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Innovation Policies in South Korea and Taiwan

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Contents

1 INTRODUCTION

1.1 Background

East and Southeast Asia experienced remarkably high and stable economic growth rates from the 1960s until the 1997 July financial crisis. Much has been said about the economic and industrial development in this part of the world. A controversial effort to explain the success of eight high-performing Asian economies (Japan, Hong Kong, South Korea, Singapore, Taiwan, Indonesia, Malaysia and Thailand) was The World Bank’s study (1993) *The East Asian Miracle*. To a large extent, the debate over the ‘miracle’ was about industrial policy, which differs greatly throughout the world with industrialized economies as well as developing countries, adopting a variety of policy regimes. Although they are frequently grouped together, the world’s newly industrializing countries are a highly heterogeneous collection of economies. One conclusion from the study (1993) was that the state’s role in East and Southeast Asia has been restricted to that of ‘getting the fundamentals right’ and facilitating the free operation of market forces. This view has been a target of much criticism (Lall; 1994, Wade and Evans; 1994, Singh; 1995) as in reality the state has been fundamental to the industrialization of these economies.

According to Perkins (1994), government involvement took different forms in different countries: the manufactured export-led state interventionist model of Japan, South Korea and Taiwan; the free-port service, commerce-dominated model of Hong Kong and Singapore, and a model of economies poor in human resources but rich in natural resources (Indonesia, Malaysia and Thailand).

Economic competitiveness has many dimensions, most outstanding is technological change, which is perhaps the most important source of structural change in an economy, because it both enhances productivity and alters the mix of products, industries, firms and jobs which make up an economy. It causes these changes in a subtle manner, creating new jobs and firms, destroying old ones, and disturbing the equilibrium (Schumpeter, 1934).

Another element, which builds upon human capability, is knowledge. A more accurate perspective of national economic differences is not a focus on differences in resource endowment or differences in the rate of growth of capital or labour. Perhaps it is “the growth and accumulation of useful knowledge, and the transformation of knowledge into final output via technical innovation, upon which the performance of the world capitalist economy ultimately depends" (Griffin, 1978). This is implicit in the new growth theories, and in the role of institutions, whether through explicit policy or through more subtle modes of social regulation.

It could be said that the High-Performing Asian Economies (HPAEs) were autarchic and outward rather than inward-looking and this orientation seems critical for all economic development (Malecki, 1997). Import substitution was used as a means of infant-industry promotion, and producers were pushed to meet market pressures with regard to prices and product quality in rather short time (Evans, 1995). Market orientation is usually aware of world standards, and domestic technological basis to attain them is the challenge for development. The learning processes depend critically on local conventions, institutions and the development of inter-firm linkages, but they only reach the desired development results when global and local market needs are met.

One of the most systematic approaches to developing technological capability is the followers' strategy for technological development. It emphasizes the need for human resources to allow an economy or a region to 'shift' from labour-intensive operation found in the early stages of the product cycle to more skilled-intensive activities at higher levels in the international division of labour (Sen, 1979). Japan was the first country to follow this strategy and was later followed by South Korea and Taiwan. In the initial stage, implementation of imported foreign technology and dependence on foreign experts prevail. The second stage, assimilation of the technology, permits product diversification based on indigenous capabilities. Sometimes a local component industry develops, too. The third stage comprises improvement of technology to enhance competitiveness of both product and processes in international markets (Kim, 1980). Tied to this phase is the development of local scientific and engineering talent. The fourth stage emphasizes the development of an independent innovative capability.

For small countries complete self-reliance is practically impossible, and therefore both an R&D capability and links to knowledge in the world at large are essential (Freeman and Lundvall, 1988, Walsh, 1987). Specialization, cooperation and internationalisation are the best choices for small economies in the global context (Simai 1990, pp. 115-116).

Stages in industrial development that generally correspond to the notion of technological learning are found in the sequences of industrial development in several Asian countries. Four tiers of industries correspond to successively higher capital-labour ratios and higher levels of technological sophistication (Ozawa, 1995; UNCTAD 1995, pp. 239-244)

- Tier 1: labour-intensive light industries (toys, clothing, footwear, sporting goods)
- Tier 2: scale-intensive heavy and chemical industries (steel, metals, fertilizers, basic chemicals)
- Tier 3: assembly-based industries where product differentiation and both scale and scope economies dominate (motor vehicles, televisions and other consumer durables)
- Tier 4: innovation-intensive 'Schumpeterian' industries in which R&D and close customer interaction are key inputs (aircraft, computers, pharmaceuticals)

Economies that are early on the development path seek to develop industrial sectors where the significance of economic and industrial development is felt in the future.

National and economic growth is a very complex process which, despite similarities between places, is locally, regionally and nationally specific. The penchant to compete as well as to imitate successes in other places has been especially pronounced in the case of policies to create technological capability. At the national level, this is manifested in industrial policies and science and technology (S&T) policies that try to 'target' certain industries and technologies which are considered to have especially high potential for future growth and to protect traditional industries (OECD, 1991). Industrial policy measures used to protect established sectors include subsidies, government procurement, tax preferences and national product standards. Macroeconomic policies are also critical since they influence the flow of finance to new industries and firms and create stable conditions in which entrepreneurs can operate (Porter, 1990, Roobeek, 1990).

National differences in the institutional and organizational structures supporting technological change are usually known as national systems of innovation, coined by Lundvall (1985). These structures go beyond a narrow view of innovation, and beyond earlier accounts of national research systems (Movery and Rosenberg, 1989) to encompass the range of state-societal arrangements and their influence on competitiveness (Freeman, 1995).

In recent years the ”triple-helix” model has been much discussed as a tool to understand university-industry-government relations. The ”triple-helix” thesis states that the university can play an enhanced role in innovation in increasingly knowledge-based societies. As knowledge becomes an increasingly important part of innovation, the university as a knowledge-producing and disseminating institution plays a larger role as a part of an innovation system. Industrial innovation was earlier an activity largely the preserve of either the industry or government or it may have been a bilateral interaction between these two institutional spheres (Etzkowitz et.al, 2000). Thus, industrial policies focused upon the government-business relationship, while in the ”triple-helix” model three institutional spheres (public, private, academic) are looked upon as critical elements in the innovation process.

Globalization has raised several fundamental issues for most countries. Firstly, national governments want to support their own national companies but nowadays its is no longer clear which companies are national as the identity of firms are increasingly blurred. Secondly, national policy makers have to formulate science and technology programmes that are in tune with the rapid technological development (Sigurdson and Cheng, 2001). The first issues requires a shift in policy focus from the macro to the micro-level, where governments seek to influence the performance of firms and industries. The second issue requires an increasingly close interaction with a global system of innovation (ibid).

1.2 Objectives and outline of the study

South Korea and Taiwan (R.O.C.) are two of the most well-known examples of newly industrializing economies which have been remarkably successful during the past three decades.

Particularly critical to understanding their success is the complex interaction of different institutions and policies – implicit as well as explicit.

The objectives of this study are:

- To give an update overview of South Korea’s and Taiwan’s policies concerning innovation and technology.
- To compare between these two economies, main point of strength and weakness regarding innovation systems, mainly based on institutional framework of the Triple Helix model.

Chapter 2 gives an account of various parts of *national competitiveness*, focusing on innovation systems, knowledge-based economy and state polices. Chapter 3 and 4 deals with South Korea and Taiwan respectively, providing an account of their *development policies, innovation and technology policies.* In the case of Taiwan two industry-specific perspectives have are included, the IT-sector and the efforts to develop a commercial aerospace cluster and innovation system in the economy.

Chapter 5 gives an overall evaluation and comparative perspectives of strength and weakness of South Korea’s and Taiwan’s innovation systems.

2 NATIONAL COMPETITIVENESS

Due to the width of the concept, there is disagreement about the exact nature and influence of national systems of innovation. Technology systems (Carlsson and Jacobsson, 1994) and innovation communities (Lynn et.al., 1996) also are similar to national systems of innovation. Interacting institutions, user-supplier linkages and other agents give rise to a critical mass of knowledge. This ’co evolution of technology and organization takes place in the case of new technologies through the user inputs, linked firms, government and ’spanning organization’ (Rankin, 1995). This system, however, need not be national, and especially for small economies, it can involve international linkages in a major way. Despite the differences in terminology, all of these approaches incorporate the role of institutions as integral to the accumulation of technological capability and economic change (Metcalfe, 1995; Zysman 1994).

National systems of innovation are a complex combination of institutions that support learning processes and technological accumulation. However, empirical work is difficult because it is hard to identify which institutions, incentives and competences are important (Patel and Pavitt, 1994). Useful, historical studies, such as Nelson (1993), have been unable to discern adequately such things as the role of large firm, the benefits of basic research, and the influence of workforce education and training. Perhaps more importantly, they have not been able to compare the institutional competences and ways in which they facilitate learning processes systematically (Patel and Pavitt, 1994) Differences across sectors and technologies, as well as differences related to interaction and cooperation within and between firms, result in varying competitiveness of national industries (Guerrieri and Tylecote, 1994).

Another concept is technology infrastructure. This can be defined as the scientific, engineering and technical knowledge available to private industry, but must be considered to include generic technologies, ’infra-technologies’, such as government laboratories whose research results are widely available, forums for collaboration, standards and intellectual property rights (Tassey, 1991). The technology infrastructure is provided by a variety of institutions, public and private, with its principal objectives to create capabilities and build markets for new technologies (Justman and Teubal, 1995). The benefits of technology infrastructure centre around the self-reinforcing interaction that results from external economies, strong domestic industries, a skilled labour pool and supplier base, and the knowledge base in an economy (Krugman, 1992).

As defined by the OECD (1996), a knowledge-based economy is an economy in which the production, distribution, and use of knowledge are the main drivers of growth, wealth creation, and employment across all industries. The term ‘knowledge-based economy’ has drawn considerable attention in both academic and political arenas, but its exact meaning is still rather blurred. Since knowledge is an intangible good, it implies that an economy based on materials or manufacturing differs from a knowledge-based economy. There are many different features of knowledge, and the most important include:

First, as knowledge has become increasingly important as an economic good, the distance between knowledge and economic activities has shrunk. This could be applied to the ‘third mission’ of institutions of universities and other institutions of higher education and research. Second, knowledge as an input generates scale and scope economies, but the magnitude of these economies depends on the speed at which knowledge depreciates and becomes obsolete as well on market size. Therefore, speed and first-mover advantage are central aspects of industrial competition in the knowledge-based era (Chen and Liu, 2003).

