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KNOWLEDGE-BASED INDUSTRIES IN ASIA

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Knowledge-based Industries in Asia

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FOREWORD

Following a Forum discussion by the OECD Industry Committee, the Directorate for Science, Technology and Industry (DSTI) published a report in 1999 entitled *Asia and the Global Crisis: The Industrial Dimension*. This study pointed to key structural weaknesses in the development of knowledge-based industries, especially those based on information and communications technologies, in the Asian industrialising countries. The present study – which covers Korea, Singapore, Chinese Taipei, Malaysia, Thailand and China – goes one step further in examining the status of technology-intensive sectors in Asia and highlighting issues important to their continued development. While Asian countries have made considerable progress in developing knowledge-based industries, they are still faced with a number of major challenges. The study considers four key areas: improving information infrastructure; investing in education and carrying out educational reform; strengthening core innovation capacities; and benefiting from foreign direct investment.

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CURRENCY CODES

Country	Currency	ISO code	National currency per USD (July 1999)
China	Yuan	CNY	8.28
Korea	Won	KRW	1 172
Malaysia	Ringgit	MYR	3.80
Singapore	Singapore dollar(s)	SGD	1.70
Chinese Taipei	New Taiwan dollar(s)	TWD	32.3
Thailand	Baht	THB	36.9
United States	US dollar(s)	USD	–

Source: The Economist, 10 July 1999.

SUMMARY

Many Asian economies – including Korea, Singapore, Chinese Taipei, Malaysia, Thailand and China – have weathered the financial crisis of 1997-98 only to face the challenge of developing into knowledge-based economies in order to remain competitive. Advanced OECD countries are well on their way to developing knowledge-based industries which are intensive in technology and human capital. Asian countries have made progress in developing sectors based on information and communication technologies (ICT), including semiconductors, computers, electronics and communications equipment and services. Other sectors now receiving attention include aerospace, biotechnology and environmental equipment and services. Apart from China, these countries have formulated far-reaching strategic plans for becoming cyber societies, including *Cyber Korea 21 Vision*, *Vision 2020* in Malaysia, *IT2000* in Singapore, the *Plan to Develop a Knowledge-based Economy* in Chinese Taipei, and *Thailand IT2000*.

However, these visions, which feature top-down government development strategies, may be partly unrealistic since the Asian economies continue to have structural weaknesses as revealed by the financial crisis. Deficiencies include an overemphasis on manufacturing and large firms to the detriment of services and smaller enterprises; inadequate investment in education and innovation capabilities; and changing competitive advantages due to rising labour costs which have led to a decline in foreign direct investment. Korea, Singapore and Chinese Taipei have well-developed ICT sectors but further advances depend on local sourcing of components and technology and better protection of intellectual property rights. In countries such as Malaysia and Thailand, ICT industries are less developed and still suffer from a lack of information infrastructure and qualified human capital. Low-end labour-intensive electronics dominate in China, which may take another 10-20 years to catch up to the industrialised countries.

Because these countries are at different levels of economic development and vary in their strengths and weaknesses, the policy reforms warranted also differ. In general, all need to upgrade their information infrastructure, invest in education, improve innovation capabilities, and enhance conditions for gaining

from foreign investment. China should develop its labour-intensive sectors in conjunction with high-technology industries and improve its diffusion of technology and know-how. The other countries are moving to advanced ICT sectors but need to liberalise their telecommunications markets, foster creative thinking and individualism in education, and move away from government-led growth strategies to stimulating private sector R&D investments and innovation.

INTRODUCTION

As the advanced OECD countries enter into a new era of knowledge-based economies, the question arises as to how well the Asian economies are doing in developing their knowledge-based industries. And, more broadly, how have Asian countries adjusted their policies in response to the challenge of the knowledge-based economy? In the 1970s and 1980s, Asian newly industrialising economies caught the world's eye for their achievements in rapid industrialisation and economic growth. In the 1990s, Asian countries impressed – and puzzled – many people by making major strides into some high-technology industries, notably those based on information and communication technologies (ICT), including semiconductors, computers, electronic equipment and communications equipment and services.

However, since the late 1990s, the Asian financial crisis that occurred between 1997-98 has posed doubts about the actual strengths and potential of the Asian economies (OECD, 1999a). The Asian crisis revealed severe structural weaknesses in these countries, including industrial over-capacity due to excessive investment in manufacturing, lack of domestic technological capabilities, and inadequate policy emphasis on the development of small and medium-sized enterprises (SMEs). Importantly, these failures run counter to what is deemed crucial to developing knowledge-based economies, which are defined by their emphasis on both technology and human knowledge. In many countries, these two factors are taking on greater importance (particularly in terms of value added) than more traditional production factors such as natural resources, physical capital and low-skilled labour.

This study examines the development of knowledge-based industries in Asian economies and discusses key policy issues. Countries considered include Korea, Singapore, Chinese Taipei, Malaysia, Thailand and China. First, the overall visions and strategic plans of these Asian countries for their transition to a knowledge-based economy are reviewed. The study then investigates the development and, to the extent possible, reflects on short- to medium-term prospects of key knowledge-based industries in Asia. Knowledge-based industries are those which are relatively intensive in their inputs of technology and human capital (OECD, 1999c). These include aerospace, chemicals/biotechnology, ICT equipment and services, consumer electronics and the environment industry. These are the industrial sectors reviewed in this study; however, it should be noted that industry definitions and classifications vary widely by country and therefore do not allow for comparative quantitative evaluation.

The underlying conditions required for further development of these sectors are assessed, including in terms of national information infrastructure, education, innovation and foreign investment. Finally, the study summarises key policy issues facing different groups of Asian economies in the continued development of their knowledge-based industries.

FORMULATING NATIONAL STRATEGIES

Asian countries are at different stages of their transitions to knowledge-based economies due to differing levels of economic development and capabilities for producing and using ICT. In part, this reflects the fact that the Asian countries have different visions of how to develop knowledge-based economies as well as varying governmental traditions and styles. They thus emphasise different aspects of the transformation into knowledge-based economies. At a deeper level, their approaches reflect differences in the social institutions, cultural values and capabilities that underpin the political and economic systems of individual Asian societies. They all tend to be top-down approaches, raising concerns about excessive government intervention. These factors have a strong influence on the abilities of various Asian countries to manage the challenge of developing knowledge-intensive industries.

Korea

The Korean Government's vision of a future knowledge-based society emphasises that it will be a creative nation, with competitiveness and living standards at the level of advanced OECD countries. Work on the first draft of the *Cyber Korea 21 Vision* began in March 1997, building on the Master Plan for information promotion (1996-2000) and was further developed in June 1998 under Section 5 of the "Framework Act on Information Production". It comprises three parts: *i)* the vision of a creative, knowledge-based society; *ii)* key initiatives of *Cyber Korea 21*; and *iii)* promotion strategies. The quantitative targets to be achieved by 2002 are shown in Table 1. The basic objectives of the *Cyber Korea 21 Vision* are set out as follows:

- Early establishment of an information infrastructure.
- Increasing productivity and transparency of all economic players, including business, government and individuals, through the utilisation of advanced ICT.
- Promoting new businesses and creating new jobs through the utilisation of ICT.

- Designating competitive telecommunications products and services as key export products.

A number of initiatives will make qualitative improvements in the social, economic and welfare aspects of Korean society based on government leadership and massive public investment. For the implementation of the *Cyber Korea 21 Vision*, the Korean Government will concentrate resources between 1998-2002 on three key areas: *i)* information infrastructure; *ii)* wiring government, business and individuals; and *iii)* reinforcing growth in the software and information provider industries. The government will also promote private sector participation in the implementation of the *Cyber Korea 21 Vision* through incorporating market principles and in a manner consistent with Korea's World Trade Organisation (WTO) obligations.

Table 1. **Quantitative targets of *Cyber Korea 21 Vision* to 2002**

	1998	**2002**
Network service speed	33.6 Kbps	2 Mbps
Number of Internet users	3 million	Over 10 million
Number of schools connected to the Internet	1 613	10 400
Number of institutions using digitised public procurement	556	26 000
Market volume of e-commerce	KRW 55 billion	KRW 3.8 trillion
Number of local administrations with electronic information system	4	232
Total number of PCs (number of PCs per 100 persons)	6.63 million (14)	15 million (32)
Information & communications industry's: – Production value[1] – Export value[1]	 KRW 90 trillion USD 30.1 billion	 KRW 136 trillion USD 47.1 billion
World ranking in computerisation	22nd	Among the most advanced information societies

1. Forecasts by the Korea Information Society Development Institute, December 1998.
Source: Korean Ministry of Information and Communication (1999).

Singapore

Singapore is following its *Industry 21* blueprint for future industrial development which envisages that its knowledge-based economy will be driven by the twin engines of manufacturing and services. Development will be nurtured under key programmes for electronics, chemicals, life sciences, engineering, communications and media. Singapore also plans to develop high-value-added services in education, healthcare, logistics and headquarters for multinational corporations. A recent competitiveness report by the Committee on Singapore's Competitiveness (CSC) recommended a dual emphasis on manufacturing and services, strengthening exports, building world-class companies, strengthening local SMEs, developing human and intellectual capital, leveraging science, technology and innovation, optimising resource management, and enhancing government as a business facilitator (CSC, 1998). In the aftermath of the Asian financial crisis, the government introduced a SGD 10.5 billion cost-cutting package in 1999, corresponding to 7% of GDP, as a short-term strategy to strengthen the international competitiveness of industry. The package includes tax rebates and reductions in wage costs, land rental fees and electricity charges.

Singapore is well ahead of other Asian economies in becoming a knowledge-based economy based on its strategy *IT2000: A Vision of an Intelligent Island,* which states:

> *In our vision, some 15 years from now, Singapore, the Intelligent Island, will be among the first countries in the world with an advanced nation-wide information infrastructure. It will interconnect computers in virtually every home, office, school and factory. The computer will evolve into an information appliance, combining the functions of the telephone, the computer, the TV, and more. It will provide a wide range of communication means and access to services. The vision of the IT2000 is based on the far-reaching use of IT.*

This plan was formulated in August 1991 as a response by the National Computer Board to "The Next Lap", a master plan for development formulated by the Singapore Government. *IT2000* was based on a study of eleven economic sectors including: construction and real estate; education and training; financial services; government; healthcare; information technology industry; manufacturing; media and information services; retail and wholesale trade and distribution; tourism; and transportation. The study tapped the expertise of more than 200 senior executives from the public and private sectors to ascertain how information technology can be pervasively applied to improve business performance and quality of life. There are five aspects:

- *Developing a global hub* for Singapore to become a switching centre for goods, services, capital and information worldwide, and a hub for business, services and transportation.

- *Improving the quality of life* through a wide range of electronic applications in the economy, society and households.

- *Boosting the economic engine* by using ICT to revitalise Singapore's traditional economic sectors.

- *Linking communities locally and globally* to enhance communication between the Singaporean community at home and abroad and with the rest of the world.

- *Enhancing the potential of individuals* through government provision of improved opportunities and technologically advanced means for lifelong learning.

The action plan entitled *Singapore One* is a major milestone in the realisation of the *IT2000* vision focused on the creation of information infrastructure, including: *i)* a broadband infrastructure level of high-capacity networks and switches; and *ii)* advanced applications and services built on the technological advantages of the infrastructure. As for the development of knowledge-based activities, *Industry 21* is a blueprint for the development of electronics, chemicals, life sciences, engineering, education, healthcare, logistics, communications and media, as well as promoting Singapore-based multinational enterprises.

Chinese Taipei

The transition to a knowledge-based economy is well underway in Chinese Taipei, and the island has emerged as the third largest computer hardware producer in the world in recent years. Indeed, the share of technology-intensive industry in total manufacturing grew from 31% in 1991 to 40% in 1998, which was one reason why Chinese Taipei was better able to weather the economic impacts of the Asian crisis (Yue, 2000). Despite these developments, a fully fledged vision for the future of the island's economy was not formulated until September 2000. The *Plan to Develop a Knowledge-based Economy in Taiwan* (Chinese Taipei CEPD, 2000) summarises the government's strategy for developing Chinese Taipei into a "Green Silicon Island" which would combine a knowledge-based economy and a just society with a sustainable environment. Based on Chinese Taipei's advantages, the government's principal goals are to accelerate the commercialisation of new inventions and the creation of new markets by developing mechanisms to encourage innovation, foster start-ups, and promote the application of IT technology and the Internet; and to review basic infrastructure, laws and regulations, labour supply, and government administrative procedures, fine-tuning as necessary with a view to supporting the development of knowledge-intensive industries and narrowing the “digital divide”.

In addition, concrete measures are identified with timetables set for actions by government agencies in the short and medium term to set up mechanisms to encourage innovation and foster new ventures; expand the use of information technology and the Internet in production as well as in daily life; lay the groundwork for an environment supportive to Internet use; modify the educational system to meet personnel needs through appropriate training and import a sufficient pool of knowledge workers; establish a service-oriented government; and formulate precautionary measures against the social problems arising from the transformation of the economy.

The objective set out in the plan is for Chinese Taipei to reach a level of development as a knowledge-based economy comparable to the advanced countries within the next ten years. To achieve this objective, resource allocations are planned, and targets set, as follows:

- Raise R&D spending to 3% of GDP, with 30% of funds coming from the government and 70% from the private sector.

- Increase the production value of knowledge-intensive industries to at least 60% of GDP.

- Enhance the contribution of technological progress to account for at least 75% of economic growth.

- Boost government and private spending on education to at least 7% of GDP.

- Strengthen broadband network installation and reduce utilisation fees to a level similar to that of the United States.

