 sold on the domestic market. But production so far has been by smaller companies producing low-capacity assemblies of foreign look-alikes.[11]

This pattern is changing as the four major companies gear up for their entree into the computer trade. Their eyes are mainly on

producing high-capacity microcomputers for institutional and business markets. They are also looking at school and home users where inexpensive computers are needed. None of the Korean firms is planning to produce large minis or mainframe computers.[12]

As in other industries, the Korean companies are looking at export markets as the principal outlet for increased output, in order to attain large-scale production as soon as possible. Most production is an assembly operation, but Korean-designed microcomputers are in the test stage for eventual marketing as their own brand name products. All of the companies are lining up technical and marketing ties with U.S. and Japanese firms. The first 16-bit systems were produced in 1984 and output was projected at 10-15,000 units in 1985.[13] The recession in computer trade in early 1985 stalled reaching this target, but by year's end sales were bouncing back and were expected to surpass earlier projections in 1986.

Gold Star Semiconductor is a subsidiary of Lucky-Goldstar and a joint venture with AT&T. It began production of 16-bit micros in early 1985 at its plant in Gumi, near Seoul. Lucky-Goldstar Group, the Korean partner, was reported as expecting to invest over $900 million in 1984-85 in information technology including fiber optics, computers, semiconductors, and telecommunications.[14]

The Samsung company is producing computers at its new complex outside of Seoul, where it also makes semiconductors. This installation is being enlarged in a four-year expansion program. Samsung has signed technology agreements with U.S. and Japanese firms. The most important is a joint venture with Hewlett-Packard, which is to develop and produce

semiconductors and computer products. One of these is a 16- bit personal computer that is already being produced. Another is the SSM-16, designed jointly with the Korea Institute of Electronics Technology (KIET), a government-backed R&D agency. While Samsung's microcomputer production has always gone to American firms for packaging, the company has steadily increased marketing under its own trade name.[15]

The other two Korean majors, Hyundai and Daewoo, have encountered official roadblocks in trying to move outside customary heavy industry and construction areas. This accounts, in part, for delays in making decisions on some of the risky investments.

Hyundai is one of Korea's largest conglomerates but has had little experience in electronics. Hyundai began negotiating with IBM in 1983 on its proposal to produce and market IBM's personal computers. The closely held negotiations ran into difficulties over local production. An early version was scuttled when the Korean government refused to approve it because it called for local sale of imported IBM computers during the interim before production at Hyundai could be marketed. A later variation, for Hyundai to assemble the IBM 5550 using both imported and locally made parts, also ran into trouble over how local production would be handled.[16]

During the early months of 1985, an arrangement was negotiated by IBM with the Korean government and several local manufacturers, including Hyundai. The agreement provides for a wholly owned subsidiary of IBM (the Korea Systems Corporation) to assemble and market micro-computers with local and imported parts. Four Korean subcontractors

supply components, Hyundai the CPUs, and subsidiaries of Goldstar the printers, keyboards, and monitors. An IBM executive explained that the company wanted "to maximize specialized experience of the Korean manufacturers."[17]

IBM is furnishing technology to each of the subcontractors for manufacturing and testing, including technology for high-density PCBs, hard disks, floppy disk drives, and high resolution displays needed for presenting Korean language characters. Local marketing is handled by Hyundai, and units of the Ssangyong and Daewoo groups. Qnix, the Korean representative of Microsoft, is a value-added dealer for IBM's Korean venture. But IBM itself is marketing its subsidiary's product elsewhere in Asia. With total output projected to rise to $279 million by 1989, the arrangement appears to provide IBM an efficient production base for East Asia; it also gives Hyundai and the other Korean subcontractors an effective entree into the international computer industry.[18]

Daewoo, the fourth major computer producer, first entered the trade seriously in 1983 when it took over the third largest electronics manufacturer in Korea. The Daewoo Semiconductor Corporation was founded a few months later, in April 1984, as the conglomerate's principal entrant in the industry.

The new company increased its R&D staff and soon began producing an 8-bit personal computer with aid from Microsoft and the Ascii Company of Japan.[19] Daewoo's strategy, its executives say, is to begin with the sophisticated custom chips and work backwards into making mass-production semiconductors. It has begun design work on futuristic products like robotics, avionics, and laser-optics. Unlike the other

Korean companies, Daewoo is working from the beginning on original products, and minimizing reliance on external technology.

According to Daewoo's chief advisor on electronics -- from Schlumberger Ltd. -- the company has developed an IBM-compatible personal computer. It received an order in 1985 for 270,000 PCs, worth $400 million and deliverable over a five-year period. Leading Edge Products of the U.S. is the buyer. The contract was hotly contested by Daewoo and several firms in Taiwan. According to trade sources, Daewoo quoted prices of 10-20% lower than its competitors on the basis of its anticipated large-scale operations.[20] Leading Edge computers were rated as a "best buy" by Consumer Reports.

While the four conglomerates dominate the computer industry, many other firms, and numerous American and Japanese companies affiliated with them, are also in production. Several small Korean firms are surviving. Some are doing quite well. Indeed, official policy calls for a stronger small-business sector in high tech industries.

One small-business success is Tri Gem Computer, founded in 1980 with a paid-in capital of $13,000. Tri Gem sales have mounted rapidly, to $13 million in 1984, rising to $22 million in 1985. By 1985, they employed 240, with 30 engineers specifically assigned to R&D. Tri Gem is operating at a factory finished in 1984 in the Panwol Industrial Estate.[21]

Timely official support has sped Tri Gem's rise. Two critical actions that helped Tri Gem were a $500,000 development loan from a government investment corporation and a government contract for 5000

educational computers in 1983. Tri Gem has continued to receive favorable financial and contracting help through official channels.

The company's principal product is the Tri Gem 20 XT, an 8-bit personal computer compatible with Apple products. A unique feature of the 20 XT is its capacity to operate in Korean language characters. This is vital for selling in local markets, and it was developed by the Tri Gem research unit. Buoyed by its success with the 20 XT, Tri Gem's R&D group has produced an IBM-compatible, 16-bit system marketed by Personal Computer Products in the U.S.[22]

Software and Services

The dynamism in the plans of Korea's computer companies makes evident the need for a vigorous software and services capability. Software, however, is usually regarded as the least attended part of computer advancement. An American executive who is closely linked with a major electronic producer holds a typical view shared by many Koreans in the trade. He says that Korean companies are inclined to place excessive interest in hardware and to neglect or ignore software requirements; he also believes that this attitude could change quickly.[23]

Such observations suggest a troublesome situation. Everyone expects the major companies to provide a full range of software systems for their products. In practice, they appear less worried about how their systems are operated than about how they are made and marketed. Their research units in Silicon Valley, for instance, are working only on hardware problems. They rely on the software of their contractors when producing for export. Yet, the software that comes with their

newly designed computers for domestic consumption is limited in breadth and depth.

This attitude contrasts with the evident need for domestic software, as seen in the comments of knowledgeable observers about in-house modifications in software for commercial systems. The most compelling reason is that the software market in Korea is dominated by foreign companies. Imported software can rarely be used in unmodified form. It has to be revised to accommodate the functional lines of the foreign software to the administrative structures and managerial concepts of Korean business. Personnel and accounting, as well as financial control items, that are laid out in American software have no direct equivalence in Korean business houses. Something has to bend; either the software must be modified or unfamiliar internal systems have to be adopted.

An equally important factor is transferring foreign language concepts to Korean equivalents. Programming and systems development is done in English, while software for the end-user must be written in Hangul. A strict transfer of meaning is impossible and software often needs revision. The options are to modify or to restrict severely the Koreans' use of their information systems. But such modifications risk the computer's not understanding what it is to do, a dilemma with no easy -- or efficient -- answers.

In-house software production, by this reasoning, is a costly way of solving some problems common to many Korean users. The shortage of readily marketable software systems for business management may be an important deficiency in Korea's computer community.

These observations, however, tell only part of the story -- perhaps only the beginning. Activity taking place behind the commercial scene could lay the groundwork for meeting the software and system operation requirements as they arise.

Most important is the possibility of setting standards for the production of software, an important area that has been subordinated to other priorities. Priorities seem to be shifting, and software is getting more attention.

Operating system standards are one of the critical areas. Many of Korea's leading computer scientists attribute the lack of strong domestic computer demand to the proliferation of software and hardware operating systems. According to some, dozens of different systems are used. This may reflect the habits inherited from pirating days when software was counterfeited along with everything else. The emphasis given to export market may make proliferation a commercial necessity, for Korean suppliers under contract to foreign companies must comply with the buyers' technology.

The lack of a standardized operating system is a costly handicap for the development of domestic software. It means that any program written for a particular system is specific to that system and may not be used on others. There can be few economies of scale, for the cost of writing application software can be shared by only a limited number of buyers. Software costs per unit are high, as there is no mass marketing. The prospect of profits from writing software is slight, and the business doesn't appear attractive.

Another important cost of not having a standard operating system is the added difficulty in networking, which is essential for large-scale corporate computer systems that tie microcomputers into larger mainframe and minicomputers. But networking is unlikely to work when its components are using different systems. Information stored in one system can rarely be retrieved from another based on a different operating system. In these circumstances, potential users shy away from computers. They can hardly be expected to invest large capital in systems that have such serious operation handicaps.[24]

Several computer experts believe that the software standard impasse will be shortlived. Several key technological agreements in 1985 indicate that the Microsoft (MS DOS) technology may become accepted in practice as the standard operating system. A number of leading PC makers have secured rights from Microsoft to use MS DOS in their computer production. Equally important is the progress of Microsoft's agent in Korea, Qnix, in translating the English version into a Korean language system.

If these efforts succeed and the Microsoft system that is also widely used in the U.S. becomes a common standard, it will mean the clearing of a critical bottleneck in the computerization of Korea. For instance, use of American software products in translation will become much simpler.

Another indication of changing priority is the establishment of software subsidiaries in 1985 by several key manufacturers -- such as Ssangyon, Gold Star, and Samsung. A different tack is IBM Korea's program, aimed at independent software production. IBM Korea is

contracting for a large number of independent producers to prepare Hangul software for its principal microcomputer series. Daewoo is also pursuing this route and is signing up several independent software houses.

One further sign that software is not likely to continue as a neglected technology is the attention paid by the Korean government. Indeed, the Korean government has declared that software and systems constitute a strategic industry and has expressed its intention that Korea should become a regional software center. A software export target of $150 million has been set for 1986 -- though it is widely regarded as overly optimistic. Nonetheless, the Korean government is backing up its declarations with support programs that address many pressing problems.

The most important is the Software Development Center set up in 1967 as a part of the Korea Institute of Science and Technology (KIST). The Center initially consisted of one officer who still heads the organization, though it has grown to a staff of 500. Its functions have broadened as well, and it has become the nation's focal point for computer system design. One of its continuing research tasks is trying to improve the software for Korean language (Hangul) use in computer systems and printers.[25]

The Center has been organized as a self-supporting institute affiliated with KAIST (the Korea Advanced Institute of Science and Technology formed in 1981 as successor to KIST). It provides consulting and design assistance for public agencies or private companies whenever they seek it. The Center has provided software systems for computer-

aided architectural designers, and for engineering and management systems. It is deeply involved in designing educational materials and oversees the computer grading of examinations given to the nation's school children each year. A major activity of the Center is responsibility for the software for the Asian Games and the Olympics to be held in Korea in 1986 and 1988.

The Center also serves as a postgraduate training school for software and systems engineers. Although they are brought into the Center to work on system design, they are given additional training to meet the Center's professional standards. Many of the Center's "graduates" move on to other senior work in company labs or universities.

Another software education program has been set up under an agreement with IBM. The Software Engineering Center is modeled after the Institute of Systems Science that IBM helped to organize in 1982 at the National University of Singapore. It opened in the summer of 1984 and is expected to turn out about 900 professionals each year. Table 3 outlines annual targets set by the working committee.

Table 3

Software Engineering Center

	Planned Enrollment
Software Engineers	400 per year
Systems Engineers	200 per year
Manufacturing Engineers	150 per year
Management and Executives	120 per year

Source: Documentation provided by the Bureau of Information Industry and Technology Promotion, Ministry of Science and Technology.

IBM is providing the head of the Center, as well as various professionals on the staff. IBM facilities will be available for doing the actual research on up-to-date software technology. The Ministry of Science and Technology and KAIST, where the Center is located, will also provide personnel for the Center.[26]

Research and Development

Many of Korea's software and system problems are not yet solvable on an operations level. Although the Koreans are relying on foreign technology, they must first answer critical research and development questions.

Korean R&D, despite inadequacies, is remarkably advanced. Public institutions are able to offer practical answers to many of the country's problems in technology application. Firms in the private

sector, the large conglomerates in particular, are devoting increasing amounts of their own funds to finding technological answers to commercial problems. In 1982, R&D amounted to $701 million and was 1.09% of gross national product. The current science and technology plan envisages an R&D expenditure of 2.0% of GNP in 1986, which is comparable to the percentages in Europe and North America. U.S. research and development, for instance, runs about 2.5% of GNP.[27]

The principal reason for a relatively advanced state of R&D in Korea is the systematic attention that has been given to it for many years. The Ministry of Science and Technology was set up in 1967, along with specific agencies for research. Its goals and strategies have paralleled economic advance in Korea and have reinforced planning measures for industrialization. Its research and development programs have been designed to anticipate demands in successive stages of the Korean economy, from the earliest emphasis on light industry, to the later focus on heavy machinery and basic production, and to the present stress on information and knowledge-intensive industries.[28]

The long-range development plan, accordingly, has the following goals:

-- continuing the expansion of high-level manpower for technological research and development;

-- enhancing the effectiveness and productivity of research and development;

-- developing indigenous industrial technologies; -- supporting private industry R&D; and

-- promoting public understanding of science and technology and its role in modern Korea.