Third, as knowledge is increasingly integrated into economic output, giving rise to the dematerialisation of final products, the boundaries between manufacturing and services and between hardware and software are not clear. Fourth, information technology and networks, which are central to the creation, distribution, and utilisation of knowledge, are necessary conditions for industrial development in the era of knowledge-based economy.

Technology, in general, is an enabling or facilitating agent that makes possible new structures, new organizational and geographical arrangements of economic activities, new products and new processes (Dicken, 1998). Already Joseph Schumpeter points out (1943) that,

“the fundamental impulse that sets and keeps the capitalist engine in motion comes from the new consumers’ goods, the new methods of production or transportation, the new markets, the new forces of industrial organization that capitalist enterprise creates” (p. 83).

Technological change is the ‘the fundamental force in shaping the patterns of transformation of the economy’ (Freeman, 1988) and ‘the chronic disturber of comparative advantage’ (Chesnais, 1986). Although technologies, in the form of inventions and innovations, originate in specific places, they are no longer confined to such places. Innovations spread or diffuse with great speed under current conditions.

A fifth aspect of a knowledge economy is that it is characterised by the globalization of a wide range of corporate value-added activities. Production innovation involves an assortment of knowledge related to various stages of the value chain. Knowledge applied to manufacturing, marketing, and customer services is complementary to the knowledge used in product innovation.

Vertical integration of the innovation function in the value chain is only justified if internalisation is the best way to acquire the relevant knowledge, and this is not always the case. Because of network externalities and product compatibility, successful innovations for technical systems entail intensive interfacing among actors with different knowledge- and skill-bases in an innovation network (Windrum 1999). On the one hand, innovations often result from collective efforts of interrelated firms. Moreover, the value chain does not need to be completely internalised within any individual firm. On the other hand, technology sourcing has been driving firms to internationalise their R&D (Gerybadze and Reger 1999, Niosi 1999) and to form inter-firm partnerships (Delapierre and Mytelka 1998). Thus, firms can build competitive advantage based on knowledge by leveraging and aligning both their internal and external networks on different geographical scales.

Over time, and under specific historical circumstances, societies have developed distinctive ways of organizing their economies, even within the universal ideology of capitalism. Capitalism comes in many different varieties and governance models with their differing conception of the role of government in regulating the economy (Berger and Dore, 1996; Doremus et. al, 1998; Turner, 2001; Whitley, 1999)

In *neo-liberal market capitalism,* exemplified by the United States, market mechanisms are used to regulate almost all aspects of the economy. Individualism is a dominant characteristic, where short-term business goals and 'share-holder value' tend to predominate. In *social-market capitalism*, a higher premium is placed upon collaboration between different actors in the economy with a broader identification of 'stakeholders' beyond that of owners of capital. This kind of capitalism can be exemplified by Scandinavian countries. In developmental capitalism, exemplified by Japan, South Korea, Taiwan, the state plays a much more central role, although not usually in the terms of public ownership. This mode of governance is characterized by the setting of substantive social and economic goals as well the as existence of a comprehensive industrial policy.

The most obvious stimulatory measures concerning industrial policy are various financial and fiscal incentives governments may offer to private sector firms (Dicken, 1998, 2003). The financial measures most commonly used fall into two categories. On the one hand, governments may provide capital grants or loans to firm to supply part or all of the investment required for a particular productive venture. The other major financial, or rather fiscal, incentive employed by governments is that of tax concessions. Under this banner a whole variety of measures may be employed, such as allowing firms to depreciate or write down their capital investment against tax at an accelerated rate, granting them tax reductions or even tax exemptions.

The rapid and far-reaching technological developments in innovation, products and processes, transportation and communication technologies etc, have led many governments to try to stimulate research and developments in key sectors and to encourage technological collaboration between firms. The perceived need to stimulate entrepreneurial activity has produced a whole battery of policies to encourage small and medium-sized enterprises. Governments may also attempt to restructure firms – and even entire industries – to improve their international competitiveness.

Regulation of national industrial activity can also take a variety of forms, such as state ownership of productive assets, although a current trend in many market economies is towards increased privatization. Entry into particular sectors may be discouraged through the operation of merger and competition policies, despite the current trends towards deregulation of certain industries such telecommunications and financial services. The various stimulatory and regulatory policies may be applied generally across the whole of a nation's industries or they may be applied selectively.

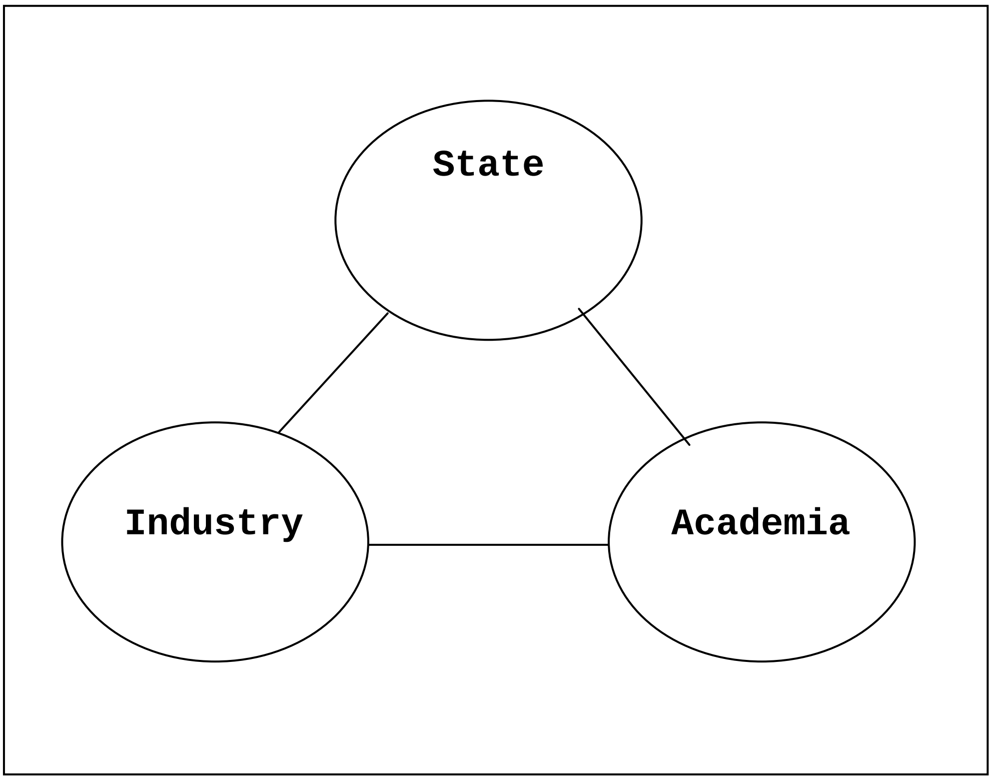
Industrial innovation was earlier an activity largely the preserve of either the industry or government or it may have been a bilateral interaction between these two institutional spheres.

Industrial and technology policies focused upon the government-business relationship, while in the ”triple-helix” model three institutional spheres (public, private, academic) they are viewed as critical elements in the innovation process. The ”triple-helix” thesis is analytically different from the national systems of innovation proposed by Lundvall (1992) and Nelson (1993) which regard firm as having the leading role in innovation.

The evolution of innovation systems, and the current conflict over the path to be taken in university-industry relations, are reflected in the varying institutional arrangements of university-industry-government relations (Etzkowitz and Leydesdorff, 2000). First, one can distinguish a specific historical situation which one can label Triple Helix 1, where the nation-state encompasses academia and industry and relations between them. The strong version of this model could be found in the former Soviet Union and in the Eastern European countries, while weaker versions were formulated in the policies of many Latin American countries and to some extent in European countries such as Norway (ibid).

A second model consists of separate institutional spheres with strong borders between the different spheres, as well as highly circumscribed relations among the spheres. Finally, ”triple-helix” III generates a knowledge infrastructure in terms of overlapping institutional spheres, with each taking the role of the other and with hybrid organizations emerging at the interfaces. Triple Helix 1 is largely viewed as a failed developmental model, with few possibilities for ”bottom up” initiatives. Triple Helix II entails a laissez-faire policy, nowadays also advocated as shock therapy to reduce the role of the state in Triple Helix 1.

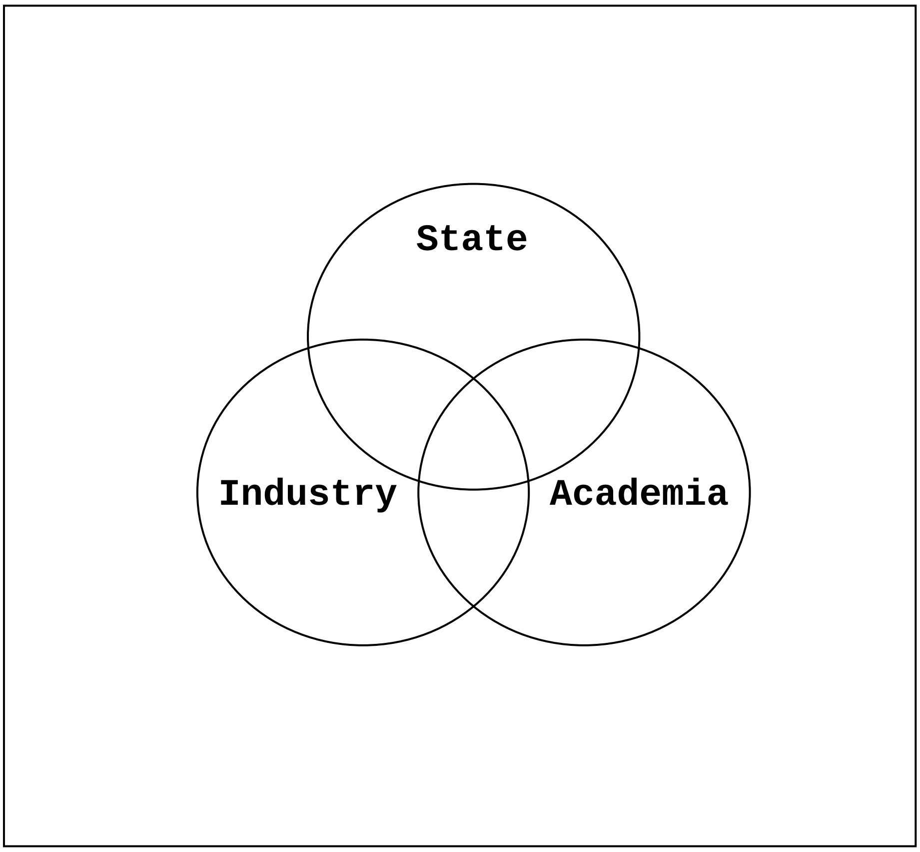
Figure 1: Triple-Helix II



Source: Etzkowitz and Leydesdorff, 2000.