Prior to the announcement of the development plan for a knowledge-based economy, related issues have been dealt with in Chinese Taipei’s long-term master plan for social and economic development, the *National Construction Plan over the Centuries* (1997-2006). As regards information infrastructure, a National Information Infrastructure Special Committee was set up under the Executive Yuan in 1994 to act as an interministerial co-ordinating agency in developing a national information infrastructure (NII). This covers ten areas –

all of which are now covered in the new development plan for a knowledge-based economy – with priority given to:

- Promoting use of the Internet to reach 3 million users by end-1999 (this goal has been successfully achieved).
- Connecting all senior high schools and vocational schools to the Internet by 2000, and all junior middle schools and primary schools by 2002.
- Making Chinese Taipei an Internet hub in the Asia-Pacific area through full liberalisation of the communications market, and linking it with all Asia-Pacific countries to attract international information service providers and major net users.
- Developing Chinese Taipei into an online "Global Chinese Content Centre" for Chinese cultural heritage.
- Fostering a multimedia industry combining computer, telecommunications and multimedia technologies as a pillar of the island's economy.

Malaysia

Malaysia is now implementing its second *Industrial Master Plan* (1996-2005); this will require a total investment in the manufacturing sector of MYR 250 billion, thus averaging MYR 25 billion per annum to 2006. It is based on a strategy of moving from assembly-based to value-chain-based manufacturing, from sector-based to cluster-based development and from performance targets to productivity-driven growth. The plan introduces two new strategies for industrial development: *i)* a *manufacturing plus-plus strategy*, which encourages Malaysian industry to move beyond assembly-based and low-value-added production to higher-value-added activities such as research, product design, distribution and marketing and to achieve productivity-driven growth through automation and measures that increase total factor productivity; and *ii)* a *cluster-based development strategy*, which emphasises the identification and development of key clusters to enhance value added and strengthen the economic foundations of Malaysian industry.

Box 1. **Malaysia's Multimedia Super Corridor**

On 1 November 1995, Prime Minister Dr. Mahathir Mohamad announced the establishment of the Multimedia Super Corridor (MSC), and in June 1996, the Multimedia Development Corporation (MDC) was set up to oversee its implementation. Geographically, the MSC is 15 km wide and 50 km long, stretching from Kuala Lumpur city centre to the New Kuala Lumpur International Airport in Sepang. Intended to deliver a number of sophisticated investment, business, research and lifestyle options, the ambition of the MSC is to become:

- A vehicle for attracting world-class hi-tech companies to Malaysia and for developing local industries.
- A multimedia utopia offering a productive, intelligent environment for producing a multimedia value chain of goods and services to be delivered across the globe.
- An island of excellence with multimedia-specific capabilities, technology, infrastructure, legislation, policies and systems for competitive advantage.
- A test-bed for invention, research and other ground-breaking multimedia developments.
- A global community living on the leading-edge of the information society.
- A world of smart homes, smart cities, smart schools, smart cards and smart partnerships.

The implementation of the MSC plan within a 20-year timeframe will be carried out in three phases:

Phase I: Initial conceptual and physical phase to attract a core group of world-class companies, launch seven flagship applications (these include Electronic government, National multipurpose card, Smart schools, Telemedicine, Borderless marketing centres, Worldwide manufacturing webs, and R&D clusters), put in place a framework of cyber laws, and establish Cyberjaya and Putrahaya as leading knowledge-based cities.

Phase II: The MSC will be linked to other cyber-cities in Malaysia and the world; a web of corridors will be created; a second cluster of world-class companies will be attracted to Malaysia; and Malaysia will set global standards for flagship applications.

Phase III: Malaysia will be transformed into a knowledge-based society as a global test-bed for new multimedia and IT applications and a cradle for multimedia companies; it will have a cluster of intelligent cities linked to the global information super highway, and become the platform for the international Cybercourt of Justice.

Source: Malaysia Multimedia Development Corporation (1999).

Other objectives of the plan are to further develop human resources, research and development, technology acquisition, absorptive capacity, physical infrastructure and business support services; to nurture Malaysian brand names and manufacturers; and to develop more information-intensive processes through adoption of ICT in manufacturing. The eight industry clusters to benefit are electrical goods and electronics; chemicals, including petrochemicals and pharmaceuticals; textiles and apparel; transportation, including automotive, motorcycles, marine and aerospace; materials, including polymers, metals, ceramics and composites; machinery and equipment; resource processing including wood, rubber, palm oil and oil palm; and agro-based and food products, including fish, livestock, fruits, etc.

Moreover, Malaysia has embarked on an ambitious plan to leapfrog into the information age in the context of its five-year development master plan. *Vision 2020* is a national agenda that sets out specific goals and objectives for long-term development calling for the country to grow into a fully developed, mature and knowledge-rich society by 2020. As a first step, Malaysia has created the Multimedia Super Corridor (MSC) which aims to bring together in an integrated way the elements and attributes necessary to create a global multimedia climate (Box 1).

Thailand

Thailand's vision of a knowledge-based economy is unique in emphasising the importance of addressing a wide range of social issues through the use of information technology (Box 2). It is contained in the 1995 plan on information technology development entitled *Towards Social Equity and Prosperity: Thailand IT Policy into the 21st Century*. The plan addresses the importance of correcting the imbalance in social and economic development between urban and rural areas through preferential provision of information infrastructure in rural Thailand. The issue of social equality is central, with greater emphasis given to human development than to the information technology industry itself. However, based on available evidence, it is difficult to judge the extent to which this plan has been carried out. The concept of the knowledge-based economy is still virtually unknown in Thailand.

To promote the information industry and the use of information technology as well as implement the national plan, Thailand set up the National Information Technology Committee (NITC). Through a host of new technologies including computers, data communications and electronic media, Thailand plans to build on information technology to achieve a well-educated population and improved quality of life; more effective rural development and wealth distribution; an improved environment and natural resource conservation; and new directions for building economic strength and social harmony. There are three action agendas:

- *Investing in information infrastructure* to empower human ability and enhance the quality of life.
- *Investing in people* to build a literate population and adequate ICT manpower.
- *Investing in good governance* to re-engineer the public sector and enhance government service.

Box 2. **Thailand's vision of social equality**

Thailand's information technology plan – *Thailand IT2000* – states:

> *Information technology can play a pivotal role, in particular to support many of the government's policies for better distribution of wealth and opportunities for rural inhabitants; for equal opportunity in personal and corporate development, healthcare and other public services; for solving the chronic traffic gridlock and worsening pollution; for conservation of the nation's natural resources and environment; in addition to making the country a regional hub for finance, manufacturing and trade, transportation and tourism.*

The government recognises that strategies for information technology development must be geared to reduce the substantial gap between the information "haves" and "have-nots", not to widen it. In most cases, it is easy for the more affluent and better-educated segments of society to gain most from the use of information technology while the city-poor and rural residents are likely to be left even further behind. The overriding objective is one whereby information technology applications in support of national development can create equal opportunity and provide benefits for all segments of society, including the underprivileged, the disabled and remote rural residents. Only then can national social and economic development be successful in transforming Thailand into the sustainable economic power-house of South-East Asia where a high standard of living is available to all in the Information Age.

Source: Thailand National Information Technology Committee (1995).

China

Apart from strategies for sectors such as science, education and telecommunications, China lacks a comprehensive vision for its transition to a knowledge-based economy. A strategy for revitalising the nation through science and education was framed in "The Decision on Speeding-up Scientific and Technological Progress" jointly issued by the Central Committee of the Chinese Communist Party and the State Council on 6 May 1995. The implementation of this strategy was launched at a national conference on science and technology later that month. Further progress on a national strategy can be expected in China's next five-year plan to be issued in late 2000.

Despite the lack of a national strategy, in 1998 the Chinese Government initiated a campaign underlining the importance of the knowledge-based economy with the translation of relevant OECD publications, the issuance of a series of studies by Chinese research institutes, and dissemination of information on knowledge-based economies. Newspapers have carried a large number of articles on the topic. Today, there is a broad initial awareness in China regarding the knowledge-based economy, especially among government officials, intellectuals and well-informed citizens. A conference on "The Knowledge Economy and China's Development: Analysis and Policy" held in July 1999 yielded the following impressions (Dahlman, 1999):

> *First*, there is tremendous interest in the knowledge economy in China, where it is seen as a fundamental element for future development. Analysis is being done not only at the national level, but also at the provincial level including detailed sector-level assessments and ambitious development plans, particularly for Shanghai.
>
> *Second*, there is an awareness that China should look not just at the science and technology system, but also at the broader framework conditions, including economic incentives and the role of market mechanisms. There is a focus on the need to go beyond ICT to cover software, high-value-added services and even culture as fundamental elements of the knowledge-based economy. However, while emphasising development of high-technology sectors, China still lags in its ability to diffuse and absorb technology throughout the economy.
>
> *Third*, there is concern with developing domestic capabilities and building better ties to Europe *vis-à-vis* the United States. China needs to develop its domestic science and technology base as well as knowledge creation capacity and must reach out more to Europe and other advanced nations to reduce its technological dependence on the United States.

STATUS OF KNOWLEDGE-BASED INDUSTRIES

This section reviews current developments in knowledge-based industries in Asia by sector, although the coverage is not uniform across countries. The choice is made based on the importance of a given industry to a country's economy and, to a lesser extent, on the basis of data availability. The industries chosen comprise not only the knowledge-intensive sectors that have developed strongly in Asian countries, but also some that are yet to develop. An attempt is made to review the development of ICT-based sectors (including semiconductors, computers, software, electronics and telecommunications equipment and services) because of their key role in knowledge-based economies. However, the data used in this section are taken from official national sources which are not strictly comparable across countries and reflect differences in industrial groupings and classifications. Knowledge-intensive service sectors are not considered here due to the lack of reliable, systematically collected data on these industries in Asian countries.

Korea

Semiconductors

The semiconductor industry is expected to make a major contribution to Korea's economic recovery in the aftermath of the Asian financial crisis. Accounting for one-third of global production, Korea's semiconductor industry is the third largest in the world and generates some 10% of the value of Korea's exports. However, the sector suffers from certain structural shortcomings. First, the semiconductor market is characterised by cyclical and unpredictable market fluctuations. This increases the vulnerability of Korea's industry, which is dependent on a single product – memory chips – for nearly 90% of revenues (Box 3). Second, Korea is heavily dependent on exports, which account for about 90% of production, and is thus susceptible to fluctuations in international markets. Third, the Korean semiconductor industry is highly reliant on imports for constructing facilities and for production equipment.

The Asian crisis had severe impacts on the Korean semiconductor industry, worsening these structural weaknesses. Before the onset of the crisis, to correct the production imbalance between memory chips and other types of semiconductors, the Korean Government and industry had made substantial investments in Large Scale Integration (LSI) systems. However, during the Asian crisis, Korean firms sold their LSI facilities acquired overseas and returned to memory chip production. This reversal of restructuring efforts threatens the long-term viability of the Korean semiconductor industry (KIET, 1998). During and following the Asian crisis, the liquidity crunch and the further pressure on Korean firms to improve their balance sheets by reducing bank borrowing have cut into their efforts to upgrade their innovation capabilities and develop future generations of products. In the short- to medium-term, the Korean industry is expected to suffer from insufficient production capacity and reduced competitiveness, particularly when market demand shifts to the next product generation, *e.g.* 256M DRAM.

Box 3. **Market cycles and Korean semiconductors**

Although ranked among the world's top semiconductor manufacturers in 1995, the three large Korean producers were badly affected by market developments in 1996. For the past few decades, there have been cycles of highs and lows in the world semiconductor market. In 1995, under the influence of the Intel thrust, a business peak occurred seven years after the last one in 1988, and many believed that the world semiconductor market would move onto a higher path. But then prices for 64M and 16M DRAMs plunged, with 4M and 1M DRAMs following shortly afterwards. Relative to a year earlier in 1995, prices fell by 85%, 78%, 80% and 44%, respectively.

The profitability of the world semiconductor industry was again at a low level and, in 1996, almost all world semiconductor producers, particularly those focused on memory chips, postponed their mass production schedules. It is estimated that the 1996 global semiconductor market was about USD 1.5 billion, a decrease of 8.8% from the previous year. However, all categories of semiconductors did not suffer to the same extent. A sectoral breakdown shows that micro-products grew by 19.3%, and logic and analogue products only suffered a slight drop, while memory products fell by 32.6% over the same period in 1995.

The terms-of-trade shock resulting from the collapse of semiconductor prices was one link in the chain of events that made Korea vulnerable to the Asian crisis in 1997, as it undermined corporate profitability, and led to a rise in bankruptcies and non-performing loans.

Telecommunications equipment

Large investments in research and development in the 1980s have improved the technological capabilities of the Korean telecommunications equipment sector. In addition, the openness of the telecommunications equipment market improved after July 1997, when the *Basic Telecommunications and Information Technology Agreement* (ITA) became effective. Despite the forecast of sluggish demand between 1998 and 2000, production of telecommunications equipment has more than doubled over that period and the booming domestic market for cellular phones suggests that not all of the increased production was for export. The domestic market for telecommunications equipment is estimated at USD 6 billion, with imports of approximately USD 2.3 billion. Domestic production is about USD 6.5 billion, of which 42% is exported.

Despite continued research and development, the competitiveness of the Korean telecommunications equipment sector lags behind other advanced countries. Korean firms have acquired advanced production technologies, particularly related to electronic switching systems. However, the industry still lacks core technologies such as materials technologies, and high-quality human resources are also in short supply.

Software

The Korean computer software sector is rated behind more advanced countries, especially for advanced applications. The technology level of domestic firms is judged to lag 10-20 years behind that of the United States while, with regard to application software, Korean firms are still one level below Japanese firms. The sector is characterised by middle-level technology and is making progress in certain areas such as database management systems. Domestic production is valued at around USD 6 billion, with only 1.6% of output exported. The low level of exports and high reliance on imports for systems software (30%) is a continuing cause for concern.

Problems stem from a lack of brand-name recognition as well as a dearth of qualified software engineers. Korean software companies have experienced difficulties in raising capital in the wake of the Asian financial crisis. Software development is also somewhat hampered by the lack of adequate protection of intellectual property rights. According to the Business Software Alliance, Korea ranks sixth among countries in software piracy, which was as high as 78% in 1994, and the country has been among those on the watch list of the Special 301 Review of the United States. Piracy makes it difficult for software companies to earn adequate returns to investments, which in turn leads to difficulties in raising funds on capital markets.