These are very modest goals, evidently intended to fill critical current needs and to serve as a catalyst to private R&D. Official R&D has an important role for immediate technology requirements; the intent, however, is to rely much more on the private sector. Under legislation passed in 1973, the private sector has various tax and other incentives for investing in research and development. These include special depreciation allowances for investment in testing and research facilities, a 10% tax exemption on R&D investments, an exemption for any reserve funds that are set aside for R&D, and easy access to long-term, low-interest funds and grants for technology development.[29]

As a result, private research and development expenditures have risen significantly and are expected to contribute the major portion of total R&D by 1986. Private expenditures rose from 23% to 32% of the total between 1970 and 1980 and, as seen in Table 4, were projected at 60% by 1986.

Table 4

Investment in Research and Development

	Million U.S. Dollars			
	1963	1970	1980	1986 (plan)
Government	9.2	31.0	325.2	702
Private	0.3	9.5	155.2	1,054
Total	$9.5	$40.5	$480.4	$1,756
Percentage of GNP	0.24%	0.48%	0.91%	2.0%

Source: Republic of Korea, Ministry of Science and Technology, An Introduction to Science and Technology in the Republic of Korea, Ministry of Science and Technology, Gwacheon, Korea, 1984, p. 34.

The operating authority for research and development is the Korea Advanced Institute of Science and Technology (KAIST). Some specialized bodies have been formed to meet priority demands for research in higher technologies, and to complement the work of KAIST. The overall structure was recast in 1981 (when KAIST was formed by combining two other institutes -- the Korean Institute of Science and Technology and the Korean Advanced Institute of Sciences). The framework for supporting the information industry includes the institutions listed in Table 5.

Table 5

Research and Development in the Information Industry

Institution	Date of Formation	Purpose
Advanced Institute of Science and Technology	1981	Research and development of national projects
Institute of Electronics Technology	1976	Research on semiconductors and computers
Institute for Research in Electrotechnology and Telecommunications	1981	Development of technology for electrotechnology and telecommunications
Institute for Research on Systems Engineering	1982	Standardization of systems, automation, and information processing
Institute for Software Development	1982	Software and systems design and development

Source: Documentation provided by the Bureau of Information Industry and Technology Promotion, Ministry of Science and Technology, 1984.

In addition to those institutions directly concerned with information technology, others conduct closely related programs. These include the Korea Standards Research Institute as well as those doing research on energy, machinery, metals, and chemical technologies. Research in energy conservation and in precision machinery, for example, is strongly skewed toward computerized solutions.

The various institutes work under a new national program, initiated in 1982 to apply a more systematic approach to R&D on advanced technologies. The criteria for the national projects are that they must be large-scale R&D, top priority, and not implemented by private industry alone. Knowledge-intensive and resource-saving technologies

that enhance international competitiveness are favored in the present program.

In 1983, 182 research projects were selected as national projects. About $28 million was provided officially and $16 million by the private sector. Information industry spending, shown in Table 6, was about $10 million, 23% of the total.

Table 6

National R&D Projects in the Information Industry
(1983)

	Million U.S. Dollars		
	Government	Private	Total
Semiconductors and Computers	5.7	2.9	8.6
System Industry	1.3	0.5	1.8
Total	7.0	3.4	10.4

Source: Documentation from the Bureau of Information Industry and Technology Promotion, Ministry of Science and Technology, 1984.

Education

A key measure of Korea's concern about future computer systems requirements is its public system for education and training.

The Korean universities offer higher degree courses in their computer science departments. The leading institute is KAIST, whose graduates are generally regarded as professionally able scientists comparable to the best in advanced nations. KAIST graduates about 30 persons a year with M.S. or Ph.D. degrees. Seoul National University

turns out slightly fewer M.S. and Ph.D. holders, judged as perhaps a cut or two below the KAIST graduates.

In addition, 32 colleges in Korea offer a bachelor's degree from their computer science departments. These colleges graduate about 2500 persons a year. There is, naturally, a wide variation among the graduates. The calibre of education in the bachelor programs, however, is commonly regarded as adequate-to-good preparation for middle-level software and systems jobs, at least with additional on-the-job experience.[30]

For lower-level manpower requirements, Korea relies on its chain of junior colleges, the vocational training centers attached to colleges, and private training institutes. All these schools turn out some 5000 to 6000 graduates a year.

These prospective availabilities of trained and professional manpower may be compared with estimated requirements of the Ministry of Science and Technology, shown in Table 7. Requirements for programmers and systems analysts in 1983 were estimated at 12,000, compared to approximately 8000 professional and technical graduates. Although requirements were expected to rise rapidly to an estimated 25,000 in 1986, the number of additional trained personnel needed was not expected to rise much above the number of 1984 graduates.

Table 7

Software and Systems Manpower Requirements

	Thousands of Persons			
	1976	1980	1983	1986
Systems Analysts	0.7	2.1	4.2	8.6
Programmers	1.7	2.7	7.5	15.9
Operators	0.5	2.0	4.8	12.2
Key Punchers	2.3	5.0	9.8	20.3
Total	5.2	11.8	26.3	57.0

Source: Documentation provided by the Bureau of Information Industry and Technology Promotion, Ministry of Science and Technology, Gwacheon, Korea.

These data show discrepancies between manpower requirements and manpower availabilities. They are especially pronounced at the upper professional levels. The discrepancies may be lessened somewhat by adding in the Korean students matriculating in foreign universities and training institutes. Some 290 science and engineering students were sent abroad in 1981, and about 3000 official scholarships were awarded in the 1983-86 period. Korean corporations often add to the rolls by sending personnel to foreign institutions for specialized training and advanced education.[31]

Several uncertainties cloud estimates of the effectiveness of foreign education on manpower needs of the computer industry. In the past many students sent abroad have remained there, presumably because of limited opportunities at home. Many who have returned have entered a

different field than that in which they were educated. The Korean government has taken steps to cope with "brain drain" problems, and the emergence of a high technology economy has dramatically changed prospects for computer scientists. While precise results may not be predictable, the "brain drain" of the past may be largely overcome. Indeed, some of those who remained abroad in the past may be lured back to Korea.[32]

There is much room for error in these statistical collections and in their interpretation. The data seem to point to shortfalls in trained manpower that will continue well into the future. Other evidence also seems to confirm shortages of computer specialists at all professional levels: the large number of unfilled positions, the long time needed to fill them, frequent job changing, and pressures on wages and salaries of information system personnel. The shortage is acute in the upper ranks and is the essential reason for Korea's attempt to repatriate scientists and professionals living abroad, as discussed earlier. The shortage is not likely to end in this decade.

Telecommunications and Data Communications

Progress in national computerization is closely related to the state of the country's communications system, a correlation that grows stronger with the intensity and spread of computer employment. There are two basic reasons: First, the two systems share a common technological base that makes many specific uses virtually indistinguishable; and second, the greatest economic efficiency from either system comes when computer systems are merged with telecommunications systems.

Until recently, however, the contribution that telecommunications could make to economic development has been discounted. Other resource uses, it has been argued, deserve higher priority and should come before telecommunications. Such reasoning has prevailed in international and bilateral lending agencies, as well as in technical assistance organizations, and has generally guided individual Third World countries in setting domestic development priorities.[33]

These assumptions prevailed in Korea also, at least until the early 1970s. As a result Korea's communications system suffers from years of neglect and is regarded by many as an important deterrent to more rapid computerization. A summary report by Edward Roche of his survey on Korean computer utilization states that "the evidence is strong that the lack of adequate communications infrastructure both at the international and domestic levels is the primary factor in Korea retarding the application of information technology."[34]

Yet as in Korean software situation, a corrective program is already making headway and promises to revamp and modernize the telecommunications system. Since a decade ago Korea has made heady progress in extending communications to more users and communities as well as in steadily improving the technological level of the system. By the end of 1983 the number of telephones had increased by 267% in five years and telephone density was 12.3 per 100 population. This was substantially greater than other Third World countries -- though low in comparison with about 85 per 100 in the U.S. Moreover, telephone services were reaching villages with 20 or more people in all parts of

the country. Improvement in quality of service has been just as impressive, as Table 8 suggests.[35]

Table 8

Korean Telecommunications Services

	1977	1983
Lines installed (thousand)	1666	5337
Subscribers per 100 population	4.2	12.3
Long distance lines (thousand)	30.4	153.1
Direct dialing lines (thousand)	5.1	34.4
International telephone circuits	701	1699

Source: Korea Telecommunication Authority, Annual Report, 1983. Seoul, Korea, July, 1984.

By 1983, more than 92% of the subscriber lines were automatically switched, about one-third in digital systems. Most of the five-fold increase in long-distance lines was in microwave and high-capacity coaxial carrier. Growth in international telecommunications also was in the upper technology levels. Direct dialing was possible for international calls to 24 countries in 1983. Three satellite earth stations were in operation in 1983, and a fourth was added in 1984. Special services, such as radiopaging, mobile telephone, and computerized directories have also been made available. Korea's first optical fiber system was installed over the 35-mile span between Seoul and Inchon in 1983.

Telecommunications services are provided by the Korea Telecommunication Authority (KTA), a public monopoly. The Ministry of Communications is its governmental counterpart for policy.

Other public communications are handled in other agencies. Postal services are not provided by KTA. The Korea Broadcasting System is separate and responsible for television and radio. It operates two television channels and a radio network. A radio and television network, partly owned by KBS, and the Christian Broadcasting System also provide media services. All, plus some small independent radio stations, are dependent on a government-controlled wire service for news and information.

A crucial part of the telecommunications effort is its R&D program. About 2% of gross income is allocated for R&D, carried out mainly in the Korea Electrotechnology and Telecommunications Research Institute. Much of the research is aimed at applications of foreign technology in the Korean environment. Projects include electronic switching, optical communications, long-range integrated system planning, and Korean language processing for videotex and teletex.[36]

A long-range master plan for a management information system was formulated in 1983. The plan is intended to provide an overall management system in telecommunications services by the end of the century. It is to be accomplished in three phases: 1983-88, computerizing all parts of the system; 1988-95, building a database system; and 1996 onward, intensifying employment of the system.[37]

The vehicle for accomplishing the master plan is the Data Communications Corporation of Korea (DACOM). DACOM is a joint venture,

30% of which is owned by the Korea Telecommunication Authority and the Korea Broadcasting System, and the remaining 70% by 26 private firms. It was established in 1982 as the exclusive data communications supplier in the country.

The legislative act that authorized DACOM to function as a value-added network if other systems could also be set up within DACOM's structure. The legislation did not provide for private networks; however, it evidently would allow private VANs to operate under administratively prescribed conditions. Guidelines for other network operations -- public or private -- have not yet been prepared by the Ministry of Communications. When this is done, other networks will most likely provide specialized services for a segregated part of the market. One public network under consideration would service the banking system.

DACOM made impressive progress in the first three years of its existence. It uses a packet-switching system that has provided service to the three main cities -- Seoul, Pusan, and Taegu -- since 1984. It inaugurated electronic mail service in mid-1984. A small-scale pilot videotex system has about 50 terminals capable of handling Korean language text in the Hangul characters.[38]

Within six months of its authorization, DACOM had opened the first leased line service in the Seoul area. Since then service has been extended outside Seoul, through four other nodes, including Taejun, Kwangju, and Pusan. DACOM's network service covers all major cities in the country through a multiplexing system that operates through the five nodes. International services have been offered since 1983, covering 52 countries by 1986.

DACOM subscriber list of 150 in 1984 has increased to more than 600. Most users are multinational companies, both Korean and foreign as very few purely domestic firms use the service. Lack of domestic data banks and other local information services, especially in the Korean language, deter many potential customers. Approximately one third of DACOM's users are educational or scientific institutions that are accessing databases in the U.S. and Europe. Some subscribers have dedicated lines and use DACOM as a backup when their regular facilities are out of order or overtaxed. Many customers, foreign banks for instance, indicate that their usage is limited by the restrictions imposed by DACOM on message switching, preventing them from providing information services to their own customers.[39]

DACOM's lines are leased from the Korea Telecommunication Authority, a situation that is not likely to change. All the lines are high-quality circuits, capable of transmitting high-speed traffic. DACOM also has responsibility for the dedicated lines leased by some large users. These are usually for local traffic, as intercity requirements of most corporations are not yet large enough to justify the expense of a dedicated line. Many of the DACOM customers use leased lines over short distances and DACOM services over long distances where usage is less intensive. DACOM's public rates are related to the volume of traffic, while leased line rates are fixed per month.[40]

SWIFT (the Society for Worldwide Interbank Financial Telecommunications) is beginning to function in Korea, after prolonged negotiations. Korea's security laws prohibit external control over communications in a way that conflicts with the SWIFT system's

insistence that transactions should not be monitored. A problem for many nations, this conflict eventually was settled on SWIFT terms. DACOM expected to resolve the situation and proceeded with system planning in the anticipation of SWIFT ties to Korean banks. Since the matter was settled in late 1985, the Korean banks have begun to make their specific arrangements for using SWIFT lnks for international transactions.

The banking and financial communications requirements in Korea are shaping up as a unique case likely to result in a special and separate network. DACOM's policy is to accommodate these special requirements as much as possible. Other special cases are expected to arise, and DACOM will end up running a family of both general and special service networks.[41]

Computer Usage in Industry and Commerce

The framework described in these pages is intended to boost computer development. Usage throughout the economy is the ultimate goal. "Our main efforts," according to the Ministry of Science and Technology, "will be concentrated on building the infrastructure needed for efficient use of computer systems."[42]

The effectiveness and impact of computerization can only be approximated from available statistical data. The records cover only a short period of time, and many collection problems remain. Definitions and terms in surveys are not uniform. Thus, there is a lack of reliable data on numbers and types of equipment and software, and even more on the depth and quality of usage. These inadequacies will be a costly handicap for computer policymaking until they are corrected.