In various forms, many countries are now trying to attain some form of Triple Helix III. Main objectives are to create an innovative environment consisting of university spin-offs, tri-lateral initiatives for knowledge-based economic development, and strategic alliances among firms, government laboratories, and academic research groups

Figure 2: Triple-Helix III



Source : Etzkowitz and Leydesdorff, 2000.

3 SOUTH KOREA

3.1 Development policies – general views

Korea had very limited contacts with the rest of the world until the opening treaties of 1876-83. After 15 years of adjustment, rapid development seemed possible but was cut short by Japan's annexation in 1910. The colonial era left in all Koreans a profound psychological trauma, which essentially tended to induce conservation of traditional ways of thinking (seen as Korean) and dislike of modern ideas (seen as Japanese) and at the same time to enhance the status of two modern forces seen as anti-Japanese – Christianity and communism. Unlike other colonial countries the Koreans did not feel hostility for the West, which was seen as a natural ally against Japan.

South Korea came into being in 1948, following the partition of Korea into two parts. Korea had been a Japanese colony, very tightly integrated into the imperial economy.

Korea emerged from the colonial period as an incomplete economy in two senses: liberation separated the Republic from its major export market, Japan; and the division of the country separated complementary functions – light industry and agriculture in the south, heavy industry and energy sources in the north. The United States Military Government attempted with fewer resources and far less information, to apply the kind of reforms General MacArthur was making in Japan. It was hampered by ignorance, left-wing and centrist opposition, uncertainty about long-term division of the pensinsula, and even guerrilla war. Despite these handicaps, by the time the United States handed over southern Korea to an elected domestic government in 1948, the economy had recovered to a considerable extent despite the shutting off of power supplies from north of the 38th parallel in February 1948 and difficulties in obtaining raw materials (Michell, 1988).

Reconstruction started in 1951, since the front line was reasonably stable from that year onwords and American air superiority prevented bombing of the south. A total of 2,080 million current dollar poured into the republic of Korea during the 1950s, whereas total damage was evaluated at 5,000 million (1953) dollars (KDI, 1975, p.13).

Attention was given to creating an effective national education system as well as a land reform. The land reform of 1948-50 removed the old landlord class and created a more equitable class structure and a redistribution of

Japanese-owned and state properties to individuals which helped to create a new Korean capitalist class (Koo and Kim, 1992).

According to Michell (1988), South Korea's development since the Second World War has passed through five stages:

- The transition from a colonial to an independent economy (1945-50)
- The Korean War and reconstruction (1950-59)
- The transition from low to high growth (1960-69)
- Export-led growth (1970-77)
- Unstable growth and recession (1978-82)

The 1993 study by the World bank, divided the Korean development into the following five stages:

- War, reconstruction and land reform (1950-60)
- Export takeoff (1961-73)
- Heavy and chemical industries drive (1973-79)
- Functional incentives and liberalization (1980-90)
- Financial sector liberalization (1990-)

The *export takeoff phase* (1961-73) was a period with an aggressive promotion of exports combined with classic import protection at home. Korean policymakers maintained close control over trade, exchange, and financial policy, as well as aspects of industrial decision-making. In contrast to their controlled economies, they used these instruments to pursue the primary objective of export growth. The trade regime was biased in favour of exports as a whole but essentially neutral with respect to their composition.

From 1962 to 1997 South Korea achieved remarkable economic growth, with an average of nearly eight per cent per year and Korea's version of the state-led growth model achieved what some believe to be the greatest development success in history.

Between 1948 and 1988, when political liberalization occurred, South Korea was governed by a succession of authoritarian, military-backed and strongly nationalistic governments. These governments operated a strong state-directed economic policy articulated through a series of five-year plans. The emphasis changed over time from primary import-substituting industrialization (food, beverages, textiles, clothing, footwear, cement, light manufacturing), through primary export-oriented industrialization (textiles and apparel, electronics, plywood, chemicals, petroleum, paper, steel production), secondary import-substituting industrialization and secondary export-oriented industrialization (automobiles, shipbuilding, steel and metal products, petrochemicals, electronics, consumer electronics etc.).

In the 1950s, the economic policy was under public control due to heavy US foreign aid for South Korea's reconstruction after the Korean War. In comparison, every major shift in industrial diversification in the 1960s and the 1970s was planned by the South Korean government (Amsden, 1989), a signal that the state planned and decided upon the major milestones in South Korea's industrialization. A powerful economic bureaucracy was created, with a key role played by a new Economic Planning Board (EPB). The bureaucracy has still managed to retain itself as one of the power elite groups along with the military and the most privileged organ, the EPB, headed by the deputy prime minister (Kim, 1987).

At the same time, the financial system was placed firmly in the hands of the state; the banks were nationalized, and the Bank of Korea was brought under the control of the Ministry of Finance. This highly centralized "state-corporatist" bureaucracy, in effect, "aggressively orchestrated the activities of private firms" (Wade, 1990, p. 320). Another part of the policy was to actively encourage the development of a small number of extremely large and highly diversified family-controlled business groups, the *chaebol*, that still continued to dominate the economy. The South Korean government deliberately created and nurtured chaebols to use them as locomotives for rapid economic development. These business groups were the backbone of industrialization in the labour-intensive industries and played a major role in expediting technological learning in industry, upgrading South Korea's technological capability and globalizing South Korean business. They consequently generated the lion's share of production and exports from South Korea.

By controlling the financial system, particularly the availability of credit, the Korean government was able to operate a strongly interventionist economic policy. The chaebol were favoured and long-term relationships were developed between them and the state.

Access to modern technologies was a major need and for most part these were acquired from abroad. South Korea adopted a restrictive policy towards inward investment (table 3.1). Until 1983 it placed curbs on foreign direct investment that restricted the permitted level of foreign ownership, specified a minimum export performance and local content level. As a consequence, the share of FDI in the Korean economy has been extremely low.

Table 3.1 Investment share of GDP (Per cent)

		1990	1999
Developing countries		**13.4**	**28.0**
	Singapore	76.3	97.5
	Malaysia	24.1	65.3
	Chile	33.2	55.2
	Indonesia	34.0	46.2
	China	7.0	30.9
	Argentina	6.4	22.2
	Brazil	8.0	21.6
	Thailand	9.6	17.5
	Pakistan	4.8	17.2
	Mexico	8.5	16.4
	Philippines	7.4	14.9
	Taiwan	6.1	8.0
	South Korea	2.0	7.9
	India	0.6	3.6

Source: UNCTAD, 2001.

In the early 1980s, however, the emphasis of Korean economic policy shifted towards a greater degree of liberalization. State control of the financial system was eased in 1983, and at the same time the domestic market was to some extent opened up to a greater degree of imports. Inward foreign direct investment began to be encouraged following the 1984 Foreign Capital Inducement Law that increased the number of manufacturing industries open to foreign direct investment. Some relaxation of South Korea's stringent labour laws, otherwise the most restrictive and repressive of any East Asian NIEs (Deyo, 1992), occurred.

In 1988, the military regime was replaced by a democratically elected government. Some attempts were made to persuade the *chaebol* to change some of their practices, but with only limited success (Dicken, 2003). During the 1990s much of Korea's traditional industry policy was weakened (Chang, 1998). Major changes were made in policies of financial regulation, exchange rate management, and investment coordination. The central pillar of South Korea's industrial policy – the coordination of investment – began to be dismantled.

The financial crisis that swept through East and Southeast Asia in the late 1990s did have profound effects on South Korea's economy. The country's problems were attributed by the IMF, and by the Western financial community in general, to the existence of an over-regulated, state-dominated economy with excessively close relationships between government and business. Certain reforms were needed as both the Korean economy and the broader global environment were changing. Not least was the need to reform *the chaebol*, which had come to distort the economy and which were, themselves, in great financial difficulty. That battle is still going on. The question is whether the push for the Anglo-American institutional model, half voluntary and half under IMF pressure, is the right reform program for a country such as South Korea, which has been developing successfully employing other institutional methods.

3.2 Technology policies

Over the years, the Korean government has adopted an array of policy instruments designed to facilitate technological learning in industry and in turn strengthen the international competitiveness of the economy. The government not only stimulates the demand side of technological learning through industrial policy instruments but also gives rise to the supply side of technological capability through technology policies.

At the outset of economic development, South Korea as well as Taiwan, had to rely on foreign technology imports. However, Korea's policies on foreign licenses were quite restrictive in the 1960s. In the case of manufacturing, general guidelines from 1968 gave priority to technology that promoted exports, developed intermediate products for capital goods industries, or brought diffusion effect to other sectors. The restrictive policy on licensing strengthened local licensees' bargaining power on generally available technologies, leading to lower prices for technologies than would otherwise have been the case (Kim, 1997).

In a bid to attract more sophisticated technologies, a change in national policy was introduced in the 1970s. Restrictions on foreign licensing were eased in 1970 and 1978, resulting in the increase of royalty payments. Most foreign licensing in the early years was associated with technical assistance needed to train local engineers to run turnkey plants (ibid).