Specialty chemicals

Despite sustained growth since the mid-1970s, the Korean specialty chemicals industry has not advanced technologically due to a continued reliance on imported components. This sector includes pharmaceuticals, pesticides, cosmetics, dyestuffs and organic pigments, paints and printing inks, and other high-value-added chemicals. Production value is estimated at USD 18 billion, with pharmaceuticals and cosmetics serving as twin engines of growth. Since 1990, exports have increased from about 4 to 9% of the value of output.

The Korean specialty chemicals sector is highly reliant on imports for high-technology and high-value-added core inputs, while purely domestic products are generally low-value-added goods. The industry imports 60-70% of its intermediate inputs from abroad and had a trade deficit with the United States of USD 3 billion in 1997. Approximately 56% of firms in this sector rely on imports for key technology-intensive components, while 44% of firms have developed their own production processes and inputs. It is estimated that in some areas, *e.g.* the development of new pharmaceuticals, Korea’s technological capability is 50% below that of US firms.

Biotechnology

The Korean Government has designated biotechnology a key industry for the 21st century and is supporting research and promoting technological advances in related fields. However, there are considerable gaps between scientific research, applications research and technology commercialisation, and most production technology is imported from abroad. In 1993, the government initiated the *Biotechnology 2000 Programme* to fund research for a period of 14 years. Implementation involves seven government ministries, and the budget for biotechnology has been increased by 40% over earlier years.

There are an estimated 150 Korean companies in the biotechnology sector, of which two-thirds are large businesses and the remainder SMEs. Of the 3 000 people employed in this industry, more than half are engaged in research and development. Production was valued at USD 900 million, of which 40-50% is exported, including vaccines and antibiotics to primarily South-East Asian countries. Approximately 26% of domestic demand is imported. For many of the larger firms, biotechnology is a sideline activity to their core businesses in chemicals, pharmaceuticals, food processing, etc.

Regarding the technological capabilities of the Korean biotechnology industry, basic abilities have improved due to continued research over the past two decades. As concerns production technology, Korean firms are mainly at the stage of imitating technologies developed by more advanced countries. Taking into account the strengthening of international protection of intellectual property rights, Korean firms will find it more difficult in the future to imitate technologies from advanced countries and will be forced to develop indigenous core technologies.

Environment industry

The Korean environment industry was launched in the 1990s, when the government began to pay attention to environmental issues. The industry concentrates on production of environmental protection equipment. It grew on average by 15% per year until the onset of the Asian crisis in 1997, when firms decreased their environment-related spending during and after the crisis. There are some 11 700 enterprises engaged in the Korean environment industry, with sales revenue of USD 8.9 billion in 1996. Exports and imports of the environment industry grew rapidly during the period 1990-96, with exports increasing by 210% and imports by 70% per year. In 1996, exports and imports reached USD 461 million and USD 286 million, respectively. Main export markets are Indonesia, Malaysia and India, where Korea's main competitors are American, Japanese and German firms.

Since the late 1980s, the Korean Government has provided a policy environment conducive to the development of the domestic environment industry. In 1987, an amendment was made to the Korean Constitution that provides citizens with the constitutional right to a clean environment. The government subsequently increased public spending on the environment at the central and local levels; environmental spending ran at a level of 1% of GDP during the 1990s. Furthermore, the government has developed an *Environmental Vision 21* and plans to implement a *Green Country Construction Plan* by 2005. For the period 1997-2001, the government plans to spend KRW 32.6 trillion on improving the quality of water, air and waste disposal.

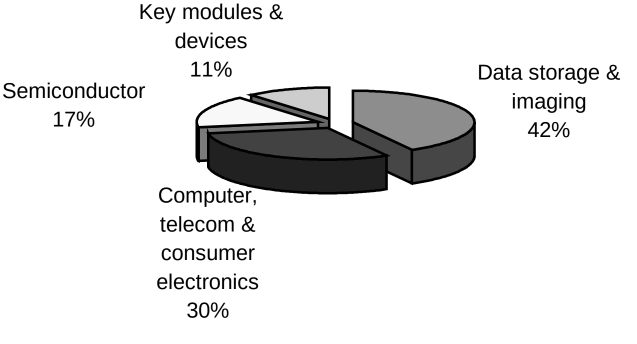
In support of research and development in the environment sector, the government committed KRW 489 billion between 1997-2001 to the *G7 Environmental Engineering Technology Development Project*, through which it hopes to upgrade Korean technological capabilities to the level of advanced countries. It also invested KRW 40 billion during 1995-97 to develop cleaner technology. However, the technological competitiveness of the Korean environment industry is still relatively low. With regard to standard environmental equipment, the technology competitiveness of Korean firms is 20% below that of advanced countries with regard to basic equipment, 30-35% lower with regard to intermediate equipment, and 80-85% lower in the advanced equipment segment.

Singapore

Electronics

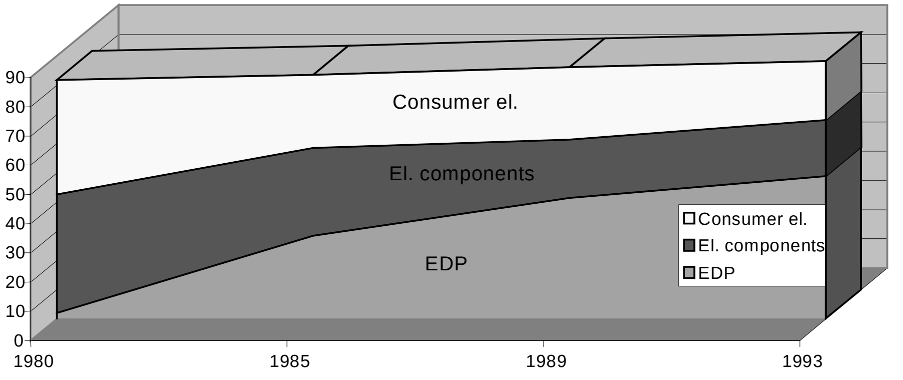
Singapore's ambition is to develop a world-class electronics sector which leads in the creation and management of new products, applications and markets. The aim is to promote the growth of electronics output at an average of 8% per year to USD 150 billion and attain employment of at least 50% skilled workers by 2010. Electronics production totalled SGD 63.4 billion in 1997 (but decreased by 3% in 1998), with the data storage and imaging sector dominating and accounting for 42% of output value and an increasing share of exports (Figures 1 and 2). Electronic data processing products are high-value-added, and the proportion of low-end consumer electronics as well as low-value-added electronics components has decreased over time. This reflects a continued technological and structural upgrading of the electronics industry in Singapore.

Figure 1. **Breakdown of Singapore's electronics industry by production value, 1997**



Source: SEDB Annual Report (1998).

Figure 2. **Composition of Singapore's electronics exports, 1980-93**



Source: Based on data from Ernst & Guerrieri (1998).

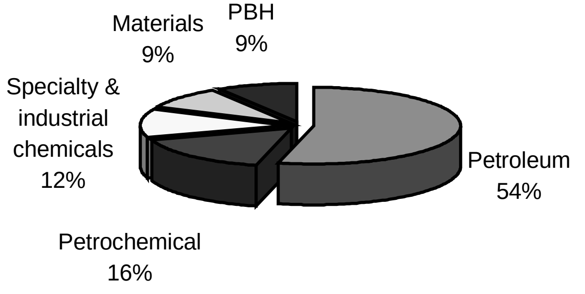
Information technology

Singapore's information technology (IT) industry consists of three businesses: software, hardware and IT services. Total sales revenue to end-users reached SGD 11.95 billion in 1997. Of this, hardware sales accounted for 77.6%, services for 11.9% and software for 9.3%. The annual growth rate was 32.3% over that of the previous year. Exports totalled SGD 7 billion, accounting for 59% of total sales. Exports increased by 37% in 1997, yet this was 16% below the 53% increase recorded in 1996. Hardware accounted for 89% of exports, with software and services contributing 6.3 and 4.7%, respectively (SNCB, 1998).

Chemicals

Chemicals production continues to increase in Singapore, growing by over 15% in 1998. Production value reached SGD 27 billion in 1997 and the government hopes to expand output to SGD 75 billion by 2010. The main product is petroleum-based products, accounting for 54% of the total (Figure 3). The share of specialty and industrial chemicals is just 12% of the total. Plans are to develop the chemical industry into a world-class petroleum and petrochemicals hub with investment commitments totalling SGD 3 billion in 1998, accounting for 39% of manufacturing commitments for the year.

Figure 3. **Singapore's chemical production, 1997**
Percentage value



Source: SEDB Annual Report (1998).

Biotechnology

Plans also exist to develop the life sciences industry, including pharmaceuticals, medical devices, biotechnology and agro-technology, in the first decade of the 21st century. Goals include making Singapore home to 15 world-class life sciences companies by 2010 as well as a regional centre for clinical trials and drug development (SEDB, 1999). The life sciences industry grew by 60% per annum between 1997 and 1999, albeit from a small base, reaching a production value of USD 6.3 billion. Investments amounted to SGD 511 million, or 6.1% of the total commitment to manufacturing industry, in that year. The government supported more than 500 innovation grants, of which local firms received 59% while slightly more than 40% went to multinational companies. Twenty-seven per cent of the projects were carried out by multinationals and 73% by local firms, including smaller enterprises.

Chinese Taipei

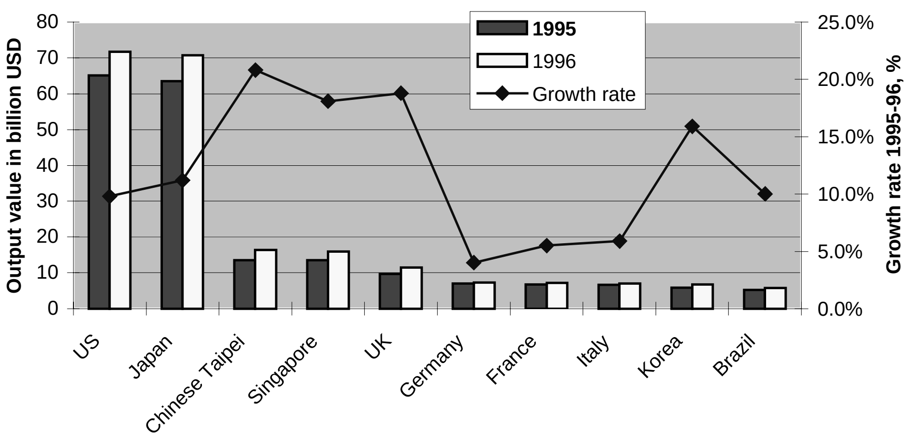
Information technology

Chinese Taipei's information technology (IT) industry began by manufacturing monitors and terminals for international vendors and was upgraded in the 1980s to assembly operations based on its own motherboard production capability. With increasing international demand for Original Equipment Manufacturing, Chinese Taipei's market shares in 14 IT product categories exceeded 30% of the world total in 1996 and 50% in nine of these categories. The comprehensive and internally consistent structure of its IT industry has helped Chinese Taipei develop into a "one-stop shopping centre" for importers.

Chinese Taipei's onshore IT production value was USD 16.4 billion in 1996, a 20.8% increase from 1995. Main products include monitors (32.6% of output value), notebook computers (22%), desktop computers (14%) and motherboards (12.7%). The fastest growing product segments between 1995-96 were notebook and desktop computers, desktop scanners and motherboards, which all required a high level of systems integration capability and have added-value components.

Over the past decade, however, Chinese Taipei's IT industries have invested in offshore production in Malaysia, Thailand and China due to shortages of labour and other factors. Offshore production increased from USD 973 million in 1992 to USD 7.8 billion in 1996, accounting for 32% of the total value of Chinese Taipei IT output. Chinese Taipei was the third largest IT hardware producer in the world after the United States and Japan, in 1995 and 1996 (Figure 4). With output growing by nearly 21% a year, it recorded the fastest growth among the world's top IT-producing countries during that period.

Figure 4. **Asian countries among the top 10 IT hardware producers**
Production value and growth rates, 1995-96



Source: Chinese Taipei Industry Technology Information Service (1997).

Technological and structural upgrading of the electronics industry has increased the proportion of value-added products in exports such as electronic data processing equipment, including mainly personal computers and laptops (Box 4). The importance of low-end consumer electronics is declining, while the proportion of relatively low-value-added electronics components has remained low (Figure 5).

Box 4. **Chinese Taipei's information technology industry**

Through continuous upgrading of its technological capabilities and industry structure, Chinese Taipei's information technology industry managed to stay internationally competitive while climbing upwards in the value-added chain. In the early 1980s, the country specialised in low-cost assembly with price as the main competitive advantage and slender profit margins. In the mid-1980s, Acer, Mitac and other vendors in the electronic games segment began assembly of semi-finished goods, and established the foundation of Chinese Taipei's PC board-based peripherals industry centred around domestic motherboards. During this period, competitive advantage derived from an abundance of skilled engineers who, operating out of SMEs as specialist manufacturers, became a vital part of the global IT manufacturing structure.

In the early 1990s, Chinese Taipei began to face high land and labour costs which, in addition to lower tariffs granted other nations through GSP preferences, created pressure on the labour-intensive segments of the industry. Many manufacturers moved their labour-intensive procedures offshore. Mass production capability created huge demand for components and the bulk of investment went into semiconductor components, which in turn made 8-inch semiconductor wafer production a driving force in the industry. Effective competition depended on access to capital and technology.

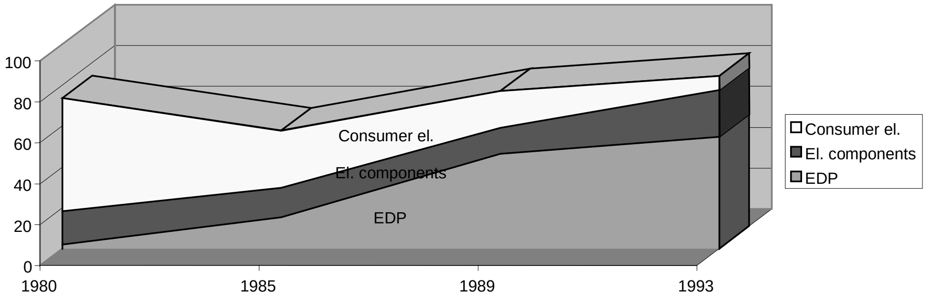
In 1995, new logistics systems jointly invented by Compaq and Mitac required IT manufacturers to gain proximity to markets, marketing support and maintenance services. Companies set up assembly plants in their main markets and the ability to attract staff with international experience became a key to success. Many companies contracted out production to Chinese Taipei and other Asia-Pacific countries, who invested heavily in production facilities and established assembly plants close to main markets.