Use of information technology systems has expanded at a fast rate from a low base.* The number of computers in Korea, as shown in Table 9, has grown about one-third each year from 1979 through 1984. Official data for 1984 show 1241, a number that rose to more than 1800 by the end of 1985.[43] Use has risen fastest in the smaller computers, as mainframe and minicomputer sales have been slowing for several years. The trend toward small, increasingly powerful computers is expected to continue.

Table 9

Computers in Use in Korea

	Main-Frame	Super-Mini	Mini	Super-Micro	Micro	Total
1979	62	45	94	94		296
1984	87	118	231	378	427	1241

Source: Ministry of Science and Technology. Documentation from the Bureau of Information Industry and Technology Promotion.

Despite its increased usage rates, Korea appears to lag behind East Asia -- though deficiencies in statistical collections of other countries and differing definitions and use of terms mean that comparisons have an even greater element of uncertainty than do estimates of national usage. The annual survey in the Asian Computer Yearbook, 1984 indicates that Singapore, Malaysia, and Hong Kong, and possibly others, have higher computer densities.[44] As Table 10 shows, the Roche survey for 1981 also suggests that computer use in Korea is not as great as in several other Asian nations, with both Singapore and Taiwan having much higher usage rates.[45]

The head of the computer department in a Korean university has presented the lag in a different and ingenious context. He reasons that computerization should be correlated to international position. Because Korea does 1% of world trade, he believes the number of computers in the country should be made to approximate that ratio. He has proposed that the government should set a first target of one-tenth of 1% of the world's computers, which is substantially greater than is now the case.[46]

Table 10

Computers in Use in East Asia

Country	Number* Per Million of Population
Korea	19
Taiwan	36
Singapore	97
Japan	208

*Data for Korea as of 1982; Taiwan, 1981; Singapore, 1978; Japan, 1981.

Source: Edward M. Roche, "Korean Transborder Data Flows: A Policy Matrix For Newly Industrializing Countries," prepared for the Second World Conference on Transborder Data Flows, Intergovernmental Bureau For Informatics, Rome, May 1984.

The most experienced users are in the Korean public sector, where the computer was introduced in the 1960s. Its early use was for passports and visa issuance, public utilities, education and economic statistics, budgeting, and transportation systems.

A master plan for the public sector was set up during the mid-1970s. Many ministries already had installed systems, as the principal objectives were to tie the systems into a national network, speed up interagency communications, and pool information for improving distribution. The Plan also called for technological upgrading and correcting incompatabilities in the system. It has been well supported in official budgets.[47]

The first phase of the Plan (1978-82) involved 17 ministries and 42 provincial and city government units. Phase 2 (1983-1987) added other parts of both central and local governments to the network. DACOM's facilities and KTA's upgrading of line quality in the telecommunications system have made the network much more effective than it otherwise would have been.

Outside of government, the financial sector has been a leading area for computer usage in Korea. Most banks have computerized record keeping. Some have limited on-line transactions capability. A few urban banks have installed automatic tellers. Computer usage is still thin, however, and largely limited to in-house accounts. Interbank clearances are handled manually, as are transactions with the central bank, the Bank of Korea.[48]

Korean banks are generally regarded as slow in adopting new technology. This is attributed to an uncompetitive ambiance in domestic banking, abetted by strict regulations on foreign banks and international finance. "Korean banks are not aggressive," a leading Seoul banker says. "They sit and wait for clients to come to them."[49] With

few competitive pressures, Korea's bankers are indifferent about improvements in services.

The problems of the financial sector are recognized, and an effort is underway to correct them. The largest government-owned banks have been privatized but are still closely subject to official instructions. Banking reforms are being put into effect, and the system is opening up. While the reforms are proceeding slowly against strong resistance, Seoul's banking community seems to agree that liberalization is having a positive effect on computer usage.[50] Roche's survey shows many banks are expecting to join the SWIFT system when Korea enters. This will require a much higher degree of banking automation.[51]

Industrial computerization is probably less advanced than banking. It is found primarily in the export segments of the large conglomerates. Few small or medium-sized firms have been attracted by the potentially usable microcomputers.

Office automation systems are accepted practice among large international firms -- though data on depth of use are not available. Many have set up management information systems and hired staff for procuring and overseeing MIS operations.

The Daewoo Group's system is typical. The Daewoo Group has MIS units in the central company, as well as its heavy industry, shipbuilding, and motor car branches. The professionally staffed units employ more than 200 executives, programmers, and systems analysts. Their work covers a wide range of information system functions -- production control, construction estimates, payroll, order control, personnel, inventory, budgeting, marketing, and word processing. The

Daewoo system, like other conglomerates in Korea, connects its home offices with its foreign branches.[52]

While MIS units have an important part in specific functions of Korean multinationals, they have an ambiguous role in decision making. Top management, according to business analysts, regards computers as useful for performing specific jobs, such as accounting or budgeting, but has not begun to use their computer systems as integral parts of corporate decision making.[53]

Software and operational systems are often dropped in budget making, according to corporate and academic officials. The head of a university business school says that upper management thinks hardware may be needed but is willing to cut corners on other items. A computer evidently is still looked on as capital equipment, rather than a device for thinking about business. This management view is obsolete and is hampering effective use of information, in the eyes of business consultants who have been associated with major firms. They are not optimistic that it will change soon.[54] The head of the computer department in one of Seoul's universities cites its experience with programs designed for upper management. Few top executives enroll, and many of those drop out, saying they are too busy.[55] This attitude may not change materially until the new generation of "information age" executives replaces today's leaders. But managerial performance could be inhibited if this cultural lag is not dealt with.

Meanwhile, Korea's business community is making considerable use of computer technologies on the production line. The large conglomerates are the leaders. They profess strong commitments to computerization and

high tech as the answer to future profit making. In practice they are wary about upgrade investments in labor-intensive industries that show low profits, and sometimes prefer divestment.

1. Textiles. Textiles continue to be Korea's leading foreign exchange earner, yet several companies are skeptical about investing when wage rates are rising, production in low-wage nations is expanding, and markets are closing or not growing. Technological upgrading is not popular. Nevertheless, more than half of the weaving and spinning machines have been automated, spurred by a governmental productivity fund for replacing obsolete equipment.[56]

The Paik Yang Company is one that is bringing in the newer technologies and introducing an efficiency-oriented wage system as a way to counter its low-wage competitors. Paik Yang has installed a mainframe computer for management and operations. In its main manufacturing plant, the company is using computerized machinery for embroidery, automated cutting, yarn processing, and dying. Paik Yang has also installed an R&D unit for developing new products. Paik Yang's president says, "we have to develop new products constantly to stay in the leading position in the underwear business."[57]

2. Transportation. An automated fare collection system for Seoul's subway system is scheduled for completion in 1986. A French firm, CGA Althol, is installing ticket vending machines, the computers to operate them, a closed circuit television unit for monitoring them, and automatic gates for the system.[58]

3. Machine tools. Conventional machine tools account for 75% of output, but production of numerically controlled tools is growing by 15%

a year. Key technology agreements with foreign firms are beginning to pay off for a few companies.

Whachon Machinery, using the Flexible Manufacturing Cell system, is producing a milling machine that can process moulded materials automatically.

Korea Heavy Machinery is making a wide range of products, including numeric-controlled lathes, milling machines, and cool forged construction machinery.

Daewoo is marketing a multi-function controller with automatic checking and detection of faults. Its Quasar 1000 laser cutting machine performs many metalworking jobs, such as welding, trimming, and scribing, as well as marking.[59]

4. CAD/CAM. Many of the large conglomerates have CAD/CAM divisions providing internal services. Seoul Electron Company (SEC) is a unique independent company selling CAD/CAM services to everybody, including the conglomerates.

SEC is a venture capital newcomer with distribution rights for Computervision equipment. It also has ties to other foreign CAD/CAM firms. Sales that amounted to only $18 million in 1984 were expected to exceed $50 million in 1985.

SEC's first priority is building its staff; it is currently investing primarily in training for its own personnel. Its major services are providing instruction in CAD/CAM applications, designing and installing custom systems, and giving on-site guidance. Program maintenance has become a major service since SEC discovered that its

earliest applications were actually producing no more than 20% of the predicted returns.[60]

5. Industrial electronics. Hyundai is mobilizing to supply the industrial electronics markets that it anticipates. Closely linked to its semiconductor and computer research, the Hyundai electronic systems division is focussing on telecommunications and industrial electronic systems. The company is already making cellular mobile telephones for export under contract and began offering entire cellular systems in 1985. Their electronics research group is working on construction control systems, programmable controllers, computerized medical equipment, industrial robot controllers, and numerical controlled machine tools.[61]

The Hyundai Motor Company has been licensed by Cincinnati Milacron Inc. to produce a line of computer-controlled turning centers (a machine tool for shaping cylindrical objects) for sale in Korea. Milacron has also contracted to buy from Hyundai parts for its own production of turning centers.[62]

A Gap Remains

Abundant evidence can be cited showing strong commitments to computerization and illustrating early advances in applications. Some of the Korean multinational companies are impressive leaders in high technology methods of production and distribution. Yet these examples are still the exception, not the rule, and there is a large gap between potential and realization.

The gap reflects the great risks in computerization at Korea's stage of development. Corporate leaders face too many unknowns in

introducing high tech management systems. And the risks appear the greater because of the ambiguity of benefit from available computer systems and the dearth of convincing evidence that effective applications systems will be available.

Many corporate leaders are especially troubled by personnel problems they foresee in computerization. They worry about finding talented professionals in sufficient numbers to make expensive systems cost effective. They are concerned about what to do with present work forces, and wonder whether retraining will be possible or economically feasible. Some industrialists are eager to move ahead, but many others, even when faced with rising wages at home and declining competitiveness abroad, are looking carefully before leaping into unfamiliar production technologies.

There are many signs that high tech is still in an incubator stage in Korea. Significant gains are likely to come only gradually as Korea develops conducive institutional structures and personal attitudes needed in the computer age.

4

PRODUCTIVITY AND TAIWAN'S INFORMATION INDUSTRY

> The advantages of high-tech production lie less in the computerized technology itself than in the process that uses it.
>
> Fu Tzu Han, Chairman, China Steel Corporation[1]

Taiwan, no less than Korea, sees on one side the escalating expectations of rapid development, and on the other the narrowing options for internationally competitive production. New economic strategies have to be found because past approaches are no longer adequate.

Taiwan's response is an "information industry strategy" that was approved in 1980. Premier Yu Kuo-Hwa listed its purposes in opening the National Information Week in November 1984:

> To promote effective utilization of computers in order to improve productivity and efficiency and add to living standards.
>
> To open up the domestic market in order to spur the development of the information industry.
>
> To upgrade technology in the information industry and then to expand the domestic market into world export markets.[2]

This is an ambitious program. Fulfilling it is a complex task of integrating industrial policy with technological infrastructures. It requires a coalescence of public will and private initiative, a continuing consensus on goals and measures for pursuing them. Taiwan took a vital step in adopting its "Ten Year Development Plan For The Information Industry, 1980-90."

Ten Year Information Industry Plan

The Plan is Taiwan's policy framework for its information industry. It spells out the basic aims of computer development and utilization and

prescribes the means for achieving them. Prepared by the Council for Economic Planning and Development, the Plan was approved by the Executive Yuan as official policy in 1980. It is the product of an interagency team that compiled data, analyzed the country's complex problems, and prepared recommendations. It represents a ground-up consensus of the nation's policy requirements.

The Plan emphasizes the economic benefits of an information industry in Taiwan: It is a way to earn high-value-added returns and to support automation for raising national productivity. The Plan stresses Taiwan's unique resources, especially its tradition of universal education, as the rationale for knowledge-intensive growth. It concludes that Taiwan has a comparative advantage in promoting the industry as an export-oriented sector.

The Plan's strategy is incorporated in recommended measures in seven interlocking areas of computerization policy. These are summarized in Appendix A. For priority action the Plan calls for five major projects that have subsequently been undertaken:

Project I: Promote computerization in the government sector.

Project II: Develop 16- and 32-bit minicomputers with in-house software and distributed processing.

Project III: Establish capabilities for development of software systems, including project management, standards, documentation, and auxiliary tools.

Project IV: Expedite the increase in professional information industry specialists, especially in technology and management.

Project V: Construct an exhibit hall to increase awareness and knowledge of information products, technologies, and services.

Production of Computer Systems

Expanding Taiwan's computer and software production is a fundamental requirement in the Plan. Everything else depends on it. A major effort has been made to assure that an expanding industry will comply with the nation's development environment and attract, as well, the entrepreneurial resources and technological talents necessary for high tech advancement.

The most evident effect of the Plan is a computer industry that for five years (1979-1984) doubled output every year.[3] Total exports and re- exports amounted to $418 million in 1983 and more than $1 billion in 1984.[4] Growth slowed in 1985, because of the world's recession in computer demand, yet was estimated at about $1.3 billion.[5] Survey data indicate that 170 hardware manufacturers, 70 software houses, and 200 sales companies were active in 1983; the net numbers have grown about 25% a year even with a substantial number of business failures among the games producers in the 1981-82 period.

Segments of Taiwan's computer industry began in its consumer electronics firms. Initially, these companies supplied export markets with products or simple components that could be made with relatively little change in their factories. A major computer component for export, for instance, has been the CRT monitor that is still made by several of Taiwan's television manufacturers. And offshore computer makers looking for low-cost suppliers often preferred to contract with electronics producers with good production records.