In contrast to the gradual relaxation of government control on foreign licensing, the government policy on foreign direct investment (FDI) saw complete change in the 1960s and 1970s. The FDI policy was rather free in the 1960s, but few foreign investments were made during this decade, primarily due to uncertainties about South Korea's political an economic outlook. The government reversed its FDI policy in the 1970s, tightening its control. Joint ventures were given priority compared to wholly owned subsidiaries. Three different criterias were introduced:

1) Competition with domestic firms were seldom allowed in both domestic and international markets.

2) Export requirements were forced on FDIs.

3) Foreign participation ratios were basically limited to 50 percent

Thus, South Korea was one of a few countries with restrictions on FDI when technology was not a critical element and necessary mature technologies could be acquired through mechanisms other than FDI, such as reverse-engineering. As a consequence, the size of FDI and its proportion to total external borrowing were significantly lower in South Korea compared with many other newly industrializing countries (Korea Exchange Bank, 1987). These circumstances reflect South Korea's explicit policy of promoting its independence from multinationals in management control (Kim, 1997). This implies that FDI had a much smaller impact on the Korean economy compared with the FDI effects in other NIEs.

The technology transfer promotion through procurement of turnkey plants and capital goods led to massive imports of foreign capital goods at the cost of retarding the development of the local capital goods industry. The massive imports of foreign capital goods became a major source of learning through reverse-engineering by Korean firms (Kim & Kim, 1985). Among NIEs, the proportion of capital goods imports to technology transfer was higher in South Korea than in countries such as Argentina, Brazil, India and Mexico (Westphal, Kim & Dahlman, 1985). Other instruments also played a role in lubricating the inflow of foreign capital goods to South Korea: the slight overvaluation of the local currency, tariff exemptions on imported capital goods, and the financing of purchases by suppliers' credits, which carried low interest rates relative to those on the domestic market, all worked to increase the attractiveness of capital goods imports.

After two decades of restrictive policy toward foreign direct investment and foreign licensing, South Korea liberalized its technology transfer policies in the 1980s and 1990s. Progressively more sophisticated foreign technologies were needed to sustain its international competitiveness in high value-added industries. In the early 1990s there was a steady decline in new FDI into manufacturing, while there was an increase in FDI in service sectors. In the 1960s and 1970s foreign companies invested mainly due to low labour costs, at a time they were not so willing to collaborate with Korean companies in relatively more technology-intensive areas (Kim, 1997). South Korea has been heavily dependent on both Japan and the U.S. for technology imports. These two countries accounted for more than 80 per cent of FDI and more than 70 percent of foreign licensing and capital goods imports during the 1960s and 1970s (ibid).

The government's plan to develop the capital goods industries was initiated in 1968 but not seriously implemented until the mid-1970s. The development of local consulting engineering firms was promoted by the Engineering Service Promotion Law of 1973, which stipulated that most engineering projects should be given to local firms as major contractors with foreign partners as minor participants. From a technology diffusion perspective South Korea had no efficient mechanism for diffusion of technical information until the 1980s. In the 1960s the government established a scientific and technological information centre as a linking mechanism for disseminating technical information and a public research institute as a diffusion agent. These diffusion agents were not successful because Korean researchers lacked the manufacturing know-how that was important in the first decades of development. More important as diffusers were the government enterprises established in the 1950s and 1960s. Many engineers from these firms, mainly fertilizer and machinery industry, later went to private firms' engineering and production departments (ibid).

In the 1980s the government established an extensive network of government, public, and private technical support systems to promote technology diffusion within the economy. The Industrial Advancement Administration, a government agency, coordinates the functions of different technical support agencies for both large and small firms. The National Industrial Technology Institute and more than ten regional industrial institutes, together with the Small and Medium Industry Promotion Corporation, constitute a national network of technical services. Korea Academy of Industrial Technology, together with other government R&D institutes and industry-specific R&D institutes under trade associations, comprise a core of an R&D network for technology diffusion.

The Korea Standard Association's national network and Korea Productivity Centre promote technology diffusion among firms mainly through their educational and training programs on quality control, value engineering, physical distribution, and factory automation. To this should be added a number of private, non-profit, technical support systems mainly focusing on technology diffusion among SMEs.

In the early part of the 1960s a very limited range of technology resources was available to South Korean companies, due to lack of inadequate research infrastructure and lack of skilled manpower. But in the late 1960s and early 1970s relevant technology was available in machine-embodied form and learning by doing was relatively easy. Stimulating policies aiming at the country's own R&D were not effective. As the years passed and South Koreas industries became more technology-intensive, the government focused more attention on indigenous R&D activities, primarily through two major mechanisms: direct R&D investment and indirect incentive packages. The direct investments aimed at developing the science and technology infrastructure and promoting R&D at universities and government research institutes (GRIs).

In the late 1960s, the Korean Institute of Science and Technology (KIST) was established as an integrated technical centre to support the industry's technological learning. The ongoing sophistication in the industrial development hiked demand for development of government research institutes in shipbuilding, marine resources, electronics, telecommunications, energy, machinery, and chemicals. Another important creation was the establishment of Korea Advanced Institute of Science, which is the country's most important institution with regard to examination of PhDs in science and engineering.

Until the early 1990s university research has been relatively underdeveloped. According to the Ministry of Science and Technology (1994) university research accounted 7.7 percent of the nation's R&D spending in 1994, and 33 percent of the nation's R&D manpower, and as much as 73.7 percent of its Ph.D.-level personnel. Of South Korea's total R&D expenditures, in 1994, basic research accounted for 14.4 percent, applied research for 23.8 percent and development for 61.8 percent. The statistics also show that the private sector accounted for 45.1 percent of the nation's basic research and 64.5 percent of applied research, while universities accounted for only 29.1 percent and 6.3 percent, respectively. According to Kim (1997) there are reasons for questioning the figures concerning basic and applied research, particularly the share commanded by the private sector, because only lately have the leading chaebols begun rather limited investments in applied research in their largest technology businesses. In basic research the investment have been more limited than in applied ones.

3.3 Innovation system perspectives

In general the inadequacy of university research, including lack of well-trained scientists, has been a bottleneck in the South Korean innovation system. To deal with this weakness the government enacted the Basic Research Promotion Law in 1989, targeting basic research as one of the nation’s technological priorities. Main focus has been to introduce a scheme to organize science research centres (SRCs) and engineering research centres (ERCs) in South Korea’s universities.

The most ambitious government vision is the Highly Advanced National R&D Project, also known as the G-7 Project, which is aimed at lifting the nation’s technological capability to the level of G-7 countries by 2020. This project consists of two parts: product technology development projects and fundamental technology development projects. The former include new drugs and chemicals, broadband technology, next-generation vehicle technology, and high-definition television (HDTV). The latter consist of ultra-large-scale integrated circuit, advanced manufacturing systems, electronics and new material technology in information technologies, energy and environmental technologies, biomaterials and next-generation nuclear reactor.

To support R&D within the industry, the government has used various incentives. In the 1960s and 1970s various tax incentives and preferential financing for R&D activities were offered. The mechanisms were largely ignored by industry owing to the absence of a clearly felt need to invest in R&D and the relatively easy means of acquiring and assimilation of foreign technologies the available from many sources. In the early 1980s preferential loans became the most important means for financing private R&D activities.

Public financing, mostly in the form of preferential loans, accounted for 64 percent of the nation’s total R&D expenditures in manufacturing in 1987. The impact of this source of financing may be overstated due to rates of preferential loans ranging from 6.5 to 15 percent, thus conferred little advantage over financing terms available in markets outside South Korea (KITA, 1994). Another source for corporate R&D is tax incentives, which can be classified into five objectives: incentives aimed at promoting corporate R&D investment, reduced tariffs on import of R&D equipment and supplies, deduction of annual non-capital R&D expenditures and human resource development costs from taxable income, exemption from real estate tax on R&D related properties and a tax reduction scheme, and finally Technology Development Reserve Fund, whereby a company can set aside up to 3 percent (4 percent for ”high-tech” companies) of sales in any year to be used for its R&D work in the following three years.

There are also some indirect support programs for specific industrial R&D activities, such as the World Class Korean Products program, introduced in the late 1980s. It is a government scheme to make products world class. Twenty-seven products were selected by the government, involving fifty-nine producers in existing industries, offering various kinds of support.

Among the products chosen were sport shoes, fishing rods, pianos, tires, bicycles, CDs, ultrasonic scanners, VCRs and videotapes (KOTRA). In 1993 the government introduced the New Technology Commercialization Program, in which it offers preferential financing activities related to R&D and commercialization of new technologies developed locally.

A characteristics of the 1970s to the mid-1990s is the rapid growth of indigenous industrial R&D activities, especially within the private sector (MOST, 1994, Kim 1997). The total R&D investment in South Korea increased from W 10.5 billion in 1970 ($28 million) to W. 7.89 trillion ($10.25 billion) in 1994. That corresponds to an increase from 0.32 percent to 2.61 percent of the GNP during the same period.

Despite increasing governmental involvement in technology policy, Kim (1997b) observes several weaknesses in South Korea's innovation system: research at universities is relatively weak; there is a serious lack of interplay between universities and the private sector; there are relatively few technological spin-offs; and there is a dearth of diffusion mechanisms to transfer research results from public research establishments (PREs) to industry and particularly to SMEs. There are signs that the character of South Korea's technology policy is moving from a mission-oriented to a diffusion-oriented one. For instance, the central government has increasingly been supporting the innovativeness of SMEs and interfirm networks. According to Hassink (2001), these SME-oriented innovation policies are more strongly developed than one would expect after reading the literature on South Korea's economic policy. In the literature and journals stress is often a placed on the strong connection between the government and the chaebol, also involving large support, and thus neglecting SMEs.

South Korea's SME- oriented innovation support is judged variously in the literature. OECD (1996) and Park (1998) have negative views, while Kim and Nugent (1994) have a more positive view of the policy. Chung (1999) is of the opinion that different judgements depend on the lack of systematic evaluation.