The focal point of international competition in the IT industry will continue to change. Due to the lack of cutting-edge key technologies, Chinese Taipei will need to rely on its mature operational structure to remain competitive. Over the years, it has evolved a high level of integration between production and marketing, a competitive advantage that new entrants to the market will find difficult to match. Furthermore, many IT companies in Chinese Taipei acquired access to capital through stock issues, which facilitated their expansion.

Well-established IT companies such as Asustek have begun to target the top end of the major international markets in order to earn premium profits, while companies such as GVC, Elite and FIC have chosen to target the major international vendors. These companies have worked towards a global production strategy and maintenance system and are well positioned to benefit when IBM, Compaq and other major firms increase their global market share. Motherboard manufacturers that target vendors at the national level, such as Microstar, Gigabyte and Soyo, are also well established in their respective markets. Although Chinese Taipei's motherboard manufacturers will continue to face competition from Intel, they are likely to retain their leading world position.

Source: Chinese Taipei Industry Technology Information Service (1997).

Figure 5. **Composition of Chinese Taipei's electronic exports, 1980-93**



Source: Based on data from Ernst & Guerrieri (1998).

The electronic materials and components industry is fundamental for all electronics-related industries in Chinese Taipei and plays a supporting role, especially for SMEs. However, some key raw materials and components are not produced locally, and in recent years companies have relocated production overseas due to the pressure of increasing labour costs. Total production of electronic components in Chinese Taipei reached USD 16 billion in 1996, about 6% more than in 1995. A main product is printed circuit boards (PCB), accounting for 12% of production value. The PCB industry has, over more than 30 years, developed into a self-sustaining structure, including supporting industries. Other products of Chinese Taipei's electronics components industry include lead frames, disc recording media, small-size rechargeable batteries and liquid crystal displays. In the future, an international consortium or some kind of strategic alliance may be needed if the industry fails to obtain advanced technology from Japan.

Telecommunications

Chinese Taipei's telecommunications industry includes equipment, components and services. There are approximately 264 equipment manufacturers of which more than 40% are SMEs with a capital base of less than NTD 50 million. The production value of the telecommunications equipment and components industry was USD 3.2 billion in 1996, a 27% increase over 1995. With 78% of products sold overseas, the sector is highly export-oriented; major export markets are North America (30%), China (25%) Western Europe (17%) and South-East Asia (10%). Major products include modems, telephone sets and fax machines.

Until 1997, telecommunications services in Chinese Taipei were dominated by ChungHwa Telecommunications, an offshoot of the General Directorate of Telecommunications. Total revenue for 1996 was USD 5.72 billion. Starting in 1997, the telecommunications service market for cellular phones, paging and mobile data has gradually been liberalised. With new players entering the telecommunications services sector, the market structure and competitive environment are expected to change significantly.

Consumer electronics

In 1996, Chinese Taipei's consumer electronics industry ranked 14th in the world in terms of production value, behind South-East Asian countries such as Malaysia, Indonesia, Hong Kong (China), Singapore and Thailand which built on the advantage of low production costs. Production was valued at USD 1.75 billion in 1996, 3.3% lower than in 1995, and exports declined by 1% due to reduced orders. This sluggish performance suggests that Chinese Taipei is losing its competitive edge in traditional consumer electronics to lower-cost producers. To regain competitive position in this industry, Chinese Taipei would have to focus on the development of new-generation and higher-value-added products.

Aerospace

Due to government support, Chinese Taipei's aerospace industry made real progress in the 1990s. As of 1996, there were 27 domestic companies, which obtained quality certification in more than 330 product categories from major aircraft manufacturers such as Boeing, McDonald Douglas, Pratt & Whitney and General Electric. Chinese Taipei has 46 aerospace joint ventures with foreign partners, with more than 40 local companies participating. Total production value in 1996 was around USD 1.3 billion, a 20% increase on 1995. By the year 2004, domestic aerospace production value is projected to reach USD 4.4 billion.

Chinese Taipei benefited significantly in obtaining technology through participation in several large international co-operation projects. In addition, relying on its technological and manufacturing capabilities in information technology, Chinese Taipei plans to expand into market niches such as cabin information systems and other electronic devices. It also aims to develop aircraft maintenance services, with the goal of becoming Asia's regional aircraft maintenance caterer.

Biotechnology

Since the inception of its biotechnology programme in the early 1980s, Chinese Taipei has made considerable progress. Supported by the government's biotechnology and pharmaceutical research programmes, a research infrastructure has begun to take shape in various institutes within Academia Sinica and other research centres related to the biotechnology industry. However, the sector's potential may be limited by its short development history, lack of critical mass for "big science" innovation and the steep learning curve in formulating a national strategy. New biotechnology-based manufacturing will not duplicate the past success of Chinese Taipei's high-technology industry and will take significantly longer to develop. The success of other high-tech sectors came from manufacturing for US corporations and exporting to developed markets, primarily in the United States. Not being widely understood and acknowledged by biotechnology enthusiasts in government and industry, this pattern of manufacturing is unlikely to be the case for biotechnology companies, particularly those targeting pharmaceuticals and agriculture/food.

Malaysia

Electronics

The electronics industry (broadly defined to include ICT equipment as well as consumer electronics) is Malaysia's main industrial sector, responsible for over 30% of manufacturing value added in 1998 and a focus of the current five-year development plan. The industry is also its country's single largest foreign exchange earner, accounting for two-thirds of manufactured exports or 56.4% in 1998. The electronics sub-sector, which includes semiconductors and electronics equipment and parts, contributed 39.8% to national exports. Malaysia is a leading exporter of semiconductors and air-conditioners, while production and export of consumer electronic goods, telecommunications equipment, computers and computer peripherals have also expanded rapidly. Malaysia ranked second in world production of consumer electronics in 1996, up from fifth place in 1995.

However, the sector has suffered in the aftermath of the Asian financial crisis. Although production grew by 14% in 1997, exports declined, and in 1998, production decreased by 7.7% while exports dropped by 1.4% in US dollar terms. Output of all product categories of the electrical and electronics industry suffered a decline, with the exception of radios and televisions, which registered 3.9% growth in 1998. It is primarily an export-oriented sector, with limited links to the domestic market. However, the electronics industry has more recently benefited from increased domestic demand. Future prospects are somewhat mixed (Box 5). Measures initiated to address the Y2K problem, progress on the Multimedia Super Corridor project, the launch of the Malaysian Exchange of Securities Dealing and Automated Quotation (MESDAQ), combined with ongoing corporate investments in enterprise software, are providing a platform for recovery of the industry and production of electronics products.

Box 5. **Prospects for the Malaysian electronics industry**

A survey of foreign affiliates in the Malaysian electronics industry was carried out by UNCTAD in 1998. The survey revealed that despite the financial crisis, more than 60% of executives believed their production, sales and exports would increase in the next three years, while others felt they would remain at their 1998 levels. This suggests that foreign affiliates of large multinationals remain confident in Malaysia as a destination for foreign investment and are generally optimistic about the business prospects of the electronics industry in the short-to-medium term.

According to PricewaterhouseCoopers' executive director of management consulting services, Mr. Chin Kwai Fatt, certain measures, particularly exchange rate controls, have helped to stabilise the local business environment by enhancing certainty in business-related costs. For 1999, 5-7% growth in the electronics sector was anticipated despite the 1% GDP growth forecast. Yet, already in early 1999, there emerged bottlenecks, for example, in securing skilled workers. Investor confidence will depend on how problems in Malaysia's financial and corporate sectors are addressed.

Source: UNCTAD (1998).

The electronics sector in Malaysia has benefited from large amounts of domestic and foreign investment. Between 1994-98, the industry absorbed 23.6% of total industrial investment and accounted for 25.5% of approved investment projects in the manufacturing sector (MIDA, 1999). The electronics industry is also the major recipient of foreign direct investment (FDI) in Malaysia. It absorbed, for example, 33.7% of total FDI to manufacturing between 1996-98; this has led to a dominance of multinational corporations in Malaysia's electronics industry. There are currently over 100 sizeable electrical and electronics foreign affiliates in Malaysia. Consequently, the industry has developed a heavy reliance on imports for technology, intermediate inputs, equipment and marketing channels for its products. For example, despite Malaysia's growing machinery and equipment industry, domestic demand is still largely met by imports, which totalled MYR 34.4 billion in 1997, accounting for 20% of total (retained) imports.

Over the years, Malaysia's electronics sector has developed significant capacity and skills in assembly and manufacture of a wide range of electronic components and parts, semiconductors, and consumer and industrial electronics. Yet, the industry remains concentrated on low-end assembly operations with a high import content of inputs. Recognising this, the government is encouraging the development of upstream higher-value-added activities such as wafer fabrication facilities and the development of the information technology and multimedia industries.

Chemicals

The chemicals industry, which remains concentrated on industrial chemicals production, contributed 15.6% to manufacturing value-added between 1996-98. Output declined by 1.8% in 1998, a better performance than most other manufacturing sectors which, as a whole, declined by 10.2% in production value (BNM, 1999a). Unlike the electronics industry, chemicals is domestically oriented. Yet the development of the pharmaceutical sector still lags domestic demand, so that 60% of pharmaceutical consumption is imported.

The current industrial plan has highlighted the petrochemical and pharmaceutical sectors for further development. In terms of approved investment projects and the amount of investments, the chemicals industry accounted for 6.8 and 12.9%, respectively, of the total between 1994-98 (MIDA, 1999b). The chemicals industry is also one of the main recipients of foreign direct investment, accounting for 16.8% of total foreign investment in Malaysian industry between 1996-98. Foreign investment in chemicals increased from MYR 2 101 million to MYR 4 150 million, or by 97.5%, between 1996-98.

Although the industry has developed rapidly in recent years, the range of products remains relatively narrow. Major products include petroleum products, petrochemicals, industrial chemicals and industrial gases. Production of related products such as polyethylene, propylene, polypropylene and polyvinyl chloride (PVD) continues to be insufficient to meet local demand. And plans for intermediate products such as ethylbenzene, aromatics and ethylene oxide were only in the initial stages of development in 1999.

Biotechnology

The biotechnology industry is now being developed in Malaysia, primarily through a collaborative research effort of the Massachusetts Institute of Technology (MIT) and local research institutes and universities. The National Council for Scientific Research and Development approved an allocation of MYR 35.8 million for the implementation of the *Malaysia-MIT Biotechnology*

Partnership Programme (MMBPP) under the current development plan. In the present stage, the programme is developing products derived from oil palm and other indigenous natural resources. Research focuses on development of natural products to increase the value of traditional herbal medicines and on enhancing the economic value of oil palm (MNCSRD, 1998). It is hoped that the programme, which emphasises research as well as human resource development, will lay the technological basis for Malaysia's future biotechnology industry.

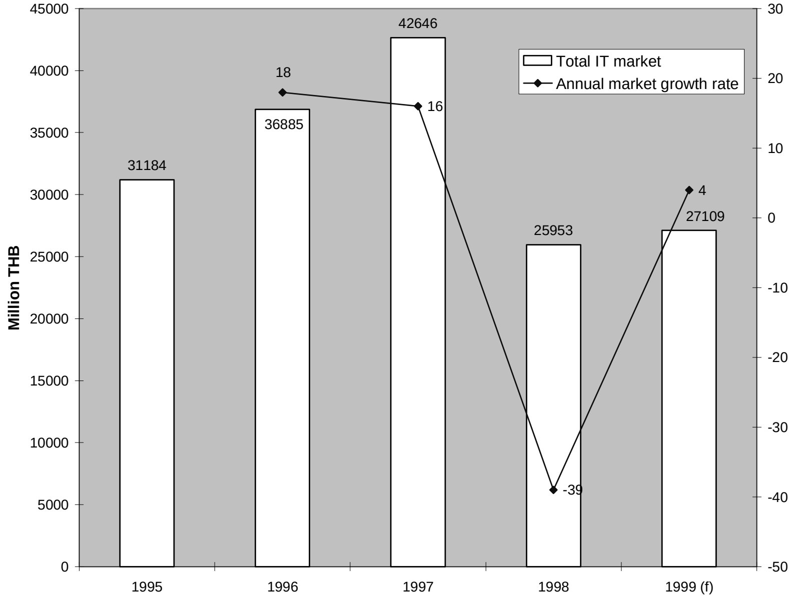
Thailand

Information technology

Thailand's IT industry experienced dramatic, double-digit growth for more than a decade from 1989 to the onset of the Asian crisis in mid-1997. The IT market in Thailand, broadly defined to include hardware, software and services, was worth THB 27 109 million in 1998, a decrease of 39% from 1997 (Figure 6). Hardware accounted for 50%, software 20%, and IT services 30%, respectively, in 1999 (Figure 7). The share of hardware fell from 70 to 50%, and those of software and IT services increased from 15 to 20% and from 16 to 30%, respectively, over the second half of the 1990s. Telecommunications was estimated to have increased in Thailand by 42.3%, from USD 1 647 million to USD 2 344 million, between 1992-97.