Although starting as an arm of consumer electronics, the new industry is undergoing a fundamental change in structure. Some consumer electronics firms -- such as Tatung -- continue and even expand. A constant influx of small new companies, producing only for the computer trade, is changing the industry profile. Since 1980 a wholly new industry has grown up looking less and less like an arm of consumer electronics.[6]

As of 1986, Taiwan's computer industry had many specialized firms producing relatively limited product lines. The contrast with Korea and its high degree of concentration in powerful conglomerates is striking, and some Taiwan industrialists fear that this may handicap them in trade competition. The product spectrum, however, is similar to that in Korea, consisting largely of components and parts. Terminals, disk drives, printers, and monitors account for 70% of Taiwan's output. As production has gone up, variety has become more extensive and technology levels have gradually improved.

Most of the output goes to foreign manufacturers; little is marketed under a Taiwan trade name. More than 75% of exports are sold to U.S. computer firms.[7] Taiwan has to import, on the other hand, controller cards, precision machined parts, and other sophisticated components to produce its own parts and components. Although small in total value, such imports are critical for some products, especially for those at the upper end of the technology scale.[8]

While Taiwan's computer production usually ends up as input for foreign manufacturers, several companies are trying to raise sales of brand-name products and of firm-identifiable components. This trend is

encouraged because higher-value-added earnings can be made; it is not pushed so far as to hamper component marketing, where the best prospects lie. Brand-name marketing of some of these products, moreover, would likely raise legal issues of patent infringement, leading to litigation and adverse publicity that both the Taiwan government and most manufacturers are trying to avoid.

Multitech Industrial Corporation has been marketing by brand name in Asian markets. Their "Microprofessor" is a popular low-cost product, with more than 60,000 marketed since it was introduced in 1982. It is sold to foreign manufacturers who can attach their own label, as well as distributed under the firm's name. Multitech is now offering a more powerful 16-bit microcomputer, the MPF-PC, that has been approved by the FCC and Underwriters Laboratories for sale in the U.S. It is available with a 10-megabyte hard disk and can be operated with IBM PC software. It is sold through distributors as well as to foreign firms for repackaging.[9]

Multitech is one of Taiwan's largest computer manufacturers. Started in 1976 with 11 employees and capital of $25,000, the company's business has doubled every year to about $80 million in 1984. Multitech is technologically aggressive and spends significant resources on R&D. It opened a branch in Silicon Valley in 1984 that is a key part of its R&D work and has licensing agreements with both Japanese and American companies. One area of technological emphasis is on Chinese language computer systems. Its "Dragon" series is the second largest seller (after IBM's 5550) in the area. Multitech, like others, expects the Chinese language market to be a large export earner in East Asia and is

going all out to be at the top of those developing these computer systems.[10]

Tatung is another major computer company, but it differs in many important respects from Multitech. It is a long-established electronics and home appliance producer, in business since the early 1900s. Tatung has appliance factories and direct distribution outlets in Europe and the U.S. It is Taiwan's leading computer products exporter, with foreign sales of about $150-160 million in 1984. The company is a major supplier of floppy disk drives to Control Data, and of terminals to IBM. It also produces daisy wheel printers and monitors for the foreign manufacturing market.[11]

Although Tatung's strength is large-scale production more than technological innovation, it has set up branches in California (Tatung Science and Technology) as well as in Boston (Tai-Tatung) to tap the R&D talents available there. The company sees computers as a principal area of future activity. It is selling appliances directly in the U.S. and Europe, and is studying the possibility of marketing computers under a Tatung label. But its market survey reportedly shows unpromising prospects, and Tatung seems more interested in producing for foreign firms.[12]

Tatung has been working with other companies on R&D projects of the Electronics Research and Service Organization (ERSO), an official body. These include research on hard disk drive units, dot matrix printers with both Roman and Chinese characters, and the design of local area networks. Tatung has been acquiring a catalog of products that can keep its business expanding for many years.[13]

The third type of computer producer in Taiwan is the international company. Although American and Japanese firms have been an important part of the Taiwan scene, they have not been large investors. Many have sales and service units. Some are active buyers of components, and several run these operations through purchasing offices in Taiwan. These include IBM, AT&T, Hitachi, DEC, Hewlett-Packard, Fujitsu, and ITT. A few, like Wang, Timex, and Texas Instruments, have operated plants for simple products, such as watches and games, or for assembly. Direct investments have had a limited place in Taiwan's information industry.

U.S. companies may be gaining a new role. Most notably, a joint venture was signed in August 1984 by AT&T and three government organizations, the Directorate General of Telecommunications (DGT), the Bank of Communications, and the Yao-Hua Glass Company. The agreement established ATT Taiwan Telecommunications Corporation (ATT-TT). More than two years in negotiating, the venture called for AT&T to invest 70% of the $40 million capital, and the Taiwan interests the remaining 30%.

Initially the company is to manufacture and market the 5ESS, AT&T's advanced digital telecommunications switching system, manufactured before only in the U.S. Several other telecommunication products, such as SLC-96, digital radio, and others can also be included for manufacture, subject to approval by AT&T and the company's board of directors. Production began in 1985 at a leased plant in the Hsinchu science-based industrial park, although full production is not expected until the company's permanent quarters are built in the late 1980s.[14]

The agreement has important implications for Taiwan's technological advancement, as well as for its exports to other parts of East Asia. A primary interest for Taiwan is the opportunity for gaining access to AT&T's technology over several years. There are several avenues of technology transfer. A cooperative relationship with Taiwan's telecommunications company, for instance, means that ATT-TT is to provide personnel training in network planning, outside plant engineering, cellular radio, and management of R&D. As several AT&T officers in the venture are Bell Laboratory veterans, ATT-TT has access to this valuable experience. And many of the personnel in the new company are to receive training in AT&T facilities in the U.S.

Moreover, much of the company's supplies are to come from local producers. Many of the 5ESS components are to be procured from local suppliers, subject to meeting price performance requirements. The target for localization is 71%, when 800,000 lines have been produced. Thus, the agreement promises to serve as a stimulus to technological upgrading for Taiwan's manufacturers who must make these supplies in accordance with AT&T's specifications.

Taiwan's export interests are also advanced by the agreement. The new company expects to export part of its goods to Asia and perhaps elsewhere. A complex clause links local procurement to the level of exported production; the export ratio is 50%, which means that domestic sales are to roughly equal the combined value of AT&T procurement in Taiwan and exports from the company.

The export marketing of the company benefits both sides. The terms of the agreement suggest that AT&T will find it profitable to export

from Taiwan. Thus, the joint venture provides a major entree for AT&T to market its technological systems to East Asia as well as to Taiwan, perhaps giving AT&T the regional base that it has been seeking.[15]

In addition to the AT&T investment, both Hewlett-Packard and Motorola have entered significant new production and R&D agreements in Taiwan. Hewlett-Packard is to produce minicomputers in a joint venture with Nan Ya Plastics. It is also supplying equipment and furnishing technical assistance for Nan Ya's automated plant for manufacturing multi-layer printed circuit boards. Motorola is establishing a facility for manufacturing semiconductors and other sophisticated circuit components. It will also undertake software development. Both companies have agreed to set up research and development centers in Taiwan.[16]

Several smaller U.S. firms also have established subsidiaries or have entered joint ventures for manufacturing advanced products. These ventures lead to technological transfer in an innovative way. In each case the American partner is headed by Chinese-Americans who have been attracted by special inducements intended to encourage such investments. This enables Taiwan to gain access to the technical knowledge of Chinese scientists employed in U.S. firms or running their own venture firms.

Taiwan's effort is similar to that of Korea, whose companies are ardently recruiting Korean-American computer specialists. There are three important distinctions between them, however. First, the Korean effort is primarily limited to large companies, while Taiwan's program involves small companies from both sides of the Pacific. Second, the Korean companies seek new employees while the Taiwan program is aimed at

setting up new joint ventures. Third, the Taiwan effort is intended to bring new capital into the country, which Korea's program is not designed to do.

Supporting Innovative Technology

These case summaries show the breadth of enterprise that Taiwan is counting on for information industry production. The industry has grown up under the umbrella of a government-wide structure called for by the Ten Year Plan.

Four agencies have key roles in the structure: the Institute for Information Industry, the Electronics Research and Service Organization, the Science Industry Park at Hsinchu, and the Directorate General of Telecommunications. These agencies have been established or substantially elevated to support the information industry strategy. They complement the governmental departments responsible for investment, finance, production, and trade: the Joint Industrial Investment Service Center, the Industrial Development Board, the Ministry of Economic Affairs, and the Bank of Communications.

The Institute for Information Industry was set up in 1979 as the country's principal agent for the new economic strategy. It has broad responsibilities beyond its essential job as software mentor for the nation.[17] An important function is promoting the industry and computerization throughout the country, a task regarded more as education than as public relations. It is dealt with in country-wide programs of public speeches, seminars, symposiums, and publications, and especially in contacts with the schools and universities. The annual Information Week is one of III's most effective programs, sending a

large exhibit throughout the country and presenting numerous awards in all aspects of computerization. Essay and research contests are conducted at many levels of accomplishment, from grade school to the laboratory and university. The program provides a valuable opportunity for educating the public on the importance of computerization, as well as its problems.[18]

It has been pointed out, however, that the III programs are mainly directed at technological aspects of computer use. These programs may not allow sufficiently for the psychological and social difficulties of adapting to new technologies. Consequently, they may fall short of potential in preparing the public for important aspects of a computerizing environment.

The Planning and Research Center is an active unit in III that furnishes business advisory services to private companies and public bodies. These services, like most of III's work for private corporations, are generally compensated. The Center makes special surveys on international and domestic trends, which are available to companies for use in planning market and production strategy. Through its marketing intelligence unit, the Center disseminates analysis and data on computer production and technology. It provides special studies upon request. The Research unit assists companies in designing software engineering methodologies and aids them in developing software systems. Among the economic reports of the Center are those on the development of Chinese language computers and on small business computerization.

III's Systems Development unit is more technically oriented, helping clients plan and implement large-scale software projects. The

unit performs feasibility studies, cost-benefit analysis, and design services. It is working on requests for software systems for automated manufacturing. Projects completed include a software system for the First Commercial Bank, a MIS system for the Ministry of Communications, and an administrative support system for the Industrial Development Bureau. The unit has worked with private companies in developing comprehensive Chinese language automation systems for office use. In addition to its domestic work, III has an international unit for cooperative software development with foreign companies. The group has performed major projects with IBM on an accounting system and with Hewlett Packard on office automation and word processing in the Chinese language. An important function of the international unit is overseeing the importation of all forms of information technology.

III's Software Engineering Institute is run with assistance from IBM. A primary objective, according to SEI officials, is to merge software engineering and the principles of management. SEI provides practical courses on a technologically high level, such as information system management, on-line application design, communication network design, software testing, and database administration and design. Courses require 30 class hours over a one-week period. About 15% of the students are management personnel and the rest are systems and applications engineers.[19]

The SEI fills an essential mid-role between the lower school that provides basic entry-level training and the university that provides more advanced work on a higher theoretical plane. Moreover, SEI courses are pegged at specific problem areas resembling actual problems in

everyday business life. SEI courses, which can accommodate about 1600 annually, have been popular -- enrollments have to be closed because classes are filled.

Course enrollment, however, is primarily of junior and mid-level personnel. Attracted to these courses are young men looking for ways to advance themselves, rather than upper managers and senior executives in decision-making positions.

IBM's association with SEI began under a two-year contract that is less extensive than similar arrangements of IBM with other East Asian countries. In this case IBM is helping to draw up teaching materials for the courses. It is also training all SEI instructors in its own facilities in the U.S. or in Singapore.

This training is a valuable enhancement to instructors who are already highly qualified. IBM equipment is used in SEI classes, but IBM Taiwan insists that the courses are sanitized and are not showcases for IBM. Although the contract has been extended, SEI officials believe that the training program can be continued without notable loss when IBM's participation eventually ends.[20]

Electronics Research and Service Organization (ERSO) provides hardware R&D services that parallel those of III in software fields. It is a part of the Industrial Technology Research Institute (ITRI) that has broader responsibilities in engineering, energy, chemicals, and materials R&D. The ITRI laboratories provide services in these other fields comparable to those that ERSO furnishes for electronic companies.[21]

ERSO employs about 1500 persons, more than half of whom are engineering professionals. Their work is in three areas: computer technology, VLSI development, and automation.[22] In addition to R&D work, ERSO is Taiwan's second largest manufacturer of semiconductors.

Projects originate from consultations with the private sector. The Industrial Development Bureau -- of the Ministry of Economic Affairs -- conducts inquiries with III, ERSO, and companies to find out what products and processes are of interest for research. Funds for support are allocated through the Ministry of Economic Affairs.

Once projects are identified, ERSO is expected to assemble the group of interested companies for cooperative R&D. Costs are shared and participating companies are entitled to full use of the results. In December 1984, for instance, IDB announced that five computer projects had been decided upon, with the government covering up to half of the estimated cost of $5.6 million.[23] The projects are (1) a 32-bit personal computer using both MS-DOS and Unix operating systems, estimated to take about 15 months, (2) a color printer that was to require about eight months, (3) a portable Chinese typewriter that will be able to store 5000 characters, (4) a 5.25-inch, 50-megabyte hard disk drive that was to take about 18 months, and (5) a 3.5 inch 820-megabyte drive that was estimated to take about two years.

ERSO's projects are undertaken on the assumption that companies are often unable or unwilling to bear the full cost by themselves. ERSO gives them another option; they can go it alone, or work with other firms that may be competitors. By pooling research personnel and money, several companies are able to accomplish what no single one could do.