In 1997, South Korea plunged into a serious economic crisis. According to Crotty and Lee (2002), the neoliberal restructuring of the Korean economy in the years preceding the 1997 crisis was to blame for the serious impact on South Korea. Kim (2001) asserts that unlike previous economic disruptions, which had been evoked by external shocks such as oil, the 1997 and 1998 crisis that affected South Korea stemmed from fundamental structural weaknesses in its institutions that support national innovation.

”The developmental state consolidated sufficient power to pick ”winners” and mobilized and allocated resources to them for ambitious development goals, achieving phenomenal industrial growth in the early decades. However this approach eventually led to corruption and collusion between the state and big business, and mismanagement of the financial sector with serious resource misallocation. The chaebol relied heavily on state protection, which resulted in diversification by big businesses beyond their financial and technological capabilities. Lack of transparency and accountability in the economic system was also a serious problem.” (ibid, p. 1)

After the Asian crisis the government launched in early 1998 major reforms in four areas: the public sector, the financial sector, chaebols , and the labour market. Prior to the crisis, reform programs had been discussed but never implemented because of inertia and resistance from stake-holders. The crisis, however, provided South Korea with a rare opportunity to carry out reform programs.

According to Kim (2001) the government, prior to the crisis, continued to function as a development state, hindering the growth of a free market economy by authorative dictates, frequent intervention in the market, and unnecessary regulations. Non-transparent policies and inaccessible administration nurtured dubious collusion between the government and chaebols, leading to political corruption. After the Asian crisis, the administration of Kim Dae Jung set government reform as a high priority, including the establishment of a Government Reform Office (GRO) with the explicit mandate to reform the public sector. Some of the central government functions have been transferred to local governments, outsourced or privatized, or transformed into executive agencies. The Asian crisis also triggered the government to restructure its administrative apparatus for coordinating public science and technology efforts.

The financial sector has long been a tool of collusion between the government and the chaebols, resulting in major resource misallocation, and had for a long time been recognized as a serious problem in the South Korean economy. As a result of the crisis major steps were introduced to reform the financial sector. Two public agencies – the *Financial Supervisory Commission* (FSC) to review, design and supervise the financial system and Korea Asset Management Corporation (KAMCO) to buy non-performing loans to recapitalize financial institutions, were created to function independent of the government. The FSC has been instrumental in reforming the financial sector, including closing many banks and hundreds of financial institutions. In recent years foreign participation and ownership in the bank sector is expected to introduce more modern market-oriented activities, accountability and transparency in operations.

Behind the successful chaebols, there was serious divergence from free market principles. Collusions with government resulted in resource misallocation at the macro level and the concentration of economic power in the hands of chaebols resulted in monopolistic exploitation at the micro level (Kim, 2000). They also stifled a healthy growth of small and medium enterprises (SMEs). Over diversification, extremely high debt rations and subsidization of unprofitable businesses made many chaebols vulnerable to the fluctuation of the international economic environment

After the Asian crisis the Kim Dae Jung administration set five principles of corporate restructuring: down-scope to focus on core business, the reduction of debt to equity ratios, the dismantling of cross-credit guarantees among subsidiaries, management transparency, and greater management accountability. Three techniques to force the chaebols to comply with government directives were introduced: threats to undertake a comprehensive tax audit, the legal prosecution of family owners, and withdrawing credits to debt-ridden firms (Krause, 2000). To meet the mandate requirements to down-scope and reduce the debt to equity ratio for core businesses, chaebols had to sell off many of their unprofitable businesses to foreign companies.

4 TAIWAN

4.1 Introduction

Taiwan shares a number of common features with South Korea. First, like Korea, Taiwan was a Japanese colony (from 1895 to 1945) and was tightly integrated into the Japanese economic system. A substantial industrial base and physical infrastructure was established by the Japanese to utilize local labour and materials; land reform was instituted. Second, Taiwan also has a difficult external political situation to face: the claim by the People's Republic of China (PRC) as an integral part of the mainland. Present-day Taiwan was established by the Kuomintang (KMT) regime fleeing from the mainland China in 1949. Third, Taiwan has followed a broadly similar path to that of South Korea, although there are some significant differences between these two economies. Taiwan shares some common features with Hong Kong, notably the influx of Chinese population, including many actual or potential entrepreneurs, from mainland China at the time of the communist revolution in 1949 and the greater importance of small entrepreneurial firms in the domestic economy.

Taiwanese business groups, or guanxichiye (related enterprise) are smaller than such counterparts in other Asian countries such as Japan and South Korea. The Taiwanese business groups typically occupy a niche role within part of one or several commodity chains, supplying intermediate products and services to other Taiwanese businesses for eventual incorporation within an export sector. The exception to this is the presence of a few integrated groups in the production of some electrical and electronic products (Perry, 1999). Taiwanese business groups, and ownership, are mainly structured around the family. Of the top 97 groups, in early 1980s, 84 were family-owned (Hamilton, 1998). Although the family enterprise is associated with a drive for economic independence, it also generates processes conducive to the formation of groups. The adaptability of a business group is enhanced by the use of subcontracting to minimize the investment and skill required to enter new activities, and ease the burden of downsizing existing activities.

Foreign multinational brand marketers primarily built the expansion of Taiwan's economy on its co-operation with buyer-driven commodity chains controlled. These connections have provided opportunities for an agile manufacturing system that is able to cope with the market fluctuations of cost-competitive and fashion-conscious industries. The high status that Taiwan has attained with its international customers is partly a product of the entrepreneurial climate in Taiwan (Perry, 1999). This is distinguished both by the intensity of ambition to be an independent entrepreneur (Hamilton, 1998) and by the internationalisation of its entrepreneurs (Lehmann, 1998). That internationalisation is reflected both in the willingness to accept foreign investment and in the Westernisation of the business class in the extent of overseas education and work experience (ibid).

When trying to explain the general performance of Taiwan's economic development, with a time frame in mind, some different approaches have been used. The study by the World Bank (1993), *The East Asian Miracle*, divided the Taiwanese development policy into five stages (see below) in which the government has implemented comprehensive but changing policy packages. Throughout, low inflation and macroeconomic stability have been a foundation for growth-enhancing policy initiatives, and since the late 1950s, export growth has also been a fundamental goal.

- Land reform and reconstruction (1949-52)
- Import-substituting industrialization (1953-57)
- Export promotion (1958-72)
- Industrial consolidation and new export growth (1973-80)
- High technology and modernization (1981-)

This classification does not fully correspond with the one usually used by the government in Taiwan. Since the World Bank study was published in the early 1990s, ten more years have elapsed, implying new policies in Taiwan and external economic and political changes. The classification in the next part is based on the time periods used in the World Bank study, but the content is further developed and deepened

4.2 Development policy – General views

Since the 1950s Taiwan's economic structure has undergone gradual reconfiguration, primarily due to international competition and the decline and growth of various domestic industries. One of the first initiatives was an ambitious *land reform program* (1949-52), which fostered social and political stability and increased agricultural production. Greater agricultural output provided raw materials for export and earned foreign exchange to fund imports of machinery, equipment, and industrial raw materials.

The next period (1953-57) was characterized by *import-substituting industrialization*, where the government attempted to develop industrial activity as the base for economic self-sufficiency.

The government invested heavily in infrastructure; U.S aid was an important source of finance, funding 49 per cent of public investment in infrastructure. Extended quantitative restrictions and higher tariff rates shielded domestic consumer goods from foreign competition. To take advantage of abundant labour, light industries, particularly textiles, were subsidized. Consumer goods industries such as apparel, wood and leather products, and bicycles also developed rapidly.

The characteristic approach was for the state itself to set up new upstream industries and then either to continue to operate them under state ownership or to transfer them to private entrepreneurs. A distinctive feature of Taiwan's development, compared with Korea, was a heavy direct involvement in production through state ownership. In each case, the state played the initiating role.

The export promotion period (1958-72) implied the termination of U.S. aid and a need to correspondingly increase the inflows of foreign currencies. The government shifted to a policy of outward orientation and export promotion. Tariffs and import controls were gradually reduced, especially for inputs to export. The Stanford Research Institute was consulted by the government to identify promising industries for development and export promotion. On the basis of Taiwan's comparative advantage in low-cost labour and existing technical capabilities, the institute chose heavy, capital goods industries, but also plastic and synthetic fibres. Other industries promoted included apparel, consumer electronics, home appliances and watches. A statement in the Second Four-Year Plan did show that the government was determined to steer the direction of investment: "The Government should positively undertake to guide and help private investments so that they do not flow into enterprises which have a surplus production and stagnant market" (Wade 1990, pp. 81-82).

As the 1970s progressed, internal and external challenges threatened the continuation of export-led growth. Taiwan's light manufacturing industries faced new competition from lower-wage producers abroad. The 1973-74 oil crisis had dramatic repercussions for the Taiwanese economy and a new development policy, called *industrial consolidation and new export growth* (1973-80) was implemented. Once again the government turned to foreign experts and commissioned the U.S. management firm Arthur D. Little to find solutions to the economic problems. Based on Taiwan's economic needs and capabilities, the Americans recommended heavy investment in infrastructure, industrial upgrading, and secondary import substitution. A government plan incorporating the recommendations focused on the development of capital-intensive, petrochemical, electronics, computer terminals and peripherals, precision machine tools, and heavy industries to increase production of raw materials and semi manufactures for the use of export industries.

During the 1970s the government also addressed how industrial sectors should be organized,

”Some sectors were identified as suitable for development by local firms, others by joint ventures with foreign companies and public enterprises (especially petrochemicals), and still others as suitable for a mix of foreign and local private firms (electronics)” (Wade 1990, p. 96).

Following the oil price shock of the mid-1970s, the Taiwanese government initiated major investments in the heavy and chemicals industries in order to reduce the exposure to external supply shocks.