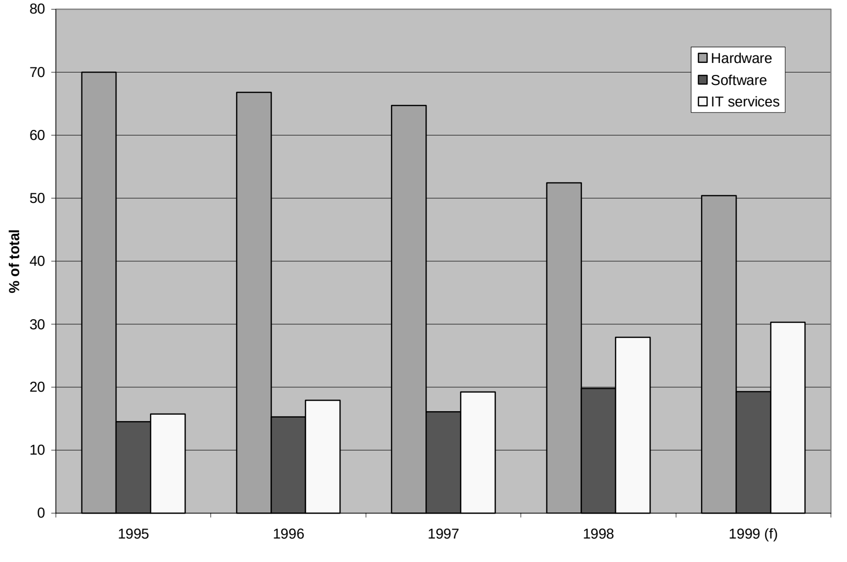
Despite impressive growth, the information technology industry in Thailand faces a number of challenges and structural weaknesses. First, Thailand's national information infrastructure, especially telecommunications and Internet access, was under-invested and over-regulated, which led to high levels of user charges that prevented an increase in telecommunications and Internet use. Second, the weakness of the Thai education system and the lack of research and development presents a long-term obstacle to upgrading the IT industry into a serious player in the global technology market. The industry faces a shortage of qualified engineers and a lack of indigenous technological capability. Third, there are legal problems caused by the lack of progress in amending outdated laws and regulations and by the delay in introducing new laws to support the development of electronic commerce. In particular, the protection of intellectual property rights is weak, and this has hampered the development of the software sector. Fourth, the government has been criticised for its lack of leadership and action in addressing these problems and in supporting the growth of the IT industry more generally. In addition, the government has failed to embrace IT as a user.

Figure 6. **Thailand's IT market, 1995-99**



(f) = forecast.
Source: Association of Thailand Software Industry and Computer Association of Thailand.

Figure 7. **Breakdown of the IT market in Thailand, 1995-99**



(f) = forecast.
Source: Association of Thailand Software Industry and Computer Association of Thailand.

Electronics

Thailand's electronics industry is an important growth sector, with shipments of electronic products, particularly computer parts and integrated circuits, worth an estimated THB 350 billion a year, making up about 30% of the country's total exports in value terms. Many major multinationals invested in electronics in Thailand during 1981-85, and today most manufacturers are joint ventures or foreign-owned companies, catering mainly to the world market. Foreign firms play the essential role in research and development of production technology, procurement and marketing (Box 6).

Box 6. **Thailand's hard disk drive industry**

The hard disk drive sector is the champion of Thailand's electronics industry. Starting in1983, the hard disk drive (HDD) sector has expanded steadily for more than one and a half decades, with Thailand producing 40 million hard disk drive units a year – 20% of the world market before the 1997 Asian crisis. In value-added terms, the HDD industry (including parts) was estimated to be worth some THB 35 000 million, equivalent to 0.7-0.8% of Thailand's GDP in 1999. HDD is Thailand's leading export industry, with direct exports of about USD 5.3 billion, accounting for 27% of total exports of electrical appliances and electronic products or 10% of total exports in 1998.

The HDD industry in Thailand has developed based on foreign capital and technologies. Seagate Technology set up the first HDD production facility in Thailand in 1983 and since that time, foreign investment has served as a main source of growth. Prior to the onset of the Asian crisis, Thailand's electronics industry enjoyed a rosy 1996, with the Board of Investment approving 138 foreign investment projects worth THB 64.3 billion in the first 11 months. Consequently, all of the main players in this industry are foreign-owned firms with the only exception being Saha Union, a conglomerate involved in labour-intensive production.

Due to a lack of technology and industry-specific experience, Thai companies, large as well as small enterprises, chose not to enter the HDD industry. As a result, there are limited linkages between the HDD industry and the domestic component and supporting industry. In addition, the Thai HDD industry faces a number of weaknesses, including difficulty in finding qualified engineers in Thailand, limited research and development and a shift towards automation and away from labour-intensive activities where Thailand enjoys a comparative advantage.

Source: Panichapat and Kanasawat (1999).

The lack of local capabilities in technology and marketing has led to structural weaknesses in the Thai electronics industry, which remains primarily labour-intensive assembly plants. The lack of skilled labour in Thailand has added to labour costs. Before the onset of the Asian crisis, workers in the electronics industry were able to negotiate annual pay rises of 25% due to their strong bargaining positions. Wages increased faster than prices. As a result of rising labour costs, the electronics industry is losing its advantage as a labour-intensive industry. Recent years have seen relocation of the industry to China and the Philippines, such as the board-assembly testing plant of Hana Microindustry Plc from Lumphun to Shanghai, China, where labour costs were said to be 40% lower. It has been argued by Mr. Sompong Nakornsri, President of the Federation of Thai Industries' Electronics Club, that if the electronics industry cannot manage to move beyond the assembly stage, it is set to become a "sunset industry" within five years, following the path of other labour-intensive industries such as textiles and footwear.

Another issue facing the Thai electronics industry is its low margin of value added. According to the Minister of Industry, the local content of electronics products has remained between 20-30%. In spite of improvements made in the late 1990s, the level of local content was still 29% in 1998 (Table 2).

Table 2. **Local content ratios of Thailand's electronics industry, 1996-98**

	Exports (THB billion)	Related imports (THB billion)	Local content ratio (%)
1996	460	438	4.8
1997	700	528	24.6
1998	798	566	29.1

Source: Compiled from *Bangkok Post* (1999/06/01).

The Thai Government has been criticised for its lack of support for the domestic electronics industry, including improving education and fostering technological capabilities. The government has tended to intervene at the wrong level, earmarking specific electronic products for development in the country's master plan – although a study by the federation of the electronics industry suggested that completely different products would have strong potential. The government is now making improvements in several areas, including education and training for skilled personnel, reducing customs procedures, and solving double taxation problems.

Another government initiative is to promote local sourcing of electronic components. The Board of Investment launched an *Industrial Linkage Development* programme in 1997 to match buyers and local suppliers of components. However, this initiative achieved only limited results as the quality and the price of local Thai components are not internationally competitive. The Thai electronics industry is faced with other constraints due to its high degree of reliance on foreign firms. Many Thai manufacturers are branch plants with limited procurement and marketing authority. Further difficulties are caused by the lack of transportation and communications infrastructure in Thailand.

Tariffs and trade policy have also affected the development of the Thai electronics industry. Prior to March 1994, most electronic components were subject to import duties of 35%, except for components imported for use in computer and television assembly. Since then, the import duty on the majority of electronic components has been reduced to 1% to favour local assemblers. However, this impedes the development of the electronics industry, as imported parts are taxed at 1% and materials at 20%, which tend to make it more expensive to manufacture components in Thailand than to import them. Recently the government has decided to cut import duties on some raw materials used by the electronics industry as part of a major tax overhaul.

Software

The Thai software industry was estimated at THB 7 billion in 1999 and was projected to grow to THB 53 billion over the next five years (Sribhibhadh, 1999). The Thai Government has identified the software industry as a sunrise sector and expects it to develop into a main foreign exchange earner. In 1999, a Software Park was established to promote the development of the industry. Nevertheless, the Thai software industry has experienced setbacks in recent years. There used to be more than 1 000 registered software houses, but today less than 500 firms remain in business, with 90% having around 30 staff (Karnjanatawe, 2000a). Some 18 local software developers have set up at the Software Park, well below the target of 100 units for forming a national cluster for the software industry in Thailand. According to the software industry, lack of support and funding from the government have affected the ability of the Software Park to attract firms. Weaknesses include inadequate telecommunications services and poor meeting and training facilities.

Other obstacles include a lack of protection of intellectual property rights. First, the country has a very high rate of piracy – over 80% – including both end-users and counterfeiters, despite the introduction of a Copyright Law covering software in 1995. For the consumer software market, there was a 90% piracy rate, which dampened the size of this market from an estimated THB 1.5 billion to a mere THB 200 million (Waltham and Dasaneeyavaja, 1999). Second, the Thai software industry suffers from a severe lack of qualified software technical personnel. Third, there is a lack of R&D activities in Thailand, including on reverse software engineering. Fourth, it is difficult for software companies to raise capital from banks.

For the development of a healthy Thai software industry, the government should take the lead as a user of software to help boost domestic market demand. Government agencies should not compete with the private sector in providing services such as professional training. It should help make available market and technology intelligence to cater for the urgent need for information. There is a need to create venture capital markets for the development of software companies. In the initial stage, the government can help by making available seed capital and soft credits for software companies to get off the ground. Government assistance might be given to encourage the use of IT in the restructuring of traditional Thai industry. Finally, long-term infrastructure support in the areas of R&D, education and affordable and accessible telecommunications, and better protection of IPR are necessary conditions for sustainable development of the software industry.

Telecommunications

Thailand's telecommunications sector is run by two state-owned companies, the Telephone Organisation of Thailand (TOT) and the Communications Authority of Thailand (CAT). TOT controls all national telecommunications and services to neighbouring countries, such as Laos, Cambodia, Myanmar and Malaysia, while CAT is responsible for all international telecommunications services except countries covered by TOT. Private sector participation in the provision of telecommunications services started in early 1988 when Cable and Wireless signed an agreement with the Posts and Telegraph Department to provide satellite service. Since then, TOT and CAT have entered into Build/Transfer/Operate (BTO) agreements with a host of private sector firms to provide telecommunications services in Thailand.

In 1994, a decision was made to allow for greater private sector participation in the telecommunications market. A National Telecommunications Committee was to be set up to replace the regulatory functions of TOT and CAT. According to the telecommunications master plan approved in 1997, TOT and CAT would in turn be privatised in 1999. The objective is to open the market in the form of concessions to operate telecommunications networks and services in competition with TOT on a zone basis. TOT will predominately be responsible for long-distance interconnecting facilities between each zone. The terms of concessions will be shifted from BTO to BOO (Build/Operate/Own) licences once the regulatory framework is put in place (TBOI, 1996b). However, the process has been slow due to vested interests and the impacts of the Asian crisis. It is estimated that the sale of shares might take several more years than expected and telecommunications market liberalisation will not be completed before 2006.

Before the Asian crisis, the Thai telecommunications industry invested heavily in expansion of capacity mainly through foreign borrowing, which became expensive to repay because of the devaluation of the baht in 1997. As a result, all telecommunications companies reported losses and were struggling in 1999. There was debt restructuring during 1999, which proceeded within the framework of payment rescheduling and the issuance of preference shares. All but one telecommunications company listed on the stock market had entered debt rescheduling with their creditors by the end of 1999. The Thai telecommunications sector is thus confronting both the implementation of the liberalisation programme and the problems of foreign-exchange-related losses and return to profitability.

China

Information technology

China's information technology industry, comprising semiconductors, computers and telecommunications equipment, produced goods worth USD 46.3 billion in 1997. Supported by strong domestic demand, this industry grew on average by 27.5% per year between 1992-97. As one of China's main export industries, the sector exported products to the value of USD 25 billion in 1997, reflecting a 16% increase on the previous year. The sector also includes colour television sets, of which China is the world's largest producer, with output of 240 million sets in 1997.

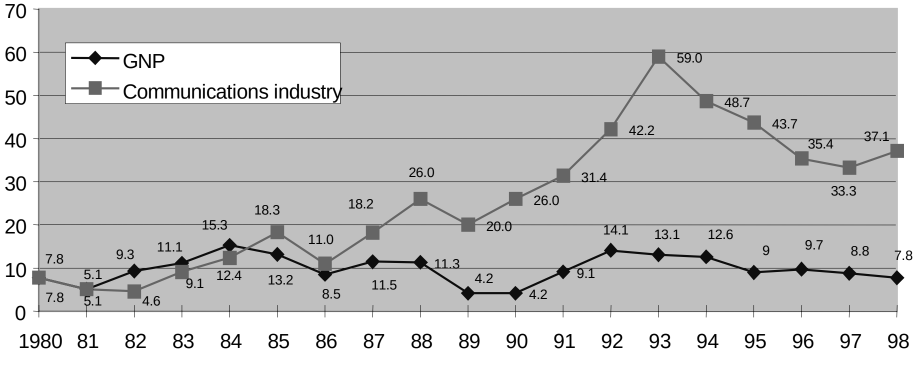
Computers and telecommunications equipment are the fastest growing segments of the information technology industry in recent years. The production of personal computers reached 1.7 million units in 1997, a four-fold increase over 1992. Domestic computer production accounts for 60% of domestic sales. In 1997, computer exports were valued at USD 8.7 billion and imports at USD 4.4 billion, leading to a trade surplus of USD 4.4 billion for that year.

The main problem facing the Chinese information industry is its low technological capabilities, which will severely check further development of the sector. Both in terms of the scale of the sector and its technological level, China lags behind the advanced countries in international competitiveness. While China is dependent on imports for core technologies and for software, the industry's absorption capacity for imported technology and know-how is considered to be limited.

Telecommunications services

Despite limited progress in liberalisation of China's telecommunications services, the sector (which includes postal services) has grown very rapidly since the second half of the 1980s, with growth exceeding that of GNP (Figure 8). In 1997, telecommunications services in China were valued at USD 19.9 billion. Through heavy investment, China's fixed telephone net capacity expanded from the 17th largest in the world in 1985 to the second largest in 1998. The ratio of telephones to 100 inhabitants increased from 0.38 in 1978 to 10.64 in 1998 and in urban areas to 27.7. Mobile telephone services are also expanding rapidly: with 25 million mobile telephone subscribers, China has the third largest mobile phone facility in the world. Growth should continue as China makes plans to open up its telecommunications services to foreign competition in preparation for its entry into the World Trade Organisation (WTO).

Figure 8. **Growth of China's GNP and communications industry, 1980-98, %**



Source: Chinese Ministry of Information Industry (1999).