ERSO engineers lead the R&D projects, but participating companies involve their own people in all aspects of the work. This not only provides practical experience in the R&D, it also gives the company guidance when the R&D phase is over and the project moves into production. Moreover, ERSO research is not limited to technical and production problems; it also tackles questions of quality control, marketing strategy, and yield. Thus, company involvement is a critical part of ERSO's process.[24]

Systems design is an area of increasing importance for ERSO, as it is for the computer firms and III. Seven companies worked with ERSO on an IBM-PC compatible local area network, a project completed in 1985. A longer term project started in 1984 involves R&D for an intelligent work station for scientific, engineering, and CAD/CAM work. Research on the work station includes linking computers in clusters to form a distributed computing system.[25]

ERSO has had its share of successes. One is a 16-bit microcomputer that is the basis for a standard product for several Taiwan companies. Another is a bi-directional dot matrix printer capable of printing 40 Chinese and 60 Roman characters a second.[26]

But ERSO's efforts are not always fully rewarded. The program to develop a hard disk drive, for instance, ran into difficulties in marketing after the technology problems had been worked out. The R&D project for 5 and 10-MB disk drives was completed in September 1984, and the technology was transferred to five participating companies. They have evidently decided not to go into mass production, probably because the market has shifted toward higher-capacity drive systems. The

resulting drop in price for the 5 and 10-MB drives has made profit prospects bleak and investment in production risky.[27]

After spending $2 million and more than 40 man-engineer years on the R&D, ERSO came up with a valuable "training exercise" and little else. While some production of the 10-MB drive may yet be salvageable, the project has not produced a commercially viable technology. The "market window," according to ERSO, turned out to be smaller than expected, and it is necessary to move quickly into the higher-capacity drives. ERSO is likely to drop plans for developing a 50 MB and begin immediately on an 18-month project for a 100-MB model. And it began a feasibility study on an optical disk drive that could be undertaken in 1986.[28]

One of ERSO's R&D techniques is "reverse engineering," a method used when working on the hard disk drives. This involves engineers dissecting a successful product, trying to understand how it is put together and how it is produced. Through precise analysis, it is possible to learn as much about a product as in a formal licensing. ERSO distinguishes between "reverse engineering," which is a legitimate form of R&D, and copying or counterfeiting, which ERSO and the Taiwan government are trying to stamp out.[29]

But reverse engineering is by no means a simple route to technology, or a cheap way to get expensive know-how. Reverse engineering takes longer than licensing to get the technological knowledge, and may produce information that is obsolete by the time it can be used on the production line. The ERSO experience with its hard disk drives is a case in point. Reverse engineering also may produce inaccurate results

that lead to costly production errors. Many industrialists and business advisors regard reverse engineering as an expensive, inadequate substitute for licensing.

If successfully done, however, reverse engineering can provide results. It is an accepted and widely practiced method of getting technological knowledge. With results not normally encumbered by the legalities of a technology license, improvements and refinements can be made without referring to the licenser. The most difficult part of R&D, moreover, is in applying technology on the production line. ERSO officials say that reverse engineering and other forms of technology transfer can only give the manufacturer detailed information. He must still apply the knowledge in his own manufacturing environment and do it in a way that will "cut production costs to the bone and still turn out a reliable product."[30]

The Science-Based Industry Park at Hsinchu has a vital place in the support structure for Taiwan's information technology industry. Established in 1980 after careful preparation, the park is the Taiwan sister of Silicon Valley. Hsinchu is the chosen site because of its proximity to industrial research laboratories and two universities with strong scientific credentials. Its purpose is to serve as the nation's center for industrial research and production of knowledge-based goods and services.[31]

The Hsinchu park is a subordinate unit in the National Science Council. It is administered by an on-site office that has extensive control over its operations. Questions of whom will be admitted into the park, however, are determined at a higher governmental level. A

Governing Board, made up of vice ministers of pertinent ministries, decides on all applications. The Board insists on high technology and management standards. Successful applicants must show extensive research and development capacities, a potential for innovation, an integrated production and development plan, and training programs for advanced technology personnel.[32]

In many respects the Hsinchu park is geared to appeal to a high tech lifestyle. Its physical site is a spacious 5000 acres that are about 10% developed, laid out much like a university, with wide boulevards, grass and trees, a supermarket, a model residential area, and its own schools and playgrounds. The headquarters building is architecturally pleasing, and some of the factories look like candidates for prizes in industrial design. All company applications are screened to weed out noise and environment polluters. Although it will be several years before Hsinchu becomes a lively community, it is clearly planned to attract rising, young professionals.[33]

But it is the combination of technology and fiscal incentives that distinguish the Hsinchu concept. They underscore the park as a marriage broker between foreign and domestic companies that are fertile producers and innovators in high tech industries:

-- Preference is given to electronics, communications, biology engineering, precision instruments, energy and materials science.

-- Foreign investors are accorded incentives equal to national investors and may invest in joint ventures or wholly owned firms.

-- Protection of patents, trademarks, and copyrights is guaranteed, and import duties are waived for machinery and supplies.

-- Technological companies are exempt from corporate taxes for five years and from taxes on goods exported from the park.

-- Land rents may be forgiven for five years.

-- Up to 49% of capital needs may be obtained from the National Science Council.

-- Technology may count for 20% of equity capital.[34]

Hsinchu is intended to attract foreign technology, either in multinational companies or in overseas Chinese firms. The Taiwanese companies operating in the park have branches in the U.S. Most foreign investors are American, predominantly Chinese-Americans. So far, only one Japanese application has been approved and the venture was withdrawn before getting started.

The science-industry park management expects to attract Chinese high tech professionals in the U.S. According to Hsinchu's calculations, more than 8000 Chinese in the U.S. have advanced degrees and experience in high tech professions.[35]

To an overseas Chinese, the park offers the opportunity to establish his own business in very favorable circumstances. The inducements are strong for an ambitious executive working for a high tech firm in Silicon Valley. Starting up in California requires much more capital, and high salaries are a greater deterrent. At Hsinchu, starting up is much easier; factory space is cheap and competent engineers, educated in Taiwan universities, can be hired at $10,000 a year. Combining an R&D unit in the U.S., where innovative ideas are researched and tested in a pilot plant, with a production unit in Taiwan, where manufacturing processes are debugged and performed on a

pilot production line, sounds like a tempting formula for ambitious executives with ideas they would like to try out.

And many have. As of 1984, five years after the park opened for business, the Governing Board had approved 64 applications. Of these, 46 had built their factories and were beginning to market products. About three-fourths of the approvals were for electronics and information companies producing, for example, computers, terminals, Chinese keyboards, microprocessors, system and applications software, and floppy disk drives. Many others were in closely related production areas, such as computerized numerical controllers, silicon crystal ingots and wafers, or laser components.[36]

The Hsinchu enterprises are a mixed lot. Some, like Multitech and Mitac International, are Taiwanese corporations with manufacturing facilities elsewhere; they are moving up the technology ladder and have set up units in the U.S. for R&D and raising capital. Others are firms that originated in the U.S., such as Vitelic, Qume, and MOSEL, and are investing in Taiwan to take advantage of the lower operating costs. Control Data, Wang, and AT&T were the only large U.S. firms to invest in Hsinchu. No Japanese firms had invested there.[37]

The Hsinchu concept could receive further invigoration from the rise of venture capital enterprises in Taiwan. These could overcome some of the limitations in the investment system. Despite high savings in the country, relatively little capital is channeled toward venture technology firms. Many promising ventures can't be launched because of the inability of the local risk capital market to generate the necessary

financing. Official funds from the National Science Council or the Bank of Communications are often the only source of local risk capital.

Venture capital enterprises could change this situation. One is Multiventure, a company formed jointly by Multitech, the computer maker discussed earlier, and the Continental Engineering Corporation. The second one is Catalyst Technologies, a joint venture between an American group and the Bank of Communications.[38]

But a big question looms over the prospects for venture capital enterprise: What happens when an investment prospers and the risk taker wants to raise capital for expansion, or wants to cash in, by selling off a part of his equity? The stock market is undeveloped and the prospect for selling shares in the secondary market is encumbered with many traps. Moreover, tax laws and tax regulations for capital gains, as well as restrictions on foreign exchange withdrawals, cloud things further.

This situation could dampen the attraction of a Taiwan investment. The lure of a venture capital investment is the possibility of an enormous rise in the value of the original shares. Inability to realize these gains fully could take some of the glitter from the prospective prize. Many potential investors may agree, however, with a Taipei lawyer: "If you make a bunch of money, it doesn't matter how much you get taxed."[39]

The Directorate General of Telecommunications (DGT) oversees the communications system and is the fourth strategic element in the support structure behind Taiwan's information industry. Since as early as 1953 Taiwan has given telecommunications a much higher priority, investing

from 0.9 to 1.2% of G.N.P., double the norm of other developing countries. As a result the system has been greatly enlarged, the quality of service has been improved, new services have been added, and the system has been technologically upgraded.

Evidence of the results may be seen in Table 11: In particular, more than 5 million telephones were available for use at the end of 1984. With a rate of increase in installations of about 20% annually, Taiwan had a telephone density in 1984 of 26.9 for every 100 persons, one of the highest in the Third World.*

Table 11

Taiwan Telecommunications Services

	Subscribers (thousands)	Telephones (thousands)	International Calls (million minutes)
1975	686	1010	7.8
1984	3799	5085	41.0

Source: Directorate General of Telecommunications, Telecommunications in The Republic of China, Annual Report, 1983/84, Taipei, 1984.

The local telephone system of Taiwan has had fully automatic switching since 1982, and DGT plans to introduce digital local switching by 1988. International dialing is available for subscribers in most parts of the country. Optical fiber circuits have been used in long distance installations since 1979 and now link several cities. Others are connected by microwave and digital coaxial cable. International communications are through three submarine cables and the Intelsat

*Comparison with Korea's telephone density requires adjustment to reflect the Korea Telecommunication Authority calculation in subscribers, not numbers of telephones. Density in Korea, calculated in the Taiwan fashion, would be about 14, rather than 12.3 per 100, in 1983.

satellites over the Pacific and Indian Oceans. Several new telephone services are being offered, such as call waiting, call forwarding, and coded dialing. High-speed facsimile has been available since 1979.[40]

Many of the advances in the system are the product of the Telecommunication Laboratories in Cheng-Li. The principal activities of TL are adapting new technologies to the system, such as those related to Chinese language requirements. The laboratory unit designed, for instance, the computerized directory that is now in use. The system employs operators who take telephone calls and respond by querying a computerized data bank, rather than a printed directory. It uses a 40-key terminal developed in Taiwan that functions through phonetic symbols. There are at present 12,000 Chinese characters stored in the system. Since it was introduced in 1977, the time to answer an inquiry has been cut nearly 50%, from 23 to 12.7 seconds.[41]

Taiwan's system is a government monopoly under the Directorate General of Telecommunications (DGT). Its operating units include the research laboratory, a data communications unit, and a training institute. The postal system is in a separate governmental body. Neither radio nor television is administered by DGT.

The Data Communications Institute (DCI) was established in 1981 to provide data communications and other information system services in the country. It designed and installed its own facilities, with initial planning beginning in 1979. According to DCI officials, the packet-switching system is similar to that in Korea. Equipment for it was purchased from a Belgian firm that assisted DCI engineers with the installation and operations in the start-up months.

The network center is in Taipei, which is also international gateway for the system. Three nodes are in Taipei, Taichung, and Kaohsiung.

The circuit switched network (CIRNET) began offering service in October 1984. Dial-up data communications and public information processing became available in January 1984, and packet-switching service began in December 1984.[42]

As Table 12 shows, the datacom network has 140 subscribers, some of whom use further services. The Institute also administers the leased lines for DGT, demand for which has risen rapidly. During the decade since the service was first offered in 1974, leased line circuits increased an average of about 50% a year.

Table 12

Data Communications Service Users

Service	Number of Users
Circuit Switched Network	140
Dial Up Data Communications Service	114
Public Information Processing Service	5
Packet Switching Network	N.A.
Leased Lines	3045

Source: Documentation from the Data Communications Institute.

While PACNET began operating only in 1983, expectations are that it will attract a lot of business. (See Table 13.) Leased lines also are projected to continue growing at a fast clip, though slower than in the past. Circuit-switched usage is expected to increase at a steady pace.

In addition to these available services, videotex and teletex systems are on the drawing boards for installation at some later date.

Table 13

Projections of Data Communications Service

	1984	1985	1987
PACNET Subscribers	N.A.	275	850
CIRNET Subscribers	135	165	225
Leased Lines In Use	3200	3950	5350

Source: Documentation from Data Communications Institute.

While other services may be added, DCI is initially providing special network services for three groups of users -- a motor vehicle and driver information system, a banking network, and a world trading center network. In each case the network is a combination of services, leased lines, CIRNET, and PACNET. The banking network, for example, offers intrabank data processing through leased lines or public circuits and interbank data processing and switching circuits.

DCI is also offering a wide variety of computerized information systems, such as management information, customer information, and engineering information systems. It plans to extend these services in the future to include specific types not now provided, such as plant graphics and project control.

The data communications system in its initial years has run into very few problems. It employs some 225 persons, about three-fourths of whom are operating personnel. Service can expand substantially without

any great increase in staffing. The biggest headaches are related to security and the government's fear that the system could be used for illicit traffic. Negotiations with SWIFT, for instance, were prolonged by the unwillingness of defense authorities to permit international money transactions without special policing. The matter was eventually resolved on SWIFT terms. As a Taiwan official says, "What else could we do? Everybody else has these international financial communications. It hurts too much not to have them."[43] Although corporate customers who use the facilities complain about high rates, they seem pleased with the system's flexibility in permitting combinations of leased and public circuits; the system is one that yields economic answers to data communications requirements.