With a new decade, Taiwan continued its integration into the world economy, but revealed structural weakness, particular in the financial system’s inability to match the increasing demands of industrialization and external trade. Externally, its persistent trade surpluses with major trading partners led to growing protectionism. Taiwan’s export faced additional losses of competitiveness due to the appreciation of the Taiwan dollar and rising wages. As a first generation East Asian NIE, Taiwan manufacturers were squeezed between lower-wage NIEs in traditional, labour-intensive manufacturing on the one hand, and high-technology products from industrial economies on the other. Once again the government moved to restructure the economy, entering the phase of *high technology and modernization* (1981-), now focusing on high-technology industries: information, electro-optics, machinery, precision instruments, biotechnology and later on (1990s) the civil aircraft industry.

Since the 1990s, technology-intensive industries in Taiwan, not least semiconductor and computer production, have become increasingly important. The percentage of technology-intensive industries within the manufacturing sector rose from 24 per cent in 1986 to 38.8 per cent in 1997 (Hsu and Chiang 2001). During the same period technology-intensive exports jumped from 22.2 per cent to 54.6 per cent (NSC, 1998).

Taiwan was far less seriously affected by the 1997 East Asian financial crisis than South Korea, although growth rate slowed down as a consequence of the turmoil. Taiwan largely evaded the currency crisis of 1997-98. This was due to its system of numerous entrepreneurs and small-scale production that shunned the level of indebtness, overcapacity and ’cronyism’ prevalent in other Asian Business groups (Ranis, 1998).

Although Taiwan’s economy has prospered in the past four decades, the economy currently faces wage increases, appreciating currency value, increased international protectionism, denting its competitive edge. Consequently, a number of industries are moving out of Taiwan, and industry growth and exports have slowed down. (Shyu and Chiu, 2002).

But also Taiwan's contested political status casts a long shadow over its future. On the one hand, the 50-year rule of the authoritarian KMT ended in early 2000, when the Democratic Progressive Party (DPP) was elected into government. On the other hand, the DPP is a long-established advocate of independence from the PRC and this creates further political tensions. In November 2001, Taiwan was admitted to the WTO as Chinese Taipei, with the status of a 'separate customs territory'

4.3 Innovation and technology policies in Taiwan

The main challenge facing the Taiwanese economic planners was how to move from a condition of little know-how, inadequate institutions, and an under-supply of trained scientists and engineers to that of a high-tech based economy. The key problem was how to keep upgrading the technological content of the products. To reach this goal an overall strategy of four key components was adopted (Lin, 1998).

- Building human resources
- Acquiring technology from the more advanced countries.
- Creating science and technology capacities
- Converting research results into commercial products

Building human resources: The building of human resources has several elements. The key element is the education system. Since the early 1960s, strengthening education has been a national priority. This applies to all levels of education, from primary to university. The number of science and engineering degree holders has increased significantly over the years. Recognizing the need to learn from the outside world, the government encouraged students to go abroad for post-graduate studies. Initially, many graduates found jobs abroad, mostly in the U.S., as opportunities in Taiwan were limited. Since the late 1980s an increasing number of post-graduates have returned to Taiwan. Knowledge conveyed by nationals who had been educated or worked abroad became an important mode of technology transfer as industrialization proceeded and changing factor prices dictated a shift to more capital and technology intensive sectors in which products were protected by patents, employed specialized equipment protected by patents and were characterized by tacit knowledge (Pack, 2001, p. 724). One major bottleneck of personnel is in the key engineering and management jobs, reinforced to some extent by satellite production for Japanese firms (Chiang, 1989).

Acquiring technology from more advanced countries: The industrial structure of Taiwan has a large number of small and medium-sized firms and a few large ones. Taiwan's technologies originally came mostly from Japan and the U.S. By establishing backward linkages with materials and technology, mostly with foreign corporations, the industry slowly developed niches of advantage. This strategy was successful in developing a strong position in consumer electronics, small machineries, footwear and textiles, bicycles and other sporting goods.

Through much of its early industrialization, Taiwan employed older machinery and manufactured standardized products that were not subject to proprietary restrictions. Knowledge about how to improve the utilization of this equipment as well as modifications of product specifications was readily available at low cost in trade literature and engineering publications, and from independent consultants (Ranis, 1979). Up to the early 1990s it seemed that reverse engineering was still the most common means of acquiring technology. Invention was a more distant goal (Hou and Gee, 1993).

In the development of knowledge-based economies there are two important issues. One is the extent to which knowledge is shared or diffused and the second is the direction of the diffusion or flow. A study by Fang et.al. (2002) investigated the R&D programs and facilities of foreign firms based in Taiwan and their impact on the flow of knowledge.

The main conclusions of the paper were that if the major purpose of a foreign R&D activity was restricted to the needs of the Taiwan market, foreign firms tended to set up a transfer technology unit (TTU) or an indigenous technology (ITU) unit in Taiwan. If the objective was to enhance technology learning, in recognition of Taiwan's strategic position in the global market, foreign firms tended to set up international interdependent laboratories (IILs) in Taiwan. Another conclusion was that most of Southeast Asian firms preferred to set IILs, not ITUs, while European firms prefer to set up IILs. According to the authors an IIL made the largest impact on the Taiwanese knowledge flow system, ITU came second, and least impact was from the TTU.

The paper had a number of limitations. IT was not a comprehensive survey of all foreign firms in Taiwan. The conclusions were based on a sample of 60 firms with R&D units and focused on the reports of quantitative measures of knowledge-flow interfaces. There are qualitative aspects that have to be analyzed as well.

Creating science and technology capacities: In the early 1970s, little research was done in Taiwan. There were few researchers, limited funds and projects scattered loosely. A similar situation existed in the manufacturing industry. Due to Taiwan's industrial structure, based on small enterprises, the development of high-technology industries is somewhat handicapped (OECD; 1988, p.39)

To change these conditions, the Industrial Technology Research Institute (ITRI) was established in 1973. ITRI is now the largest industry-oriented research institution in Taiwan. In 1973 it had about 450 employees. By 2000 it grew to 6100 employees, 900 of them hold doctoral degrees and more than 3600 had bachelor or master's degrees (ITRI, 2000). ITRI receives contracts from the government to develop generic technologies, and transfer the results to the industries in a non-exclusive manner.

It also conducts short-term R&D projects in cooperation with private organizations, generally to improve product performance and process efficiency. ITRI's research scope covers electronics and IT, machinery, biomedical and advanced materials, energy and resources, and more recently civil aerospace. At the end of the 1980's the government set up "key research institute" and "centre of excellence" at each of the four national universities - National Taiwan, National Tsing-Hua, National Chiao-Tung, and National Cheng-Kung - in the fields of applied mechanics, material science, information technology and aviation and aerospace technology.

The Hsin-Chu Science-based Industrial Park (HSIP) was established in 1980 under the guidance of national Science Council. Started with a few companies, today it hosts a large number of companies, providing employment for nearly 40 000 people (visit to HSIP, 2000).

Of all industries within the HSIP, the Integrated Circuits Industry is the largest. It is also the most important in terms of number of companies, scale of operations and sales revenues. HSIP is one of the world's main centres of IC manufacture. The second largest industry within HSIP is computers and peripherals. Major Taiwan computer makers such as Acer Incorporated, Mitac International, UMAX Data Systems etc. are located in this science park.

Converting research results into commercial products: Traditional enterprises are the mainstay of manufacturing. They consist mainly of small and medium-sized companies with assets under NT $ 40 million and account for 98 per cent of all manufacturing firms (Lin, 1998). A typical small company has 10-100 employees. The state provides support by funnelling cash for industrial automation through Chiao Tung Bank, improving management quality through the China Productivity Centre and various industrial development centres give technical support to companies.

In order to speed up the conversion of R&D results into commercialisation, The Department of Industrial Technology (DOIT) of the Ministry of Economic Affairs, employs the strategy of industry-institute joint research projects. Based on needs of companies with limited R&D facilities, DOIT also promotes a research-based ‘open laboratory’ strategy. These open laboratories give access to companies for the purpose of maximizing existing resources and minimizing investment risks before commercialization can take place (Hsu & Chiang, 2001).

Although the industrial and technological capabilities have increased dramatically in recent decades, Taiwan’s ability to innovate still falls behind advanced countries due to some short-comings in the innovation infrastructure. These include insufficient laws and regulations regarding innovation which impose too many restrictions that discourage the private sector’s interest; limited budget and manpower for innovation; the dependence of some key technologies on other leading countries (Shyu and Chiu 2002).

In addition to the previous account (4.3), the current innovation policy of Taiwan also includes:

1. Alleviation of taxation
2. Loan subsidy
3. Supply of information and technological assistance institutions
4. Government procurement
5. Protection of research results
6. Cultivation of manpower

According to Shyu and Chiu (2002), there are some important issues relevant to Taiwan’s innovation infrastructure:

1. Insufficient laws and regulations regarding innovation. Taiwan has imposed too many restrictions that discourage the private sector’s interest.
2. Limited budgets and manpower for innovation.
3. Some key technologies depend on other leading countries.

In order to maintain Taiwan's economic growth, an innovation policy of increasing incentives, based on supply side, demand side, and environment side, is essential (ibid):

- Supply side policy includes assisting firms to perform R&D activities, strengthening the function of public research institutions, setting up open laboratories, promoting cooperation between industries and academics, revising laws to speed up technology transfer, and promoting technology cooperation between both sides of the China Strait.
- Demand side policy is to stimulate market potential and assure the purchase power of customers. The government plays the role of setting up a mechanism for firms to find proper markets with export incentives or deregulation in some specific markets.
- Environment side policy should focus on building up a national innovation system, including industrial innovation, cultivation of production factors, encouragement of industrial competition and demand, as well as creation of relevant industries. Environment side policy should include development of venture capital, establishment of technologies trade centres (Techno marts), supply of favourable financing measures and fortification of the ability to collect, summarize and apply information to the roughly 1 million SMEs in Taiwan. Such an industrial information centre should be an industrial information system able to increase the competitiveness of these companies.

During a meeting in Hsinchu (January 14, 2004) discussing weak and strong links between the government, universities and industry, Dr Chiu maintained that the weakest link was that between universities and industry, while we know from previous studies that there are already very strong links between the government and the industry through ITRI and several other actors. Reasons for the weak linkages between industry and universities are shortage of human resources in the engineering faculties of universities and Taiwan's industrial structure, with the domination of SMEs with very limited resources for research, both in terms of capital and human resources. An aggravating circumstance is the difficulties for leave of absence for researchers to work in the industry. Instead many researchers chose to set up own companies although it can be risky business.