Software

In 1997, China's combined computer and software market reached USD 15 billion, of which hardware sales accounted for 80%, software sales for 8.6%, and computer services for 11.4%. The Chinese software industry started to develop in the mid-1980s, evolving into a USD 1.58 billion business in 1998. Of total software market turnover, 61% was for application software, 26% for supporting software and the remainder for system software. China counts some

2 000 software companies and approximately 100 000 software professionals. Growth in the software sector has been supported by: the active involvement of the government; the large number of well-trained software professionals in China; the high growth rate of the Chinese economy and increasing applications of information technology; and substantial public investments in information infrastructure.

The Chinese Government has taken active steps to promote the software industry in the last decade. As a result of the *Torch Plan* of the Ministry of Science and Technology, eight software industrial parks were established by the end of the 1990s (Table 3). Several other software parks have been developed under the initiative of China's Ministry of Information Industry.

However, China's software sector still suffers from a number of shortcomings. First, venture capital markets and other sources of financing need to be developed to fulfil the capital requirements of the software industry. Second, further development of the software sector awaits a regulatory framework including effective protection of intellectual property rights so as to provide rules of the game and their enforcement in the marketplace. Third, English is the common language of the international software industry and Chinese software engineers are at a disadvantage in this regard compared to their close competitors, *e.g.* the Indian software industry.

Table 3. **Main software parks in China**

Name	Starting year/location	1997 production USD million	2000[1] production USD million	1998 employees	2000[1] employees
Shengyang East Yuan	1995, Sheng Yang, East Liaoning Province	33.7[2]	122	1 000	n.a.
Chengdu West Park	1997, Cheng Du, East Sichuan Province	30.5	609	500	5 000
Chengsha Park	1997, Chang Sha, Hunan Province	22.0	183	400	1 000
Jinan Park	1997, Jinan, Shandong Province	35.4	97.5-122	400	800-1 000
Beijing Park	1998, Beijing	392.7	n.a.	n.a.	n.a.
Tianjing Park	1998, Tianjing	13.4	122	n.a.	n.a.
Wuhan Park	1998 Wuhan, Hubei Province	24.3	122	n.a.	1 500
Hangzhou Park	1998, Hangzhou, Zhejing Province	10.9	n.a.	n.a.	n.a.
Total	--	562.9	--	--	--

1. Estimates.
2. Business revenue.
Source: DRCnet (1999).

Consumer electronics

China ranked fourth in world production of consumer electronics (*e.g.* air-conditioners, washing machines, fans, refrigerators) in 1996 due to its vast domestic markets which also ranked fourth largest in the world. The export value of Chinese consumer electronics was USD 3.21 billion in 1997, an increase of 16.7% from the previous year. The United States, Hong Kong (China), Japan, Germany, France and the United Kingdom are the main markets for Chinese consumer electronics, with a combined export volume to these markets exceeding USD 100 million in 1997. Yet the domestic market clearly dominates the consumer electronics industry in China (Table 4). Apart from the notable exception of electric fans, more than 86% of all main products are sold domestically.

However, there remains a strong correlation between export and production growth for all products, which indicates that although the domestic market consumes the lion's share of products, export markets are important for the growth of the industry. This is particularly true given the saturation of the Chinese consumer electronics goods markets, on the one hand, and the existence of over-capacity of the industry, on the other hand. Faced with huge problems of over-capacity, the Chinese consumer electronics industry implemented restructuring steps in the late 1990s. Aimed at technological upgrading and enhancing economies of scale in production, the restructuring programme promoted greater concentration of companies and increased investments in new production processes.

Table 4. **Main Chinese consumer electronics products and exports, 1997**

	Production (units)	Growth (%)	Exports units (value in USD)	Export growth (%) (growth in USD)	Export/ production ratio
Air-conditioners	8.49 million	25.3	0.81 million (215 million)	71.1 (36.0)	9.5%
Washing machines	12.6 million	18.0	0.7 million (67.2 million)	26.3 (14.7)	5.6%
Electric fans	72.7 million	-16.8	67.7 million (577 million)	0.0 (-11.2)	93%
Refrigerators	9.86 million	12.9	1.3 million (107 million)	26.5 (36.9)	13.2%

Source: DRCnet (1997).

Chemicals

The Chinese chemicals industry is not a technology-intensive sector and suffers from structural problems, low efficiency and over-capacity. As a result, low-value-added chemicals and materials dominate production and exports, and the industry has not branched out to production of specialty chemical products. The production value of the Chinese chemical industry was USD 37.3 billion in 1997, marking an increase of 9% from 1996. However, sales revenues were just USD 33.5 billion, translating into an increase of 1.8% for the same year. According to a survey of some 4 386 chemical industry enterprises, profits decreased by 50% in 1997 and 41% of enterprises ran at a loss. State-owned enterprises were responsible for 52% of all losses in 1997. The export value of chemicals products was USD 34.5 billion, accounting for 10.6% of China's total exports in 1997. China is a net importer of chemical products, with a sectoral trade deficit of USD 5.8 billion in 1997.

Environment industry

China's environment industry is underdeveloped, particularly compared to the country's need for environmental protection equipment and services. The industry employed 1.7 million people, with production valued at USD 6.3 billion, accounting for only 0.7% of China's GNP at the end of the 1990s. There are about 9 000 enterprises in this industry, of which 90% have fixed capital of less than USD 1.8 million. The industry suffers from a narrow industrial structure that concentrates on producing machinery for environmental protection and waste re-use. Due to its limited capabilities, only 4% of the machinery produced meets international technological standards. With low technological capabilities, which lag more than 20 years behind advanced countries, the Chinese environment industry relies significantly on imports of technology and equipment.

DEVELOPING KNOWLEDGE-BASED INDUSTRIES

The Asian countries need to fulfil some key conditions in order to achieve continued development of knowledge-based industries. Broadly, these include enhancing market-based incentive mechanisms and improving framework conditions while reducing excessive government interventions in order to foster self-sustainable development of knowledge-based industries which are dynamic and responsive to market conditions and which are developed in line with Asian comparative advantages. A number of policy areas, such as enhancing market competition, fostering entrepreneurship and promoting SMEs, undertaking industrial restructuring, reforming corporate governance, stimulating investment in intangible assets, and developing the venture capital market, are important in this context (OECD, 1999a; Andersson, 1999; World Bank and OECD, 2000; APEC, 2000a, 2000b; Baygan and Freudenberg, 2000). More specifically, four issues are considered below: *i)* developing information infrastructures; *ii)* reforming educational systems; *iii)* improving national innovation capabilities; and *iv)* enhancing conditions for gaining from foreign direct investment.

Developing information infrastructures

National information infrastructure, in the form of telecommunications systems and networks, provides important physical conditions for the development of knowledge-based industries. Such infrastructure is crucial for spreading the use of information technology, which will generate demand for knowledge-intensive products. It is also an important factor for attracting foreign direct investment, which the Asian countries depend on for the further development of their industrial structures. Advanced information infrastructure is also crucial for Asia to keep abreast with rapid developments in industries and economies worldwide.

Most Asian countries are investing resources to improve their information infrastructures (Table 5). China's investment in telecommunications accounted on average for 1.2% of GDP between 1992 and 1996, which reflected an increase from the level of 0.26% in the 1980s. Malaysia doubled its investment in telecommunications from 0.73% of GDP in the 1980s to 1.52% in the 1990s. For the more advanced countries in Asia, such as Korea, Singapore and Chinese Taipei, the levels of investment in telecommunications decreased somewhat in the 1990s from that reached in the 1980s, reflecting that these countries have passed the period of intensive investment in infrastructures. All available statistics on Thailand indicate inadequate investment in telecommunications throughout the 1980s and 1990s. Thailand's level of telecommunications investment as a percentage of GDP and of gross capital formation was the lowest among these countries and, more importantly, there was a decline in investment during the 1990s.

To different degrees, the Asian countries have all achieved improvements in their information infrastructures. Telephone communication capacity has increased steadily over time. A comparison between the average between 1992-96 and the figure for 1999 indicates that telephone infrastructure developed very fast in Asia in the 1990s. In particular, this period saw an increase in the use of mobile phones, the penetration of which was insignificant in the 1980s in Asia. The use of personal computers and the rate of Internet connections also progressed. Again, a comparison of the average between 1992-96 and the figures for 1999 reveals the rapid spread of computers and, in particular, the use of Internet in Asia during the 1990s.

Despite the vast infrastructure investments and the achievements in improving telecommunications infrastructures, the level of information infrastructure is still low in many Asian countries. China, Indonesia, Thailand and the Philippines are directing their efforts to satisfying the need for basic services. Some countries, notably Thailand, have experienced difficulties in keeping pace with population growth and face a rapidly growing unmet demand for telecommunications services (APEC, 1998).

As a result of different levels of development, there remain major disparities in the levels of information infrastructure in individual Asian countries. Furthermore, the development of telecommunications infrastructure tends to be uneven across regions within each country. For example, the number of telephone lines per 100 persons was 11.67% in China's relatively developed East region, but much lower in the Central and West regions at 4.07 and 3.59%, respectively, in 1997 (Yang, 2000). In Thailand, the government has acknowledged that in the transition to the knowledge society "*what is particularly worrisome is the question of universal service, namely an information infrastructure that is both universally available and at affordable costs*" (Thailand NITC, 1995).

Table 5. **Indicators of telecommunications development in selected Asian economies**

		China	Korea	Malaysia	Singapore	Thailand	Chinese Taipei	High-income OECD[1]
Investment in telecommunications								
Investment in telecom. as a % of GDP (UNESCAP)	1987-91	0.26	1.13	0.73	0.67	0.41	0.91	n.a.
	1992-96	1.24	0.77	1.52	0.51	0.19	0.79	0.50 (1995-97)
Investment in telecom. as a % of gross fixed capital formation (WEF)	1996	4.22	2.58	4.17	1.06	0.54	3.10	3.03
Telephone infrastructure and use								
Mainlines, per 1 000 persons (WB)	1987-91	5.2	275.1	82.1	374.67	21.68	290.0 (UNESCAP)	458.6
	1992-98	35.7	405.9	159.9	485.6	58.4	407.3 (1992-96) (UNESCAP)	532.5
Mainlines, per 1 000 persons (IMD)	1999	84.3	449.7	219.3	484.1	84.5	569.5	585.4
Cellular phone subscribers per 1 000 persons (WB)	1987-91	0.01	1.47	3.38	1.572 (1988-91)	0.90	3.10 (1992-96) (UNESCAP)	9.69
	1992-98	5.72	85.13	52.96	149.83	20.82	30.7 (1991-96) (UNESCAP)	114.48
Cellular phone subscribers per 1 000 persons (IMD)	1999	32.68	499.04	145.05	381.45	39.57	493.60	417.9
Computer and Internet use								
PCs per 1 000 persons (WB)	1987-91	0.44	28.78	7.72	65.95	3.52	n.a.	111.78
	1992-98	0.17	9.06	3.22	15.46	1.19	7.91 (UNESCAP)	218.57
Computers per 1 000 persons (IMD)	1999	9.7	181.3	94.5	390.9	40.4	260.1	374.4
Internet hosts per 10 000 persons (WB)	1994-98	0.11	18.31	10.37	81.79	1.76	n.a.	197.25
Internet hosts per 10 000 (IMD)	1999	0.5	60.3	28.0	221.9	4.9	200.4	429.5
Television sets per 1 000 persons (WB)	1997	271.8	345.8 (1998)	166.13	347.7	236.1	n.a.	679.4
IMD ranking in infrastructure (IMD)	2000	42	31	26	13	43	22	13.7

1. 23 OECD countries with 1998 per capita GNP of USD 9 361 or more.

Source: World Bank, *World Development Indicators 2000;* IMD, *World Competitiveness Yearbook 2000;* UNESCAP (1999), *Economic and Social Survey of Asia and the Pacific*, http://www.unescap.org/drpad/pub3/svy4c.htm; WEF, *Global Competitiveness Report 1998;* Government of Chinese Taipei, *Working Plan for Enhancing National Competitiveness*, http://mis.cepd.gov.tw/imd/defualt.htm.

Gaps with regard to the provision of information infrastructure between urban and rural areas remain large in most of the Asian countries. In rural areas, facilities are mostly lacking and need to be significantly improved. For example, in Thailand, it is estimated that only one-third of the population residing in large cities would benefit from a doubling of the number of telephone lines from one for every ten persons to one for every five persons between 1996 and 2001. The 1 million telephone lines installed in the late 1990s by a private firm in the provincial areas still only serve large cities where revenues are highest. As a result, many sub-districts and villages in Thailand are still without public telephone service. Although governments in China, Thailand, Chinese Taipei and Malaysia are giving special attention to improving information infrastructure in rural areas, much remains to be done.

Asian countries should continue liberalising their telecommunications markets. Liberalisation is necessary to mobilise greater investment in infrastructure, to bring down prices and improve the quality of services. Although the trend towards increasing liberalisation of telecommunications services is well underway in Asian countries, many important markets are characterised by a monopolistic or duopolistic structure. The public sector still has a strong stake in the provision of telecommunications services in China, Malaysia, Korea and Thailand (APEC, 1998). State monopolies in telecommunications service provision lead to high levels of user charges, thus preventing an increase in the demand for services. For example, the per minute charge for an international long-distance call in China was six times higher than that in the United States. This means that Chinese consumers pay CNY 12.5 billion more a year (approximately USD 1.55 billion) (Yang, 2000). Countries such as China and Thailand are only beginning to liberalise their telecommunications markets and the process needs to be accelerated. Singapore and Chinese Taipei have already carried out liberalisation programmes and, in these countries, the process needs to be deepened to ensure that markets become truly competitive. In the case of Korea, the government should withdraw from its too-heavy involvement in the business plans of telecommunications services providers, and take steps to increase competition through measures such as easing licensing requirements, improving interconnection frameworks and using auctions to allocate spectrums. The Asian countries are also committed to opening up their telecommunications sectors to international competition under the 1997 *WTO Agreement on Basic Telecommunications* (Table 6). It will be important for Asian countries to fulfil these commitments and to follow up with further measures to liberalise telecommunications markets.