Computer Usage in Taiwan

The primary aim of Taiwan's information industry strategy is greater use of computers in domestic industry, especially in more advanced technological fields. A rough measure of usage is the number of computers that are installed and working. A survey by the Institute for Information Industry in 1984, summarized in Table 14, showed 2011 computers in use (excluding microcomputers).* Of these, 65 were mainframes and the remainder a variety of smaller machines. Overall, usage from the late '70s to mid-'80s grew about 25% each year. Taiwan, measured by this criterion, has more than 100 computers per million people, one of the highest computer densities in the Third World -- but lower than Hong Kong and Singapore (see Table 10).

*Taiwan, like Korea, lacks adequate data on usage, particularly on the quality and depth of employment. The deficiency is likely to be a handicap of growing proportions.

Table 14

Computers In Use as of June 1984

Type	Number
Mainframe Computers	65
Mid-Size Computers	127
Small Computers	789
Mini-Computers	1030
Total	2011

Source: Asian Computer Monthly, January 1985, p. 15.

Among Taiwan's principal users are the government agencies that have benefited from sizable increases in computerization budgets as called for in the Ten Year Plan for information industry advancement. One that has made useful applications is the commission that watches over policy planning and budget evaluation. The principal users include:

1. The Research, Development, and Evaluation Commission (RDEC) is a cabinet-level overseer of government operations; its job is to ferret out administrative problems for managerial improvement.[44] RDEC maintains a watching eye on operations throughout the government, similar to OMB's functions in Washington. It surveys operational and managerial problems and acts on the findings. A special task is overseeing the information systems of government agencies; it prepares recommendations for MIS and decision support systems and for legislation on social or legal issues.[45]

RDEC relies on a computerized information system to perform its duties. With a VAX main computer and Digital Equipment machines for support, RDEC keeps records on ministries and commissions throughout the government; it maintains a special watch over the top priority projects. It can draw any required computerized information out of agency data files; but the latter cannot extract from the RDEC data bank. The RDEC system consists of American-made main hardware, with monitors, terminals, and keyboards from local manufacturers. The system, largely designed internally, operates in Chinese characters.

RDEC's computer system also serves a pilot role for government-wide computerization. There is, according to RDEC officials, great resistance to computerizing, in spite of a presidential order to move ahead. The RDEC system helps overcome some of the bureaucratic drag by demonstrating efficient performance; it also provides useful experience for RDEC in advising other agencies.[46]

But the most promising areas of future computer use are in industry and commerce. Several instances of current activity may be cited.

2. The Kaohsiung Harbor Bureau's computer experience and its requirements have little resemblance to those of the RDEC. It has earned a worldwide reputation for efficient harbor operations, in part because of its computer work, but mainly because of the way it has unified computer and other functions, such as port management, warehousing, and cargo and container operations.

Kaohsiung surpassed Singapore in 1984 in container handling, to rank fourth behind New York, Rotterdam, and Hong Kong. Its big

advantage in container competition is the large land area it devotes to terminals. Kaohsiung has expansion room that Singapore and Hong Kong lack and can offer leased berths to the large container lines, an attractive option not open to some competitors. But it also must provide computerized scheduling and storing for a full-service container port. Liner officials are said to rate Kaohsiung as one of the world's most efficient container ports, handling 35 containers per hour compared to an average of 25 worldwide.[47]

Competition among container ports is especially keen for transshipment traffic. Amounting to one-fourth of Asian container trade, transshipments are growing faster than other shipping. Many lines economize by calling on only two or three key ports in the region, leaving containers for transshipment by feeder lines. Kaohsiung's sprawling terminals are especially adapted for this type of traffic. By the mid-1980s, one-third of Kaohsiung's container trade is transshipments to the Philippines, Korea, Japan, and Thailand.[48]

Kaohsiung's efficiency with containers is attained with a Cyber mainframe and auxiliaries, including 57 terminals. It is staffed by 11 programmers and analysts. With 18 leased lines, Kaohsiung offers high capacity data services to shipping firms. Three giant American lines lease berths, as do Evergreen and Yangming, the biggest Taiwan lines. Other East Asian ports, especially Pusan and Kobe, are ready to challenge Kaohsiung in a deadly competition. Even so, Kaohsiung expects to maintain or widen its present advantageous position.

3. The China Steel Corporation's automation program has dramatically increased productivity in its mills. Production of steel is 498

tons per worker, nearly 40% greater than in 1980 when computerization began. Productivity is second to Korea, but higher than Japan, where China Steel is getting its technology. Output and sales in 1984 were 35% above projections. Further expansion will raise production another 75% when completed in 1988.[49]

China Steel is also one of the country's foremost users of data communications, having 28 leased lines to link its IBM-based system and 120 remote terminals. Its chairman's commentary is perceptive; he asserts that "the advantages of hi-tech production lie less in the computerized technology itself than in the process that uses it -- maximizing the profitability of good equipment through good management and staff."[50]

4. Far Eastern Textiles is one of Taiwan's largest companies. Its principal holdings are in textiles, but it also has a department store chain, a cement firm, and shipping interests. It is a family-run business, in the East Asian custom, with an active program for keeping on top of managerial high tech.[51]

The textile arm of the group has a large data-processing unit. It runs on an IBM mainframe and smaller Wang and Prime auxiliaries, with a staff of 29. The system has 15 remote terminals. Applications include payroll and personnel, inventory, purchasing, receivable and payable accounts, cost accounting, and financial management. Far Eastern has four leased lines for data communications with its eight production units in other parts of Taiwan. The lines do their job, according to company officials; they are expensive but they permit high-speed data communications within the company. Far Eastern does not use the public

lines because they are slow and connections are not always reliable. However, as new services become available and past deficiencies are corrected, the company intends to use them.[52]

Far Eastern's computers were purchased to perform specific data processing jobs, rather than as a management system. Although there is extensive communication in the system, it is narrowly channeled; an officer explained about the IBM, the Wang, and the Prime, "no way will they talk together." Each has its assignments and goes its own way. The company's long-term plans call for a decentralized system with personal computers located at each of its plants. Far Eastern is exploring how and when the system should be set up.[53]

5. American Express operates an international banking office in Taipei that is primarily concerned with credit card transactions and travel services. Its officers describe the business environment as very favorable, especially for American Express which is regarded as a foreign exchange earner and a conveyer of high technology. For its needs, American Express maintains a data-processing system, with a Honeywell mainframe, a staff of four, and 19 remote terminals.[54]

Although Taiwan's banking regulations do not permit credit card purchases in local currency, they are allowed in foreign currencies. Many Taiwan residents hold cards acquired abroad; thus, American Express has a brisk trade that is not dependent on tourist traffic alone. The domestic credit card business, however, is in a state of transition and uncertainty. Since 1979 a "debit card" has been permitted, and seven domestic banks have been approved for this form of payment service. "Debit card" limitations -- the user must have a positive balance in a

bank account -- have been eased somewhat by permitting overdrafts, but they still restrict the card's usage. Moreover, American Express and the foreign banks that do not have local currency depositors are not permitted to offer the service.

The computer system that American Express is using is adequate, according to their officials, for the range of services that are now offered. The company would install a larger and more sophisticated system, however, if the necessary approvals could be obtained. Of particular relevance is American Express' request for a secure international telecommunications circuit. According to American Express officers, the Taiwan telecommunications officials supported approval, but the military command would not unless one of their officers were able to oversee the operation at all times. Hoping for approval in time, American Express is using national lines and a computer system that falls short of the best service. Company officials would like, they say, a faster installation that allows simultaneous transmittal of several messages. But without its own higher capacity line, the more sophisticated computer system is not economically feasible.[55]

6. The Regent of Taipei claims that it will have "a higher level of computerization than any other hotel in the world." Most hotels in Taipei and other principal cities have small systems for billing and other inside accounting and managerial functions. But reservations, credit cards, and other operations are conducted by telex, telephone, or letter.

The Regent is now under construction for a 1988 opening. It is a 570-room hotel that will have computerized check-in and check-out,

security, lighting, energy conservation, air conditioning, heating, and all administration. According to hotel officials, the Regent is planning to have a computer terminal and CPU in every room, with a drive system available for guests who request it. A wide range of communications services will be offered, according to hotel staffers, including teletex and videotex when they become locally available.[56]

A Thin Edge

These citations of computer usage point to the leading edge of technological advancement in Taiwan. It is a thin edge. Computer usage is still in a stage when institutional lag -- especially dated legal restrictions and business habits -- inhibits many potential users. A large part of the business community remains unpersuaded that now is the time to adopt a new and unfamiliar technology. Taiwan is still searching for the best forms and levels of computerization.

5

COMPUTERIZATION, HIGH TECHNOLOGY, AND INTERDEPENDENCE

> There is a new phenomenon in the world and one with which we have to deal. There exists a global marketplace for ideas, money, goods and services that knows no national boundaries . . . . It exerts global pressure on all governments to pursue sounder economic policies because it is becoming increasingly obvious that it is now impossible to hide in our new electronic world.
>
> Walter Wriston, Chairman, Citibank[1]

This examination of industrial policy in Korea and Taiwan has looked at ambitious development strategies aimed at making high technology a fundamental part of all economic activity. It describes programs that are thoughtfully conceived, thorough, and conceptually integrated with other economic objectives, as well as implementation machinery that is working effectively. In both countries, the private sector is responding actively to the incentives and objectives of official policies.

The priority objectives in this early stage of computerization have been the advance of internal capabilities. Private companies and government agencies have been preoccupied with getting launched properly and in the right direction. Questions of obtaining access to technology and enriching R&D capabilities, enlarging production capacity, enhancing telecommunications facilities, and upgrading manpower competence; these are the kinds of problems that have been getting the most attention from decision makers in government and business.

These initial objectives have been largely achieved, and long-range programs have been established for assuring robust internal capabil-

ities. Further progress, however, increasingly involves questions that are not as readily susceptible to political management. While fashioning the instruments of computerization, Korea and Taiwan have not yet developed the institutional structures needed to sustain them. Such structures take more time, for new policy parameters are being formed internationally that are not fully understood. Few domestic economic interests are unaffected by the new technologies and by the new forms of interdependence that computerization is creating. The issues are of paramount importance in all segments of society.

What this signifies specifically may be seen more clearly after a review of issues that industrialists and officials confront in the existing institutional environments. The pressures of change are complex, and they are working slowly. How they are dealt with will have a great deal to do with shaping the impact of computerization in Korea and Taiwan.

1. Corporate Management in a High Tech World

Computer manufacturers and computer users in Korea and Taiwan face perplexing managerial problems. Most consequential are their decisions on investment in production facilities. Whether it is a matter of investing in equipment and technology for computer trade or of investing in new computer systems for raising productivity and competitiveness, the high tech manager faces difficult questions in assessing profitability. The problems may not differ in principle from those in the less advanced industries; they differ in practice because of the new parameters and uncertainties in a high tech environment.

-- Uncertainty is inherent in a newly evolving industry that is subject to rapid and often unforeseen technological change. Risks are magnified for Taiwanese and Korean corporations that must depend on foreign sources of technology. How much should a corporation rely on outside licensing and how rapidly should internally controlled technology be developed?

-- Financing is more problematic, because of the greater risk of the unknown than in more established industries. Neither country has financial institutions with the flexibility and depth for evaluating and responding to high technology investments. Also lacking are the legal standards and central banking institutions needed for overseeing and regulating advanced industry in international trade. When and to what extent should venture capital, equity share sales, and other "unorthodox" financing be sought for corporate expansion?

-- Consumer response is less predictable when production is technology driven; customers may not be willing to invest in a high-priced system that may soon be obsolete. Domestic markets in Korea and Taiwan are slow in forming, and their firms must compete in alien markets and encounter additional hazards in forecasting markets for their products. Should domestic markets be promoted and the technological problems connected with Chinese and Korean language usage be given a higher priority?

-- The computer industry is highly sensitive to the business cycle. A modest change in business conditions often leads to more-than-proportionate shifts in demand. The 1985 downturn in the U.S. injured firms in Korea and Taiwan when they were most vulnerable, at a time of active

buildup when they were seeking to establish a first position in a new industry. Is market diversification a feasible strategy? Should marketing and product development be shifted from U.S. to European and other high-income markets? Can sensitivity to cyclical change be diminished by moving into final product distribution?

-- Open economies with unimpeded flows of information, goods, and technology are conducive to efficient production in high tech industries. Korea and Taiwan are more open than other Third World nations. Nevertheless, they have obstructions that were suitable when infant industries needed shielding against foreign competition, but now are a hindrance to advanced industry. How can an East Asian corporation make use of its inherent advantages and remain competitive when domestic markets are opened up to outside suppliers? Is computerization a cost-effective way to raise competitiveness against more efficient foreign suppliers in high tech service industries?

-- Managing high tech calls for a different array of talents than in conventional industry. Until Korean and Taiwanese firms acquire more experience in production that is oriented toward research and development and innovative technologies, they will be disadvantaged in international competition. What is the most expeditious way to build up the right combination of technological expertise and instill in upper executives a sense of calculated use of the computerized technologies? How can scarce high tech talents be procured with the minimum investment in unproductive training? How much useful investment should be made in long-term professional expert requirements?

These are formidable problems. They arise out of institutional situations that are likely to change slowly. Thus, the problems are a challenge that corporate management has to face within bounds of what is possible. So far producers in Korea and Taiwan have taken conservative paths, sticking closely to what they know and do best.

The best money earners have been in expanding output of parts and components. Some manufacturers are assembling and marketing micro-computers and other devices; they rely on this source of income only marginally, though it may be their most rapidly growing operation. Brand name marketing a major objective for several companies. They are not yet ready to do it on a large scale. Although some are retailing at home, large-scale direct marketing abroad is not likely in the mid-1980s.