Although Taiwan is mostly known as a newly industrializing economy, manufacturing's share of the economy has been shrinking since the mid-1980s. Manufacturing declined from an all-time peak of 39.4 per cent of gross domestic product (GDP) in 1986 to a low 26.4 per cent in 1999. The service sector, by contrast, has followed a constantly rising trend and now accounts for 66.7 per cent of Taiwan's GDP (Chen and Liu, 2003).

The Council for Economic Planning and Development (CEPD) examined the importance of knowledge-based activities in Taiwan's economy using the OECD's definitions of knowledge-based industries (KBI). The OECD (1999) definition includes both knowledge-based manufacturing (aerospace, computer and data-processing equipment, pharmaceutical, telecommunications, semiconductors, scientific instruments, automobiles and other transport equipment, electrical equipment, chemical products and machinery) and knowledge-based services (include transport and storage, communication services, finance, insurance, and real estate, commercial services, social and personal services).

Table. 4.1 Knowledge-based Industries in Taiwan. (Percent)

	All industries	Knowledge-based Industries	Knowledge-based Manufacturing Industries	Knowledge-based Service Industries
		Share of GDP		
1991	100.0	37.7	6.1	31.7
1994	100.0	39.2	5.7	33.5
1996	100.0	40.6	6.8	33.7

Source: Council for Economic Planning and Development based on Input-Output Tables.

In 1996 KBIs generated 40.6 per cent of Taiwan's GDP, which was about 10 per cent lower than the average GDP share of KBIs in the OECD countries. Nevertheless, it was larger than five years earlier. According to this classification, most of Taiwan's knowledge-based economy is the service sector, which comprises a large share of Taiwan's KBIs. But this figures can give a misleading picture of the economic importance of knowledge-based activities in Taiwan, as knowledge or information is not in fact an important input in the production of services in Taiwan (Chen and Liu, 2003).

Information Intensity of Selected Service Industries

	Information Services Utilised (NT$ million) 1	Value-added (NT$ million) 2	Information Intensity (%) 1/2
Academic research	642	22,566	2.85
Insurance	3,591	170,756	2.10
Transport	1,979	118,591	1.67
Printing and publishing	1,033	67,949	1.52
Finance	5,658	485,361	1.17
Hotels	441	42,027	1.05
Public service	7,866	852,936	0.92
Leasing	305	42,342	0.72
Food service	1,209	173,141	0.70
Real estate	1,411	217,122	0.65
Foreign trade	2,162	417,221	0.52
Retailing	3,550	709,163	0.50
Wholesale trade	2,052	434,634	0.47
Medical service	1,048	246,376	0.43
Entertainment	163	76,706	0.21
Legal and accounting	52	25,421	0.21
Advertising	194	133,163	0.15
Storage	20	223,896	0.08

Source: Input-Output Tables, Council for Economic Planning and Development.

In Taiwan the two service industries (three-digit level) with the highest knowledge intensity are academic research and insurance, while seven service industries comprise only 0,5 per cent, or lower, of value added. However, this measure understates the true information content because it counts only outsourced, or purchased, inputs of information services. Nevertheless, even allowing for the downward bias, the information content of Taiwan's service industries seems to be low.

A study by Wu (2000) compared Taiwan's manufacturing sectors and selected OECD countries according to four categories of technology-intensity: high, upper medium, lower medium, and low. High-technology manufacturing accounted for 19.5 per cent of total manufacturing value-added in Taiwan, a high figure in comparison to most other OECD countries. The growth of high-technology manufacturing in Taiwan during the 1990s outpaced the high-tech manufacturing sectors in most OECD countries. There are thus indications that Taiwan's knowledge-base is stronger on the manufacturing side than it is on the service side.

4.4 Taiwan's IT sector

Taiwan, which served as a source of cheap labour for foreign consumer electronics multinationals as late as the 1970s, is known today as a global centre of IT systems design and manufacturing. Taiwan's strength lies in PC-related information products and IC (semiconductor) sub sectors.

Local companies dominate the markets for a large and growing range of computer-related products, from notebook computers, motherboards and monitors to optical scanners, keyboards and power supplies. In addition, Taiwan’s state-of-the-art semiconductor foundries account for an important share of the global output.

From a technological and economic point of view the development of information industry products has been a success. Taiwan is the world’s third (some years fourth) largest in computer production. Many peripheral products make up a large share of world market, such as monitors, computer mouse devices and printed circuit boards.

One important explanation for the expansion can be the modular architecture (Henderson & Clarke, 1990, Ulrich, 1995) of the products manufactured. For example, the PC-industry is a highly open, modularised system with many internationally standardized components and rather easily adjustable interfaces. Even propriety CPUs and memory chips can be purchased from merchant firms. As a result, local firms could enter this industry by initially assembling final products and subsystems (keyboards, monitors, chipsets etc.) based on OEM and OBM terms.

Later on there are possibilities to produce key components and materials, such as liquid crystal displays, memory and logic chips and silicon wafers. Modularisation can reduce product complexity, lower entry barriers and increase industrial flexibility (Kogut & Bowman, 1995). An important reason why Taiwan has been successful within the electronics-, semiconductor-, and IT-industries is the fact that these sectors are characterized by many competitors, short product life cycles and rapid company turnover (Mathews and Cho 2000).

For some scholars (Lau 1994, Callon, 1995) national economic success in information technology industries is evidence of the dynamism of free markets, i.e. creation of human capital formation, domestic entrepreneurship and market competition. Others argue that the important role of state policies is the catalyst behind the success. In the case of Taiwan this implies the intervention and role of ITRI in this process (Wade,1990; Mathews, 1997)

Other analysts have looked beyond the state market-debate to study other determinants of economic performance such as geography of production, including the role of technological innovation to regional growth. Hsinchu can be looked upon as an industrial cluster, in which competition and vertical cooperation among local firms account for rising productivity, innovation and new firm formation (Porter, 1990). As in South Korea, the initial development of semiconductor production in Taiwan was boosted by the decision of US firms to locate assembly operations in low-cost East Asian locations in the 1960s. The Taiwanese government took advantage of this trend by building the world's first export processing zone (EPZ) for semiconductors in 1965.

Stages in the evolution of the Taiwanese semiconductor industry

Stage I **Pre-1976** **Preparation**	**Stage II** **1976-79** **Seeding**	**Stage III** **1980-88** **Technology Absorption and Propagation**	**Stage VI** **1989-98** **Sustainability**
Labour-intensive Semiconductor back-end operations (assembly) and testing Dominated by foreign multinationals Establishment of ITRI and ERSO	Licensing of IC fabrication technology, and its adoption by public sector R&D institute	Technology absorption and enterprise diffusion Establishment of secure infrastructure in the form of the Hsinchu Science-based Industry Park ERSO acquires skills covering all phases of semiconductor manufacturing, moving from LSI to VLSI Spin-off of private companies and entry of private sector	Entry of firms to cover all phases of semiconductor manufacturing and full product range, including DRAMs From VLSI to ULSI technology Submicron stage of public-sector led R&D Cooperative R&D system of innovation established

Source: Mathews and Cho, 2000, Table 4.1

High value-adding wafer fabrication was initiated by the Taiwanese themselves as an act of public policy through the public-sector ITRI. Its electronics laboratory, the Electronics Research Service Organisation (ERSO), entered into a technology transfer arrangement with RCA in 1976 which, for a royalty fee made available its then-obsolete 7-micron IC product and process technology, and trained a cadre of Taiwanese engineers (Mathews and Cho, p. 46).

ERSO spun off Taiwan's first mainstream IC company in 1980, the United Microelectronics Corporation (UMC), which was located on the newly established Hsinchu Science-based Industrial Park, near ITRI/ERSO.

By the mid-1990s Taiwan had become the world's fourth-largest semiconductor producer behind the US, Japan and South Korea. Compared to South Korea, Taiwan's IC industry is more well-balanced spanning over a broad spectrum of products. The industry has been developed to span all phases in the value-adding process, thereby reducing the need for imported vital components, and enhancing the sustainability of the industry (ibid, p. 47).

4.5 The Hsinchu Science-based park

Domestic companies are important actors for computer-related products, such as notebook computers, motherboards, monitors, optical scanners, keyboards and power supplies. In addition, Taiwan's state-of-the-art semiconductors foundries have a large share of the world production. Taiwan's ”high-tech” IT-sector is largely located in an area from Taipei in the north down to Hsinchu roughly 80 km southwest from the capital. In recent years science-based parks have also been established in Tainan and Taichung.

The Hsinchu Science-based park was an initiative of Taiwanese government, through the guidance of National Science Council, and more or less modelled explicitly on the success of the Stanford Research Park in Silicon Valley. It was established in 1980 and started with a few companies and had reached to host a large number of companies, providing employment for nearly 40 000 people.

The Hsinchu region, like Silicon Valley, appears as an exemplar of Marshallian external economies, in which the location of skill, specialized materials and inputs, combined with technological know-how generate cost reductions for individual firms, increasing returns to the region as a whole (Krugman, 1991). These two regions might also be viewed as industrial clusters, in which competition and vertical cooperation among local firms account for rising productivity, innovation and new firm formation (ibid).

Levy and Kuo (1991) compare the ”bootstrap” strategy of Taiwan's small, specialized PC firms with the high-volume PC assembly strategy of the vertically integrated Korean conglomerates. They suggest that the propensity for risk-taking and experimentation in Taiwan's SMEs produced an ongoing stream of innovation and the opportunity for some firms to be in the technological forefront. The competitive advantages of this ”bootstrap” were confirmed in the 1990s as Korea's chaebol fell increasingly behind the acceleration PC product lifecycle and were to source key components from Taiwan (Chung, 2000).