Table 6. **Commitments of selected Asian economies under the WTO Agreement on Basic Telecommunications, February 1997**

Economy	Foreign ownership limitations	Other major commitments
Korea	20% in Korean telecommunications (33% from 2001); 33% in all other suppliers (49% from 2001)	Competition in fixed network services and full competition in resale of telecommunications services, including voice resale as from 1999.
Malaysia	30% in existing licensed public telecommunications operator	Final offer allows foreign ownership of up to 30% of existing licensed public telecommunications operator.
Singapore	49%	Competition in facilities-based telecommunications services from April 2000 with the licensing of up to two additional operators. Open markets for cellular and other mobile services as from April 2000. Commitment to resale of public switched capacity from most basic services.
Thailand	20%	Commitment to introduce market access and national treatment in telephone, telex, telegraph and fax, as from 2006.
China[1]	25% in basic telecommunications, which will increase to 40% four years after WTO admission	Mobile network opening up after one year and fixed network after three years of WTO admission, and achieving the committed targets within five and six years in the respective markets.

1. China is not yet a member of WTO; the information in this table is based on the agreement reached between China and the United States regarding China's WTO entry.
Source: APEC (1998); Yang (2000).

Investing in education and training

To differing degrees, all Asian countries face a shortage of human capital needed for more knowledge-based economic development. Failure to address human capital needs through education and training will overshadow the future potential of the Asian countries to develop knowledge-based industries. Their past performance in providing education varies. The Education Performance Index (EPI), which takes into account key aspects of a country's educational system and can be compared to the per capita income ranking of a country, allows comparative evaluation of educational performance relative to economic development (Table 7). Several countries, including China, Vietnam and Indonesia, have achieved education outcomes far better than their income ranking would suggest. By contrast, countries such as Malaysia and Thailand have education rankings which are far lower than their income rankings. The situation in the latter countries is particularly serious; basic educational conditions such as qualified primary school teachers and textbooks are not in sufficient provision and higher education is inadequate. This group of Asian countries will have to redouble their efforts to improve their education systems.

Table 7. **Educational performance index and income rankings for selected Asian economies**

EPI ranking	Country	EP index	Per capita income (USD PPP)	Income ranking	Difference in ranking
2	Singapore	0.60	20 987	3	1
9	Indonesia	4.22	3 740	42	33
11	Korea	4.51	10 656	10	-1
14	China	5.73	2 604	55	41
29	Thailand	12.18	7 104	19	-10
32	Malaysia	12.80	8 865	16	-16
43	Philippines	17.98	2 681	54	11
55	Vietnam	23.39	1 208	80	25

Source: Oxfam International (1999).

Some Asian countries such as Korea, China and Singapore, which traditionally place a high value on education, suffer from an inability to foster students' abilities in innovative thinking and creativity – skills which are critical in the knowledge-based economy. A distinction can be made between education which involves the "absorption" of knowledge and that which strengthens capabilities to interpret and generate knowledge. The latter is characterised by an emphasis on teaching students to think and question, while the former is a form of passive learning. Although East Asian countries benefit from their strong emphasis on education, their formal schooling system lacks a focus on creative thinking. To meet the increasing need for creativity in a knowledge economy, Asian countries must reform the curricula and orientations of their educational systems.

Box 7. **Singapore's educational reform**

Learning without thinking is labour lost; thinking without learning is perilous
Confucius (quoted in a Singapore subway poster campaign)

Singapore, due to the strong influence of Chinese culture in its educational system, is faced with the same need to reform its educational system as China. Having learnt from the Asian crisis of the importance of innovation for a maturing economy in general and for the advanced IT industry in particular, Singapore is now pushing forward its educational reforms with renewed vigour. In its 1998 budget, education received an increase in funding of 30%, with expenditures of SGD 2 billion in 1998 (or 3.6% of GDP).

Reform measures include: spending of SGD 2 billion in the next five years on installing computers in schools; reviewing university entrance criteria, with greater attention being paid to extra-curricular activities and less emphasis placed on grades; overhauling the entire syllabus on advice from Cambridge, Harvard and Japanese universities; allowing A-level students sitting literature exams to take their texts into the examination rooms as a way of encouraging literary appreciation rather than learning-by-rote. Other efforts aimed at boosting innovative ability include: implementing a *National Innovation Framework for Action* building on previous initiatives, encouraging industry to be more creative in R&D and encouraging links between educational institutions and industries as a way of fostering innovation.

Korea, China and Singapore are slowly recognising the shortcomings in their educational systems. In Korea, the national secondary education system, which emphasises preparation for university admission examinations, has bred uniformity and inflexible mindsets. Similar problems exist in the Chinese educational system, as indicated by recently released results of a national survey on education which concluded that the Chinese education system was too exam-oriented. Some Asian countries recognise that they can benefit from co-operation with Western universities, which teach more creative thinking, and are now using ICT for online educational exchanges. Singapore is actively exploiting opportunities for co-operation with Western universities, including the facility for electronically transmitting lectures conducted by an MIT professor in the United States to classrooms at the National University of Singapore. Singapore also provides incentives for world-class educational institutions such as INSEAD to set up facilities in Singapore (Box 7). In addition, Virtual College offers a large number of modules in engineering, information technology and business education, providing students in Singapore with access to programmes in the United Kingdom (Robertshaw, 1999). Chinese Taipei, which has the same cultural origins, has shown some entrepreneurial spirit and the ICT sector as a whole has been innovative. Benefiting from its pursuit of overseas education, Chinese Taipei has also been more successful than other Asian countries in fostering innovative mindsets (Box 8).

Box 8. **Chinese Taipei's experience with overseas education**

Efforts to develop Chinese Taipei's electronics industry began as early as 1974 when the Ministry of Economic Affairs set up the *Electronics Industry Development Centre* (EIDC) under the newly established *Industrial Technology Research Institute* (ITRI). Chinese Taipei's semiconductor industry got its start when EIDC, in collaboration with the Radio Corporation of America, developed a manufacturing process for integrated circuits. Thirty-eight young scientists and engineers, sent to the United States to receive training in the mid-1970s, later formed the vanguard of a cadre of technical experts who laid the foundation for Chinese Taipei's information industry.

Due to inadequate opportunities for educational and professional advancement at home, many college and university graduates went abroad to pursue their career plans. There, they completed advanced degrees and obtained employment in academia or at research institutions or in the R&D departments of large corporations. This "brain drain" caused concern in Chinese Taipei in the 1970s and 1980s, when it was viewed as an irretrievable loss of valuable human resources badly needed for economic development at home. However, flows of human resources, like movements of financial capital, can be reversed – and, in the late 1980s, Chinese Taipei's expatriated human capital began to return home.

During the 1980s, 14 882 scholars with advanced degrees – compared with 33 514 students with masters and PhDs graduating from local educational institutions – returned to join the domestic workforce. During 1990-95, the flow of returning scholars increased dramatically to 30 238, more than half the number of advanced degree holders graduating from domestic institutions during the period. Many of the returnees have become valuable assets, contributing to Chinese Taipei's technological upgrading and economic restructuring in recent years.

Source: Sun (1999).

In the knowledge economy, human resources have become the single most important determinant of living standards and the costs of exclusion from education are immense. In many Asian countries, where bias against poor, rural and female elements in education still persists, universal education should be incorporated into poverty reduction strategies as well as improved access to health and support for livelihoods. Providing the poor and disadvantaged groups with access to affordable education is one fundamental way to address the risk of a widening digital divide in Asian societies. While the Asian countries are aware of the risks of a digital divide in the knowledge-based economy, as has been the case in Thailand (Box 2), greater efforts are required if this issue is to be appropriately addressed.

The accelerating pace at which new knowledge, technologies, processes, work methods and organisational forms, etc., are being introduced in the knowledge-based economy means that lifelong learning has become a necessity. People need to learn and update their knowledge and skills continuously to keep abreast with changes in their functions and, indeed, to guarantee their employability in the future. In addition, as the Asian economies become increasingly industrialised and their workforce moves from agricultural to industrial employment, there is a need for retraining of the existing labour force, particularly with a view to the requirements of the development of the service sector in the knowledge economy. The need for retraining also stems from economic restructuring which, for example in the case of China, requires retraining the huge cohorts of workers laid-off from the state-owned enterprises and other sunsetting sectors. Lifelong learning calls for new facilities to be added to the existing educational and training systems, while on-the-job training needs to be encouraged in both the private and public sectors. To compensate for the lack of public resources, enterprises and individuals must be encouraged to undertake private investment in education and training.

In summary, four issues need to be addressed by the Asian countries in reforming their educational systems, although the focus may differ by country: *i)* increase spending on educational resources and improve efficiency; *ii)* reform educational approaches to meet the increasing need for creativity in the workforce; *iii)* promote the use of information technologies, *e.g.* computers and Internet, in schools and for distance learning; and *iv)* provide equal access to education for the poor and rural populations. In addition to reforming their educational systems, the Asian countries need to expand and improve lifelong learning as a means of retraining their workforces to fulfil the skill requirements of the knowledge-based economy.

Improving innovation capacity

To different degrees, Asian countries can be characterised by a lack of innovation capability; consequently, they rely largely on foreign technology for development. Among Asian countries, Korea and Chinese Taipei are technologically more advanced. They are the only Asian countries, with the exception of Japan, to have built up the critical mass of technological and managerial expertise to compete with leading American and Japanese firms (Lehman Brothers, 2000). Nevertheless, even these two countries are faced with challenges in upgrading their indigenous innovation capability. For example, Korea is characterised by low efficiency in terms of R&D input and output ratios, in addition to other shortcomings in its innovation abilities (Box 9). The Chinese Taipei system, which has been very successful in the past, is faced with insufficient private investment in R&D due to the relatively small size of the firms that dominate its industry and a weak foundation in basic research (Sigurdson, 1999). Meanwhile, younger Chinese Taipei students studying in foreign countries tend to be less interested in staying abroad to gain work experience after their education, meaning that the benefit of having experienced scholars and engineers returning from more industrialised countries will come to an end in 5-10 years (Sun, 1999).

Box 9. **Shortcomings in Korean innovation capabilities**

Technology imported from abroad has played an important role in Korea's rapid economic development. The most important sources have been the technology embodied in imports of capital and goods, and licensing arrangements. Following the liberalisation of licensing arrangements in 1978, royalty payments rose from an annual average of less than USD 100 million to USD 1 billion by 1990, and to almost USD 2 billion by 1995. In addition, Korean businesses have participated in joint ventures with multinational corporations and acquired foreign firms to gain access to technology. In contrast, the inflow of foreign direct investment, a major source of technology for many countries, has been very low in Korea, reflecting high barriers in the past. As Korean firms have become major competitors in many fields, foreign companies are less willing to sell them technology, making domestic research and development programmes in Korea more important.

Three-quarters of Korean scientists and engineers with PhD degrees are employed by universities, which accounted for less than 10% of total R&D investment compared to the OECD average of 18%. The relatively limited role of the universities has hindered basic research, which is considered to be important for building longer-term innovative capability. Although the government has sought to strengthen R&D activities in universities by expanding budgetary resources, the gap between university research and industry remains large.

Source: OECD (1998).

Singapore, which is to a large extent engaged in medium-level assembly, stands one level below Korea and Chinese Taipei in terms of technological sophistication. Countries such as Malaysia, Thailand and China, which are involved in basic electronics assembly, are further behind. Problems stem from the low level of R&D inputs, including both R&D personnel and expenditures (Table 8). Enterprise R&D expenditures and research co-operation between universities and companies are insufficient. Reforms are needed to stimulate R&D investments by the private sector, develop enterprise innovative capability, enhance the role of the universities in R&D activities, and disseminate technology and R&D results.

Table 8. **R&D statistics for key Asian economies**

	CN	KR	MY	SG	TW	TH	High income OECD[1]
Scientists/engineers in R&D per million people (1981-95)	537	2 636	87	2 512	2 114[2]	173	3 175 (1993)
Technicians in R&D per million people (1980-95)	187	317	88	1 524	861[3]	51	n.a.
Expenditure on R&D as a % of GNP (1980-95)	0.6	2.8	0.4	1.1	1.5[3]	0.2	2.3 (1981-96)
Business expenditure on R&D as a % of total R&D expenditure (1997)	46	63	73	73	58	15[2]	56
Degree of technological co-operation among firms (2000)[4]	3.93	3.94	4.26	6.16	5.90	3.54	4.59
Degree of research collaboration between universities and firms (2000)[4]	3.58	4.11	3.59	6.03	5.27	3.05	4.77
Ranking in overall S&T competitiveness (out of 59 countries) (2000)	28	22	31	9	12	47	15

Key: CN = China; KR = Korea; MY = Malaysia; SG = Singapore; TW = Chinese Taipei; TH = Thailand.
1. 23 OECD countries with 1998 per capita GNP of USD 9 361 or more.
2. Researchers, 1985-95.
3. Average, 1985-95.
4. Measured on a scale of 1 to 10.
Source: World Bank, *World Development Indicators 2000;* Asian Development Bank, *Key Indicators 1998;* IMD, *World Competitiveness Yearbook 2000;* Council for Economic Planning and Development, *Chinese Taipei Statistical Data Book 1997*.

Countries such as China, Singapore, Korea and Malaysia (Box 10) have made the improvement of their innovation capabilities a priority in their development strategies. However, these countries face financial and human resource constraints due to their levels of economic development. There is also a need to develop a market-based innovation system, with public support facilitating – but not substituting for – private sector investment in innovative activities. Finding the right balance between the roles of government and industry is fundamental to developing innovation capacity in these countries, not least because of their traditionally government-led growth strategies. The development of a market-based national innovation system should place high priority on making knowledge-creating institutions more responsive, and on strengthening market mechanisms and framework conditions for innovation-based market competition. This will be key in encouraging firms to shift their attention and resource allocation to innovation, enabling them to become generally more competitive and raising their capacity to initiate novel products and activities.