Their most competitive production is under sales contracts with foreign companies who use the parts, components, and finished goods for marketing under their own label. The Taiwanese and Korean manufacturers have highly competent strengths in managing production of accepted technology, where the risks of using unproven processes or products are minimal. Their managerial staffs and corporate officers have limited experience in assessing either complex intercorporate demand or foreign marketing.

By concentrating on production objectives, their management can compete internationally. By extending production judiciously to include more and more in-house parts, rather than imported, they can improve technological competence on the production line and in the managerial office. The trick is to match corporate competence with advancing

technology. By inching ahead on advancing technology and moving more briskly on commercial technology, Korean and Taiwanese manufacturers can keep production moving ahead or can redirect it when necessary or profitable, without having to go far out on a limb with untested innovations.

The probabilities of success are the greater because the technological strengths of manufacturers in Korea and Taiwan are conducive to this commercially oriented strategy. These strengths lie in, first, R&D intelligence systems that yield valuable information about what is going on in the high tech world; second, technology transfer from licensing and contractual agreements for production or assembly of specified products; and third, in-house engineering that researches the technical details of intelligence collections and known technology trends.

The information collection units that several firms have set up in the U.S. are integrated into commercially effective R&D systems. They could be strengthened and extended, for the corporate intelligence units are critical to future viability. Combined with official resources, such as those in III and ERSO in Taiwan, and in KAIST agencies in Korea, as well as growing corporate R&D, these firms are able to come up with the production technologies needed for application in their factories and laboratories.

Several companies have capable engineering and management staffs. At present none has sufficient depth to tackle intensively innovative concepts. They must rely on what they observe and learn from the experiences of others. By restricting engineering development work to commercially defined parameters, they are able to focus on finding cost-

effective processes most suitable for their own managerial and production assets.

These principles of high tech management work effectively in manufacturing for a producer's offshore market, where customers are looking for competitively priced components and parts that meet well-defined technical specifications.

Different managerial principles are involved when producing for an international consumer's market. To be competitive, retailing, customer service, and other distribution skills are as important as manufacturing. Providing software and networking services are other additional managerial requirements for exporting high tech finished products. The Korean and Taiwanese companies are rightly staying away from a premature assault on these forms of computer production.

It will probably not be long before the more adventurous begin to market directly in the U.S. and other advanced countries, for it is clearly their intention. Tatung of Taiwan has been marketing its consumer electronic products since the early '80s, and two Korean conglomerates, Samsung and Hyundai, have opened distribution units in North America for consumer electronics and automobiles. This approach is likely to grow, for the production economies enable these companies to prosper in the lower end of the market. While computer selling involves industry-specific talents, the experience gained in other less sophisticated technologies is transferable. Furthermore, many Taiwanese and Korean manufacturers are already selling their microcomputers in other parts of Asia. It is only a matter of time before direct

distribution begins in advanced markets. But first, several kinks in technology and production have to be ironed out.

Internally designed computers are likely to become increasingly popular in both countries as R&D units attain greater proficiency. The technical quality of the designs is improving, narrowing the technology gap between foreign and local designs. As operating systems become standardized, computers with original Chinese and Korean character operating systems are likely to become available by the end of this decade. Software designers are likely to become more proficient in preparing software in Korean and Chinese for locally made computers. Sales prospects in Mainland China and other Asian areas are especially promising.

Official projections of exports for the 1980s indicate that the two countries expect to supply as much as 5% of the world market by the end of the decade, compared to under 2% in 1985. Their expectations are founded on fragmentary statistics that cover a brief period of time. Thus, the projections may be overoptimistic, and production may not rise so rapidly.

Nevertheless, these projections should be taken seriously. The computer industry in Korea and Taiwan is virtually certain to have a substantial impact on competitors in other countries. While world demand for computer products may increase at a respectable 10 to 15% rate, the average yearly production growth of 30 to 50% that Taiwan and Korea expect would likely have a pronounced effect on others. The competition may be healthy; it may provide benefits for consumers in

advanced nations as well as for producers in Korea and Taiwan. But it is also a source of potential trouble.

Indeed, familiar trade disputes over exports of electronics, textiles, shoes, and steel could come up again over semiconductors, microcomputers, printers, monitors, disk drives, and terminals. Differences have already erupted regarding copyrights, technology pirating, patent infringements, and trademarks. It has been possible to deal with these questions without serious ruptures in trade relations -- but not to end them. They surfaced, however, when Korea and Taiwan were producing less than $100 million a year in computer products, and damage could be calculated in terms of a few thousand dollars in small domestic markets and occasional exported products. Unless effective action is taken, they are likely to arise more frequently and could be less easily resolved when Taiwan and Korea are exporting $10 billion or more a year.

2. Software

Despite a great amount of official attention, software deficiencies seem to be slowing computerization in both Taiwan and Korea. The lag could retard long-term growth in computer usage in business and industry. Few technological advances could pay as high dividends in national development as a strong surge of high quality software output. Yet production, especially applications software, looks unprofitable and output is not forthcoming. There appears to be a gap between official declarations for making it a big export earner and the prospects of exporting at a profit.

The commonly accepted cause of a lagging software sector is the late beginning for this important industry. Training of engineers and

other technicians was once neglected as the more evident needs of hardware professionals were given higher priority. The old habit of thinking in terms of export-led economic advancement overshadowed other considerations. As a result, first priority went to hardware with a ready market and lower priority to software that had to make its own market.

But the prospect of a software bottleneck has been recognized since the early '80s. Training efforts have turned toward correcting it. Why then, isn't there greater evidence of a response in the supply of software?

One major hindrance to software production is the difficulty in obtaining financing. The absence of a venture capital market inhibits small and medium firms that often are innovators of application software. Producers in both countries are frequently under-capitalized, unable to finance anything that does not produce revenue immediately. Larger, better financed companies are usually computer manufacturers who are more interested in developing embedded than application software.

A key factor in discouraging software financing is the problem of making it exportable. This is a formidable difficulty. Few of the software designers in Korea or Taiwan are proficient in English. They work best in their native language, and their work must usually be translated to be exportable.

Translating Chinese or Korean programs, as well as recasting the culturally embedded premises, is likely to be as trouble laden as using translations of English language software. Preparing the explanatory manuals is equally problematic. And there are no software procurement

agencies in Taiwan and Korea, as there are for components and auxiliary equipment.

Software is not an industry that lends itself easily to the export-leading strategy. Japan has not been able to open markets in exporting software as it has in selling equipment. And Singapore is resetting its target dates for becoming a center for Southeast Asia.

If profits are to be made from exporting, they will be earned only after substantial investment for programming, for language and cultural transliteration, and for distribution and marketing in a foreign environment. Although the prospects might be better in East Asia, near-term projections for the U.S. and Europe look dim.

These considerations suggest a somewhat unpromising outlook for profit making in the software industry. Seen from this perspective, conservative corporate strategies are more understandable. Production companies devote their energies to embedded software needed for finished computers to be saleable, and to a lesser extent to Chinese or Korean or Chinese language products.

There is no easy answer to this dilemma: Domestic software may be essential for a breakthrough in computerization; production is flagging because the prospect of profit looks unpromising. How to break out of a dilemma that is slowing domestic use of computers?

De-emphasizing export objectives in software development might make things move faster. Concentrating on Korean and Chinese software for domestic employment might overcome some of the present inhibitions on effective and widespread usage. Proven local-language software might be the fastest route to exports.

A second step would make financing more accessible to small and medium firms in software production, including those specializing in the needs of specific industries, and in narrow areas of business or commerce. The venture capital markets that are still in a birthing stage might answer these financing needs, which might be yet another reason for pressing ahead on setting up these new institutions.

A third step would strengthen legal protections against copying of software, so that domestic producers would get the benefits of their labor. The 1985 amendments to copyright law in Taiwan provide important additional protections for software production. They refer specifically to computer programs as covered by the law. This is a step in the right direction, provided it is followed up by effective enforcement and, perhaps, further strengthening as loopholes become evident. Growing acceptance of a standard operation system in computer manufacture is both a desirable trend away from pirating and an essential foundation for a healthy domestic software industry.

Another action would encourage joint ventures between domestic firms and foreign software producers. Foreign firms would provide technical knowledge that domestic engineers could use for producing applications software in the Korean and Chinese languages. (Joint efforts usually involve large local corporations trying to strengthen computer production and software in the English language.) Other joint ventures might be valuable not only between foreign software firms and Korean or Taiwanese industrial firms, but also between smaller foreign and domestic software firms. Joint ventures could help solve the software dilemma of Taiwan and Korea.

3. Information Trade Restraints

A number of barriers have arisen in the information trade of Korea and Taiwan. They have a modest price tag compared to the overall trade. But the U.S. is the major partner in the trade, which means that the restrictions affect American exports more than others. What counts most is their symbolic importance: They are levied on goods and services where the U.S. has recognized economic advantages, and they look like a protectionist beginning for information trade.

Three specific areas where restrictions currently apply are financial information flows, operations of value-added networks, and imports of microcomputers and products.

Restrictions on financial information flows are primarily the result of banking and monetary institutions that have not yet been modernized enough to keep up with financial requirements of rapidly advancing economies or with financial information technology.

The banking and financial systems of Korea and Taiwan have been greatly revamped since the 1950s, reforms that have contributed much to growth in production and trade. But computerization of the international banking systems is placing new regulatory demands on the system. Past revisions in banking and investment regulations have exposed many parts of the structure to foreign competition and influence. High tech magnifies the exposure dramatically.

Both governments are progressively liberalizing their financial systems. Korea, for instance, has turned its major government-owned banks over to private owners and has made significant changes that partially open up its equity market to foreign investors. While moving

in principle toward internationalization, they have retained in practice numerous obsolete regulations, probably to serve as safeguards against changing too rapidly.

Many of the financial regulations impede trade in financial information or the flow of information for finance. Here are several restraints, including some vestigial rules from earlier liberalizing steps:

-- Foreign banks are not accorded national treatment by either nation.

-- The contents of all computer tapes entering each country are subject to inspection by customs agents.

-- Imports of data processing equipment are contingent on getting approval of several agencies, one or more of which often say "no."

-- All international telecommunications circuits are monitored.

-- Rigid limitations are levied on setting up branches of foreign banks. In Taiwan, only one office, in one location, is permitted.

-- There is excessive red tape in opening foreign bank offices.

-- Issuance of credit cards is prohibited, and no foreign banks are approved in Taiwan for issuing debit cards.

-- Both countries enforce rigid limitations and restrictions on foreign exchange transactions.

-- "Automatic" approval of import licenses in Korea requires a month to six weeks before it is given, slowing the flow of commercial paper to a trickle.

-- All information technology imports into Korea are licensed. Although 85% of product classifications are "automatically" approved, they are still subject to license.

These are regarded by government and business in the U.S. more as unnecessary impediments than as limitations on doing business in Korea and Taiwan. Indeed, one U.S. company official considered some of the restrictions as "necessary" in a transitional phase. They could become burdensome, however, if they continue and retard the spread both of improved banking technology and of more advanced financial practices.

Value-added networks (VANs) are not permitted for foreign firms in either Korea or Taiwan. Mitigating circumstances (for example, the recent establishment of data communications systems) account in part for the current restrictions on foreign-owned VANs. The basis of regulation differs in the two countries, but both countries have VAN barriers.

The Korean law concerning the Data Communications Corporation (DACOM) provides for privately operated VANs. DACOM itself is still getting its operations in order and did not consider the facilities available as suitable for VANs in 1984-1985. Communications authorities have not yet determined the need for them, although they are expecting to set up several types of special networks. Neither have the regulations governing VANs been adopted. It is not clear whether foreign owned VANs will eventually be permitted.

Taiwan's data communications plans provide for special networks run by the Data Communications Institute and other official bodies. Some of the special networks are already operating, although there are no

private VANs. It is unclear whether private or foreign-owned VANs will be acceptable.

Like the question of financial information trade, the VAN issue is not a pressing matter for American service suppliers. As the market for international data services expands in Korea and Taiwan, the prospect for U.S. firms offering VAN services directly is likely to improve, and their desire to operate VAN services may become more urgent.

Whenever other nations have denied access to data markets, the issue has become heated. The restrictive conditions imposed by the Japanese, for instance, led to several retaliatory bills in the U.S. Congress. Although access to data markets in Taiwan and Korea seems unlikely to create as much difficulty as in Japan, it could become a serious matter unless attended to by both sides.

Korean restrictions on imports of computers and products could become a damaging mark on U.S.-Korean trade relations. They are the result of the Decree of 1982 giving priority to foreign suppliers of large computers that obtain components in Korea, and banning imports of all small computers, printers, disks, and terminals. The decree is intended to exclude products that Korea also manufactures and to restrict domestic sales of these computers to Korean firms. Since U.S. and Japanese products are the principal imports involved, the regulation is regarded as against American and Japanese goods.

The principal cost of the prohibition is borne by Korean users and some American and Japanese computer and component suppliers. A set of losers are the U.S. microcomputer makers that are not involved in production in Korea. In the absence of barriers, they would be

distributing their goods and services in the country. But they are barred from selling in a profitable and growing market.

More substantial are the losses of Korean users who can buy neither the computer products of non-licensors, nor other non-licensed models and accessories of licensors. The restrictions raise prices and lower product quality, as a result of which users learn less rapidly and are less efficient in their usage. Such limitations on product selection could seriously deter the most effective use of the microcomputer by business and industry. Growth of Korea's computer market could be inhibited by a permanently limited selection of products. Korean advancement in computer technology could be seriously inhibited where it hurts most, in slowing down and misdirecting the application of the computer in commerce and finance.