Box 10. **Malaysia's innovation reforms**

Malaysia lacks the R&D capability required to support the development of the economy. Problems include: a low input level of R&D resources, at 0.22% of GDP, and a declining trend from 0.37% since 1992; lack of links between research institutions and industry, and insufficient human resources, as seen in the large disparities between the type and number of scientific and technological workers produced and required by the nation. According to Malaysia's National Council for Scientific Research and Development, the country is currently redoubling efforts to improve the situation by:

Increasing R&D inputs: The targeted level of investment in R&D envisaged by the *Action Plan for Industrial Technology Development* (APITD) is to increase to 2% of GDP by the year 2000.

Enhancing private sector R&D: The private sector is expected to provide 60% of national R&D expenditures, with the government providing tax incentives, infrastructure and other forms of assistance.

Improving science-industry links: This will be done through increased efforts by research institutions and universities to reach out to industry and by promoting greater industry participation in the public research agenda.

Enhancing human resource development: A *Science and Technology Human Resource Development Fund* has been created to develop a pool of skilled and trained S&T workers at a cost of MYR 300 million within the framework of the Seventh Malaysia Plan.

Entering into strategic alliances: Malaysia will participate in regional, multilateral and bilateral joint S&T activities, including the ASEAN Committee on Science and Technology, the APEC Working Group on Industrial Science and Technology, the Asia-Europe Expert Meeting on Technological Co-operation, and collaboration with the Massachusetts Institute of Technology on biotechnology R&D.

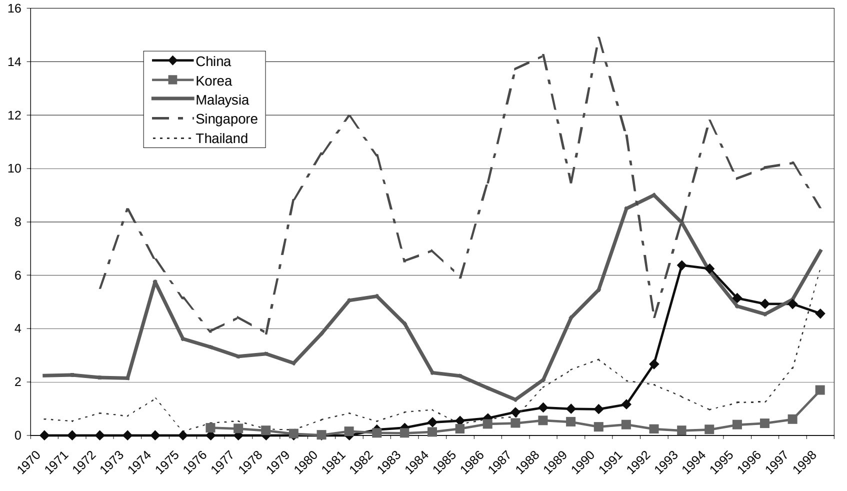
Source: MNCSRD (1998) and MSTIC (1997).

Enhancing gains from foreign investment

Given that the development of Asian innovation capability is a long-term process, foreign direct investment (FDI) will continue to serve as an important source of capital and technology. FDI had been significant for several Asian countries, ranging from a high of 10% of GDP in Singapore to nearly 5% in the case of China and Malaysia and to 1.3% in Thailand in the mid-1990s (Figure 9). FDI has been less important in Korea, accounting for just 0.45% of

GDP, due primarily to the heavy reliance of Korean firms on foreign bank borrowing. Meanwhile, on the whole, FDI inflows have served as an important channel for technology transfer to Asian countries. However, recent reports show that although many Asian economies recovered impressively from the financial crisis of 1997-98, FDI fell in the region and only Singapore and Korea showed a substantial rise in foreign investment in 1999.

Figure 9. **FDI net inflow to selected Asian economies as a percentage of GDP, 1970-98**



Source: Based on data from World Bank (2000).

In the past, the relatively cheap, abundant, well-educated and hard-working labour force was one of the decisive factors attracting large inflows of FDI to Asia. As labour costs in some Asian countries have become less competitive, the ability to attract FDI will increasingly be dependent on a number of other factors including: the size of the domestic market and demand for ICT products; the state of infrastructure, especially the quality and cost of telecommunications services and logistics such as road transport; the availability of and proximity to high-quality component producers; local R&D capability; and the quality of human resources (Table 9). These factors will also be critical to whether Asian economies can maximise domestic spillovers of technology and know-how from foreign investment.

Table 9. **Assessment of investment conditions in selected Asian economies**

	CN	KR	MY	SG	TW	TH	ID	PH	VN
Supply of labour	A	C	C	D	D	B	A	A	A
Quality of labour	C	B	C	B	A	C	D	B	D
Cost of labour	A	C	C	D	D	B	A	A	A
Infrastructure	C	C	B	A	B	C	C	C	D
Domestic markets	A	C	C	D	B	B	C	C	C
Local suppliers	C	C	B	B	A	B	D	D	D
Incentives	B	B	A	A	C	A	C	B	C
WEF international competitiveness ranking, 1998	28	19	17	1	6	21	31	33	39
IMD international competitiveness ranking, 1998	24	35	20	2	16	39	40	32	n.a.

Key: CN = China; KR = Korea; MY = Malaysia; SG = Singapore; TW = Chinese Taipei; TH = Thailand; ID = Indonesia; PH = Philippines; VN = Vietnam.
Note: The scale of assessment is from A to D, with A denoting the most favourable conditions.
Source: *Lehman Brothers 2000* for Singapore, Malaysia, Thailand, Philippines, and Indonesia; A 1995 survey of Japanese manufacturing activities in the ASEAN region quoted in *Panichapat and Kanasawat 1999*, for Chinese Taipei and Vietnam; and own assessments for China and Korea. WEF, *The Global Competitiveness Report 1998;* IMD: *World Competitiveness Yearbook 1998*.

Fundamentally, Asian countries need to re-think their FDI strategies in the context of the global knowledge-based economy, in which countries need to plug into and advance their positions in the global value-added chains and knowledge networks. FDI policy in a global economy should serve increasingly as an instrument to help countries participate in and benefit from global knowledge exchange, rather than simply exporting products while absorbing capital and technology from abroad. In the past, Asian countries have been mostly on the receiving side of the technology transfer that occurred with the inflow of FDI to their countries. However, as the Asian economies become more developed, they need also to contribute to the global knowledge network if they are to remain attractive locations for FDI and innovative activity. These considerations further emphasise why Asian countries must urgently enhance their innovation capabilities, as discussed above.

There is strong competition for FDI in labour-intensive industries from China, Indonesia, the Philippines and Vietnam. Countries such as Malaysia and Thailand have become less competitive because of their rising labour costs. According to a survey by Thailand's Board of Investment in 1999, direct labour costs in the hard disk drive industry were USD 75 per month in China, USD 150 in the Philippines and USD 170 in Thailand. Salaries for Chinese engineers and managers are only one-third of those of their counterparts in Thailand and less than one-half of those of their Filipino counterparts (Panichapat and Kanasawat, 1999).

FDI competition will be on the basis of factors that individual Asian countries can provide, and each country must enhance those conditions which will best allow it to gain domestically from inward investment. For example, China is most competitive in terms of labour supply and costs, as well as providing a vast potential market. Singapore, with the highest labour costs in the region, is more attractive than China in terms of its infrastructure facilities and the network of local competent suppliers. China would have an advantage over Singapore in drawing investments in labour-intensive mass production of low-end components and sectors, while Singapore would be attractive for foreign interests investing in regional distribution facilities and logistics and medium-to-high-end components and sectors. Given the regional differentiation in comparative advantages, it is important for individual countries to develop new competitive edges over time while improving overall conditions for FDI. However, a strategy that depends exclusively and/or excessively on FDI and foreign technology, and that neglects the development of indigenous technological and innovation capabilities, is not sustainable in the long run.

POLICY IMPLICATIONS

In addition to the four areas described in the preceding chapter, other factors are important for the qualitative development of knowledge-based industries in Asian countries – as they are for all OECD countries. The broader policy agenda should include: creating new incentives through deepening market reforms, including reform of the public sector and competition policy; improving conditions for the development of SMEs; promoting development of high-value-added service sectors; promoting investment in intangible assets; fostering the development of venture capital markets; and upgrading industrial structure, including adoption of advanced organisational and corporate governance approaches in Asian companies. Industrial restructuring and enhanced creativeness are essential to enable the Asian countries to shift away from a narrow focus on certain sectors such as electronics and to bring their industrial structures in line with the evolution in their comparative advantage, which is less and less dependent on low labour costs. Since technology advances at a very rapid pace in knowledge-intensive industries, industrial structures must also have a capacity to evolve at considerable speed. The inability of a state-led growth strategy and planning mechanism to carry out timely structural adjustments has been increasingly recognised, not least in the wake of the Asian crisis (OECD, 1999a). This suggests that the required level of economic dynamism in a knowledge-based economy may only be achievable through a dynamic market system where firms can adjust spontaneously to changes in technology and market demands. Therefore, the development of knowledge-based industries may require Asian countries to adopt a market-based growth strategy, moving away from the state-led growth strategy and government intervention of the past, in order to enable their knowledge-based industries to become genuinely dynamic, innovative and responsive to market signals. The policy challenges facing the Asian countries, however, vary according to their current level of industrial development.

Korea, Singapore and Chinese Taipei

Countries included in the first tier of Asian industrialising economies are Korea, Singapore and Chinese Taipei. These economies are at a comparable level with industrialised countries in terms of microelectronics-based industry production, and in some instances, they may be even ahead of the industrialised countries. They have acquired a skill base (including production and consumption experience) and the technological capability necessary for maintaining a strong position in ICT industries. ICT sectors in these economies are maturing and firms are slowly but steadily graduating from the "catching-up" phase of development into a phase of regional technical leadership.

For these economies, the challenges of further development include:

- Although these economies are likely to remain export-oriented in their ICT industries, they should ***strengthen links between production and domestic demand***, not just gearing output to export markets. The links between ICT industries and domestic demand should be developed with regard not only to domestic consumer markets but also to other industries and sectors of the domestic economy in order to speed up the process of restructuring of traditional industries, and upgrading the economic structure in general, through ICT applications. This will in turn give a demand boost to ICT industries, as companies need to develop differentiated, price-competitive, high-quality ICT-related products and services to meet both domestic and overseas demand. It will also further the development of local suppliers of inputs and components, thus contributing to the process of industrial restructuring. In this context, further liberalisation and deregulation of regional markets could help to create economies of scale for Asian producers in locally oriented products.

- At this stage, these governments should focus on ***enhancing key framework conditions*** and fostering a market environment for knowledge-based industries, and should refrain from more direct and possibly distorting interventions. Further industrial development will depend on an efficient institutional and microeconomic infrastructure, including the efficiency of factor markets, extension of science parks, development of venture capital markets, enhancing conditions for SMEs, appropriate competition policies, and fiscal incentives to intangible investment such as R&D and personnel training.

- Progress in ICT-related sectors, particularly computer software and electronic commerce, will depend on ***better legal frameworks and enforcement***, particularly relating to the protection of intellectual property, the security of commercial information, and privacy safeguards for consumers and companies. As in the OECD countries, governments should provide a conducive environment through the adaptation and creation of framework conditions to support progress in more advanced knowledge-based activities.

Malaysia and Thailand

Countries included in the second tier of Asian industrialising economies are Malaysia and Thailand (as well as the Philippines and Indonesia, which are not covered by this study). Despite the differences between these two countries in terms of income levels, information technology production and exports, and human resource and technological capabilities, they share the following common characteristics: reasonably high literacy rates; ICT technological capabilities which lag behind the levels suggested by their levels of income and high-technology exports; insufficient information infrastructure, as reflected by *e.g.* the number of main phone lines per 100 inhabitants; and ICT industries which suffer from structural weaknesses, including a high reliance on foreign technology and capital. It is estimated that it will take ten years or so for these countries to catch up to the lowest telecommunications infrastructure level in industrialised countries.

Areas of special policy importance for these countries (in addition to those mentioned for the first group of countries) include:

- ***Strengthening their national education systems***. Although these countries have started to pay attention to education, there is a severe shortage of highly qualified human capital, due partly to rapid economic growth. The future of these countries' knowledge-based industries will depend on how effectively and quickly they can overcome the lack of technological capabilities.

- ***Continuing investment in information infrastructure*** should be a priority, particularly in rural areas. Further telecommunications liberalisation will be necessary to allow the participation of the private sector and foreign investors in the provision of infrastructure and to introduce competition to make telecommunications services affordable for the majority of the population.

- ***Engaging in industrial restructuring*** is a necessity in the ICT industries in order to realise competitive advantages. These countries need to find ways to maintain their competitiveness in specific ICT sectors under pressure from China and other newcomers. Domestic and regional markets should be developed and better upstream and downstream linkages established with local supporting industries.

China

China's present development policy focuses on low-end, labour-intensive electronic products and some other technology-based sectors. This policy seems viable in the medium term. China may have the potential to catch up to the lowest level of industrialised countries in ten years (most optimistic scenario) to 20 years (more realistic scenario). This applies both to the development of telecommunications infrastructure and the general development of the ICT industry. The assessment is based on: its human resources comprising vast cheap labour and educated R&D personnel; improving telecommunications infrastructure and the speed at which the use of personal computers and Internet spreads; current production experience in ICT-related industries; its ability to attract FDI and compete on the basis of labour costs in electronics export markets; and its huge domestic market supporting the development of ICT industries.

Recommendations for China vary somewhat from those for the other Asian countries due to its lesser state of development. China should focus on:

- ***Continuing investments in information infrastructure***, both fixed main phone lines and mobile phone networks, and enhancing basic infrastructure such as energy and transportation. Human capital investment should be strengthened to improve both primary and higher education.

- ***Upgrading technological capacity***. Engaging in more joint research activities and attracting FDI in research would allow China's highly trained human resources to be more productively employed and increase the country's access to new technologies, experiences and skills. For this to be possible, it is important that the government provide market-based incentives and improved investment conditions, including protection of intellectual property rights, rather than targeting and picking winners. In addition, more attention should be given to upgrading basic technological capabilities and disseminating existing technology more widely.

- ***Remaining competitive in labour-intensive industries***. Experiences from the Asian crisis suggest that it is important for an industrialising economy like China to maintain competitiveness in traditional labour-intensive sectors while at the same time trying to develop high-technology industries.

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