The World Bank, in a similar circumstance in 1980, warned about using this type of import control on advanced products, which could "compromise the international competitiveness of Korea's exports."[2]

They emphasized difficulties in simultaneously controlling imports and maintaining prices in a desired relation to world markets. The Bank also suggested that a denial of imports could lead to wrong choices that would increase production costs or reduce quality in economic sectors other than the one protected. They cautioned about the adverse effects of limiting options when the differences between items of equipment can be properly judged only by the user.[3]

The gainers are the Korean manufacturers who sell on their own label, some local makers of parts and components, and the American licensors. Ironically, the restriction's impact on dollars lost and

gained may be minimal. Many of the computers and other products sold locally are manufactured under a U.S. license or by U.S. Korean joint ventures. Except for the label the product might resemble an American import. Thus, the American licensor is likely to come out about as well as he would if selling directly -- perhaps better if the license fee exceeds his normal profit margin. Indeed, local producers fear that the IBM venture (see Chapter 3) will take a big part of the local market for PCs.[4]

There is an additional important risk to Korea, if it continues these restrictions: This regulation is highly susceptible to interpretation as a symbol of a closed economy and of a denial of reciprocal access to markets. Regulating the import of what is commonly regarded in the U.S. as its most exportable product presents an inviting target. American protectionists looking for an opportunity to deny Korean access to American markets could easily, if incorrectly, portray the closure of Korea's computer markets to U.S. manufactured products as a violation of equitable standards of market access.

High Tech Policy in the Asia Pacific Community

The interdependence of high technology is bringing Taiwan and Korea an escalating array of international issues that are as new to the rest of the Asia Pacific region as to them. These issues form a comprehensive agenda, ranging from the production decisions that Asian manufacturers and software producers must make, to the adjustment problems the more advanced countries must solve.

The expanding scope of interdependency suggests an agenda that will continue proliferating. As output swells and covers an ever-widening

spectrum of technology, investment, and trade, the prospect for international dispute will grow also.

The U.S. has many reasons for avoiding such problems. For many years it has had hospitable political ties to Korea and Taiwan; many of their people have become American citizens. It seeks economic relations that reinforce its security obligations to both countries, not jeopardize them by discord or economic dislocations. The U.S. also has seen Korea and Taiwan as Asian champions of private-sector development and as collaborators in creating institutions for fair international competition.

In addition, the computerization of Korea and Taiwan presents many economic advantages for the Americans. Growing technological competence of their manufacturers provides low-cost supplies of the components and supplies that American companies need. The result is products made at minimal total cost. Both countries, moreover, are developing new consumers and creating new markets for computer and telecommunications systems that will probably require U.S. technology and services in growing volume. The American joint ventures and other investments in telecommunications and computer production export directly from Korea and Taiwan to other parts of East Asia, thereby functioning as offshore units for indirect marketing of American technology.

A major reason why the U.S. benefits from trading and investing in East Asia is the high growth rates of these nations. During the past decade when overall U.S. exports were growing 6 to 7% a year, exports to Korea were rising an average of 23% and to Taiwan by 29% a year. From less than 1% of U.S. exports in 1970, the two countries now take about

5% of American export trade. In an era of sluggish advanced economies, the vitality of the East Asians is a counterbalance to the less lively growth in other countries. Even if Korea and Taiwan are unable to keep up the 9 to 10% habits of the 1970s, they are likely to continue as important economic stimulation to the U.S.

If the free enterprise systems in Korea and Taiwan attract U.S. investment and trade, they are also the source of perplexing issues. They now have much greater potential for market disruption in foreign markets. Yet most economic disputes with the two countries are oriented around differing perceptions of how the private enterprise system should operate. A common U.S. view is that governments in Korea and Taiwan give too much guidance and direct support to their private sectors. Korea and Taiwan, like Japan and a growing number of East Asian nations, follow economic policies that provide for substantial interventions in support of their private companies. This is often seen in American eyes as regulatory actions that give unfair treatment to the U.S. and other outsiders, or in subsidies that give Taiwan and Korean exporters an unfair advantage in international markets.

Popular opinion in the U.S. is that many exports of Korea and Taiwan are subsidized by official industrialization schemes. A recent congressional investigation of trade with Korea alleged that "government involvement in 'targeting' schemes designed to protect favored industries in the home market while preparing that industry to make substantial inroads in other, more open markets." These policies, the report concluded, would require "monitoring of and rapid response to targeting practices."[5]

The chairman of the U.S. Chamber of Commerce also described the American perception of East Asian intervention:

> A ministry of trade targets a certain sector for growth. Next, the infant industry is fed on a government diet of outright subsidies, import relief, tax breaks, easy credit terms, and research grants. Then, the government protects the new industry with a host of non-tariff barriers to insulate the business from overseas competition.[6]

Americans tend to view their own system as fairly neutral, providing limited funds for R&D, but not favoring one industry or one firm over another. The chairman of the Chamber articulated this attitude when he agreed the U.S. has "its share of protected industries" but claimed "the U.S. market remains the most open in the world."[7]

A sizable conception gap exists between these U.S. views and those in East Asia. And it is getting wider. A Korean cabinet member recently expressed a view that is heard increasingly in Asia: "Protectionist sentiment in America is stimulated by misperceptions of Korea as a 'closed' market." Korea, he claims, is "not another Japan." Whenever trade and investment barriers exist, he concluded, they usually reflect delays in modernizing that are "unavoidable and should be better understood in Washington."[8]

Heard with increasing frequency in Taipei and Seoul are such comments as, "Give us time." "We are doing the best we can." "Show more understanding for the circumstances we are in."

American complaints about subsidies for new industries, it is charged, are not only invalid. To the contrary, business executives in Seoul and Taipei say, the U.S. itself is protecting old high cost producers; according to one analyst, they believe that "non-tariff

barriers in the U.S. have been created to protect declining industries that are no longer competitive."[9]

Allegations that Korea and Taiwan subsidize high tech are brushed off by comparing rather modest support for investments and research and development with the billions the U.S. has poured into NASA and the Pentagon. Korea and Taiwan may give instructions to the "invisible hand," but they believe that the U.S. guides it also, often in powerful ways that no other nation can match.

There is a clear and pending danger in these widely differing perceptions. A perfect correlation may be inconceivable, and is probably undesirable. But the gap between conflicting perceptions of how the private sector should be dealt with is excessive and makes it even more difficult to compromise on real differences in economic objectives.

A level playing field is a fair criterion for international trade, but it is necessary to see eye to eye on what a level field looks like. How should the subsidies of history be compared with the subsidies of today? Should support for declining industries be matched against support for rising ones? When does an inability to modernize become an excuse for not defending intellectual property rights, and a demand for those rights become an excuse for punishing competitors?

High tech questions can be usefully discussed through bilateral channels. But most of the issues reach beyond bilateral parameters; the liberal principles that the U.S. is advocating for Korea and Taiwan are those of interdependence and multilateralism. Moreover, many of the bilateral differences are shared with other nations, if on a lesser scale; resolved bilaterally, the result might well be a simple transfer

of the problem to others. Although specific issues may be cropping up in a bilateral context, they may in fact be more susceptible to multilateral resolution.

Two proposals for the international framework that some in the U.S. have championed for many years are relevant. Although suggested in regard to other issues, these proposals bear directly on the growth of high technology industries in East Asia. They deserve careful consideration despite their political complexities, especially in the case of Taiwan.

The first would provide partial affiliation in the Organization for Economic Cooperation and Development (OECD) for countries like Korea and Taiwan. This would enable them to assume at least some of the rights and responsibilities of the more advanced members of this organization. The two countries would have a more active role in world economic decisions, and the U.S. and other advanced nations would have a forum in which to iron out facts, attitudes, and practices on a wide range of economic issues in East Asia.

The second would involve closer coordination in preparing for the new round of negotiations in the General Agreement on Tariffs and Trade (GATT) on rules on trade, including trade in invisibles, telecommunications, and other services. The proposed round, as tentatively agreed to during 1985 GATT meetings, may not lead to a final agreement on liberalized rules for many years. In the interim, however, negotiations and consultations that involve Korea and Taiwan could have a significant impact on high technology trade practices of these dynamic nations.

Political complexities are an obvious obstacle, especially the political isolation of Taiwan. These need to be dealt with persistently until -- without upsetting international decorum -- they are gradually overcome. It is essential to bring industrialized East Asian countries into decision making on global economic issues. As Korea, Taiwan, and other East Asian economies computerize and increase high technology production and trade, increased access to the key forums of global consultation would be highly desirable.

The East Asian community differs in many ways from the Atlantic and is building its economic institutions in accordance with its own circumstances and values. There is no reason to expect those in one community to copy the other. There is every reason to advance in harmony with one another.

Orderly controversy in international forums is as essential in the development of unified, thriving private sectors in East Asia as in Europe and North America. The alternative is a computerized world that becomes increasingly embattled and falls far short of providing the economic benefits that are possible.

APPENDIX A

TEN YEAR DEVELOPMENT PLAN FOR THE INFORMATION INDUSTRY OF TAIWAN, ROC, 1980-89

The following is a summary of the strategies section in the document, "Ten Year Development Plan For The Information Industry of Taiwan, ROC, 1980-89."

1. Computer manufacturing. The Plan calls for government-wide support for development of minicomputer and microcomputer systems and for investment in manufacturing of components as well as final products. Thirteen specific "strategic" products are listed, such as fixed disk drives and Chinese word processors. Development of 16-bit and 32-bit microcomputers with appropriate software is set forth as a major national project. Support is to include priority in allocating funds of development programs and in making financing loans. Strategic products are also to be given priority in administering official investment undertakings, especially at the Science Based Industrial Park in Hsinchu.

2. Information processing. The Plan asks for government support in the development of software and data processing standards and specifications. It stresses the need for promoting methodologies and capabilities for software systems for private business requirements and applications. It establishes this effort as a national project. The Plan calls for a service center for disseminating technology and marketing information on software systems and for publicizing the use of

software applications. It also emphasizes the pressing need for working with professional groups on legal issues concerning data rights and software protections.

3. Manpower, education, and training. The Plan calls for a long-range program for manpower development that meets the needs of the country both in the information industry and in its many application areas. It also asks for greater emphasis on computer usage at all levels of the education system, including a nationwide network of educational computers. It calls for a national project to turn out more persons with advanced education that combines information and management. It recommends setting up local centers for on-the-job training of middle and upper level industrial personnel. It recommends a formal examination system that would both establish and upgrade professional standards.

4. Technology. The Plan's most emphatic directives concern the improvement of technological capabilities through (a) R&D work in Taiwan and (b) transferring technology from abroad:

-- Intensification of R&D in computer systems and computer-communications, and in MIS, CAD/CAM, and their application.

-- Establishment of a comprehensive R&D system that brings together university, private industry, and official research resources.

-- Assistance to private industry in acquiring the latest technologies from the advanced nations.

5. Applications in the public sector. The Plan states that government operations can improve efficiency by computerizing. It calls

for specific programs for computer usage and for evaluating their impact and establishes a national project for computerizing government administration. It asks for upgrading data processing divisions in government organizations. It also proposes procurement of computer requirements from domestic firms.

6. Data communications. The Plan calls for speeding up the development of data transmission and computer networks. It asks for expedited construction of the public data communication networks and for opening up of regional dial-up data transmission. It calls for strengthening ties with international networks and for easing of regulations on service charges and on registration of end-user equipment.

7. Financial and tax support. The Plan calls for tax and financial measures that will provide attractive incentives for potential investors. Among these are (a) including strategic information industry products under the "Statutes For Encouragement of Investment," (b) reducing tariff rates on computer equipment, parts, and components, and rationalizing import duties on software, and (c) making software eligible for bank finance. The Plan also calls for easier access to financing for firms in the information industry, especially for the small startup companies and software providers.

APPENDIX B

NOTES

Chapter 1. The Computerization of Korea and Taiwan

1.1 Adam Smith, The Wealth of Nations. New York: The Modern Library, 1937, p. 423.

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2.4 See note 2.2.

2.5 See notes 2.2 and 2.3.

2.6 Data and background on U.S. aid to Taiwan are from Neil H. Jacoby, U.S. Aid To Taiwan. New York: Praeger, 1946; also see Edward S. Mason, et al. (see note 2.3),. Data on Korea are from South Korea Country Study (see note 2.3).

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2.9 Ibid.

2.10 Yang Whee Rhee, Bruce Ross-Larson, and Garry Pursell, Korea's Competitive Edge. Baltimore: Johns Hopkins University Press, 1984, pp. 44-45; also see note 2.8.

2.11 See note 2.2.

2.12 Larry E. Westphal, Yang Whee Rhee, Linsu Kim, and Alice Amsden, Capital Goods And Related Services From The Republic Of Korea. World Bank Staff Working Paper, No. 629. Washington D.C.: World Bank, 1984.

2.13 Miyohei Shinohara, Toru Yanagihara, and Kwang Suk Kim, The Japanese And Korean Experiences In Managing Development. World Bank Staff Working Paper, No. 574. Washington D.C.: World Bank, 1983, pp. 43-75.

2.14 World Bank, World Development Report, 1984. Washington D.C.: World Bank, 1985, pp. 220-221; also see notes 1.2 and 1.3.

2.15 Republic of Korea, Korea Economic Institute, Government-Business Relations and Korean Growth. Seoul: Korea Economic Institute, April 1983.

2.16 Larry E. Westphal, Yung W. Rhee, and Garry Pursell, Korean Industrial Competence: Where It Came From. World Bank Staff Working Paper, No. 469. Washington D.C.: World Bank, July 1981.

2.17 Japan's strategy has been described in: Japan, Ministry of International Trade and Industry (MITI), Japan's Industrial Structure: A Long Range Vision. Tokyo: Ministry of International Trade and Industry, 1975.

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