This kind of approach suffers from its focus on regions in isolation. It overlooks the growing role of international trade and investment in economic growth, and cannot explain the emergence of successful new regions such as Taiwan's Hsinchu that are located far from established centres of technology and skills (Saxenian and Hsu, 2001). The importance of a transnational community that shares information, trust and contacts (Portes, 1996) has been largely overlooked in account's of Taiwan's development. Saxenian and Hsu (2001) argue that the contributions of this technical community have been a key to the success of more commonly recognized actors such as government policymakers and global corporations. The connection to Silicon Valley, in particular, explains how Taiwan's producers innovated technologically in the 1980s and 1990s independently of their OEM customers (ibid).

The Silicon Valley-Hsinchu relationship nowadays consists of formal and informal collaborations between individual investors and entrepreneurs, SMEs as well as larger companies. A new generation of venture capital providers and professional associations serve as intermediaries linking decentralized infrastructures of the two regions (ibid).

The emergence of new centres of technology, like Taiwan, in locations outside of the old industrialized countries has been possible due to a radical transformation in the structure of the IT-sector. The dominant competitors in the computer industry from the 1960s to the early 1980s were vertically integrated corporations that controlled all aspects of hardware and software development and production. The rise of the Silicon Valley industrial model spurred the introduction of the PC and initiated a radical shift to a more fragmented industrial structure organized around networks of increasingly specialized producers (Bresnahan, 1998).

Today, independent enterprises produce all of the components that were once internalized within a single large corporation.

The number of actors in the industry has increased dramatically and competition within many horizontal layers as well. Yet this is far from a classic auction market alone. Other important factors in this are cross-cutting social structures and institutions that facilitate the coordination of this decentralized system (Aoki, 2000). The deepening social division of labour in the industry creates opportunities for innovation in formerly peripheral regions – opportunities that did not exist in an era of highly integrated producers.

The HSIP offers firms attractive working environment and living conditions, in contrast to Taipei and some other large cities, as well as proximity to technical expertise and design and manufacturing facilities.

4.6 Taiwan's aerospace sector

The aircraft or aerospace industry is the 'archetypical knowledge-intensive sector' (Samuels 1994, p. 278). It has a potential for linkages and spill over to other sectors, which few other industries can match. It is not one industry but a compound of several that share an interest in producing aircraft, space vehicles and missiles.

The aerospace industry is characterised by complex, very high-value added products in relatively small quantities, produced by relatively few players.

Products have long development periods, i.e. extremely long product life cycles, and high development costs. The industry is also characterized by volatile markets with orders affected by a variety of financial and political factors. The high technology requirements necessitate a high level of research and development. No other industry exhibits more of inter-dependence and cross-fertilization of advanced technology than the aerospace sector. Consequently most of the world’s large aerospace companies are located in advanced economies such as the USA, the UK, France, Germany, Canada, Japan, Italy and Sweden. They are also to be found in Russia, and former Soviet Republics, and to an increasing degree in Developing and Newly Industrializing Economies (Eriksson, 1995) The Brazilian manufacturer Embraer developed into one of the most important manufacturers of turboprop commuter aircraft, and in recent years large-scale production of jet-driven commuter/short haul aircraft.

Indonesia is another developing country which invested heavily in civil aircraft development and manufacturing. During Suharto’s rule the establishment of IPTN/IAe was the largest and most ambitious investment by the Indonesian government to promote technology development in the country. Despite huge investments in engineering and production facilities and impressive technology resources, the company is now struggling to right itself with state funding drying up, the company now faces the challenge of defining its own ´raison d`etre`, away from the political motivation of national prestige (Eriksson, 2003a). Developing countries entering R&D high-technology industries have an extremely demanding task of trying to compete with the leading companies in the international arena. Several major reasons can be cited for the failure of IPTN. These include a lack of business, management and marketing competence and the decision to go it alone, a strategy contradictory to the situation in international aerospace manufacturing (ibid).

Today, in the early 21th century, we see a global overcapacity, due to military disarmament, too many production facilities in developing countries and a general downturn in aircraft orders. This implies that new actors in emerging economies have to compete with companies in developed, developing as well as transitional economies in the former East European countries.

One of the most significant features of world aerospace manufacturing today is production-sharing and subcontracting. The requirements to ‘offset’ costly purchases of aircraft and pressures to find lower-cost sources of components to lower production costs are the main reasons (Todd 1992). A study by Eriksson (1995) shows extensive subcontracting linkages between emerging aerospace companies in East- and Southeast Asia and the established aerospace companies in Europe and North America. A big proportion of these technology linkages are the result of offset policies. This development illustrates that these economies have entered into the global aerospace production network, which also reflects the integration of the industry value chain. However the future success of these technology linkages at the destination level, i.e. Asian economies, is determined by other factors, among them the strategy of the sourcing company as well as installation of technology of the receiving company (Eriksson 2003b).

Aircraft, whether military or commercial, are assembled in many countries, but few of them have the capabilities to design, develop and produce an entire aeroplane, i.e. systems integration. Technology used in modern aircraft is extremely demanding due to the high levels of functional performance, reliability, safety and efficiency required at the system level. With its integrated architecture, most functional design specifications and standards in this industry are imposed by the upper-tier buyers or integrators. Much of the expenditures to develop a new aeroplane are spent on integrating numerous technologies and systems with origins from various fields and industries such as metallurgy, composites, electronics and petroleum.

There are only a few companies in the world with the technical expertise and economic resources to make a new design of a large modern jet-driven airliner or an advanced, state-of-the art combat aircraft. Companies in the emerging aerospace nations and most of those companies in the old industrial core have to co-operate with the leading corporations, mainly located in America and Europe.

A similar trend is discernable within the aero-engine industry. The costs of developing a new civil jet engine are extremely high. Very few companies, if any, have the ability to bear such costs on their own. This has forced engine producers to co-operate in a network of partnership, mainly directed towards risk/revenue-sharing (Eriksson, 2000).

This creates webs of collaborative agreements involving large producers and subcontractor/alliance partnerships. As a result, the aerospace sector has one of the densest networks of strategic technology partnering (Hagedoorn 1995).

The extremely high technology requirements, rising development costs and too many system integrators have in recent years escalated merger activities and weeding out of companies. Thus, the system integrators have drastically declined and in general the entry barriers seem to have become increasingly difficult to conquer. For instance, in the large jet airliner market there are only two companies left, Airbus and Boeing.

The aircraft industry in *Taiwan* can be traced back to 1946, when the Bureau of Aircraft Industry was established in Nanking on the mainland. After the Kuomintang Government's move to Taiwan, the Bureau followed. The first military aircraft to be built in Taiwan was a slightly modified version of the American Pazmany PL-1. It was assembled in 1968 by the Aeronautical Research Laboratory, then a branch of Bureau of Aircraft Industry. In 1969 the Aero Industry Development Centre (AIDC) was established as a successor to the Bureau of Aircraft Industry. AIDC became a subsidiary of the Chungshan Institute of Science and Technology (CIST), the government's main, defence-related, research and development facility. CIST was created to develop defence technology facilities (Eriksson, 1995).

During the Nixon years, the United States´ foreign policy underwent a change with regard to China. The integration of the People's Republic of China into the international system meant that many nations terminated their diplomatic relations with the Republic of China in Taiwan. During the 1970s Taiwan's isolation in the international community also meant that it had no access to foreign military equipment. This constituted an important impetus to try even harder to develop a domestic military aircraft industry (ibid)

In 1974 AIDC started licence production of Northrop F-5. In 1975 AIDC started with the assistance of Northrop to develop a new two-seater advanced training aircraft for the Air Force, the AT-3. The biggest project up to now has been the development of the Indigenous Defence Fighter (IDF). It was designed to replace the American models in service. The development started in 1982 after the US Government blocked the purchase of the Northrop F-20 Tigershark. The Reagan administration also stopped the sale of the F-5G under political pressure from the P.R.C.

The IDF was designed with the assistance of General Dynamics. It largely resembles the F-16 (developed by G.D./Lockheed) but is modified to adopt a twin-engine configuration. The first flight took place in May 1989. The aircraft became operational in 1993 and originally some 250 were expected to be built. A planned development of the IDF was cancelled as Taiwan was finally able to buy 150 F-16, when George Bush administration reversed commitment it had made to the mainland P.R.C. not to sell arms to Taiwan. Due to delivery of the F-16s and an agreement to buy up to 60 Dassault Mirage 2000-5s the need for IDFs was slashed to 130 The IDF production line ceased in January 2000.

Prior to the 1990s Taiwan's aerospace knowledge was heavily centred around AIDC in Taichung. It was based on military aircraft production, where much of the knowledge and technology flows/information had its origin in the United States (Northrop, Lockheed). AIDC's main facilities are located at Taichung (head office, parts/components production, avionics factory), Sha Lu in the outskirts of Taichung (aircraft assembly, development tests facilities, flight test) and Kang Shan, close to Kaohsiung (aero-engines).

In 1990 the government decided to embark on the development of the civil aerospace industry in an effort to upgrade Taiwan's industrial and technological capabilities, with the explicit expectations to foster further economic development and to create "spin-off" effects to other industries and sectors. The civil aerospace industry was listed as one of the top new strategic industries to be promoted by the R.O.C. government under the Six-year national Development Plan 1991-1996 (Eriksson, 1995).

This project required access to advanced foreign technology and a huge amount of capital. In the projections the output value of the whole Taiwanese aircraft industry was expected to escalate tenfold from 1989 to 2000 (information from CASID and Taiwan Aerospace, August 1991). The main target was to join international co-operation in order to expand sales of materials, components, airframe parts, avionics, engines and aircraft maintenance works abroad. The strategy was to encourage local companies to form joint ventures with foreign companies to implement technology transfer (ibid). Another aim was to obtain offset deals from foreign aircraft manufacturing companies, such as Boeing, McDonnell Douglas and Airbus.

The government introduced the "Aeronautics and Space Industries Development Program" to function as a guide to the industry. Concrete measures included:

- Planning the development of the aerospace industry
- Strengthening international co-operation and expanding the export market
- Encouraging domestic research and development
- Establishing a government inspection and certification system to upgrade the quality of aerospace products

Source: Aeronautics and Space Industries Development Program (Published on August 16, 1990 by the Ministry of Economic Affairs)

The development of the industry was drawn up by an ad hoc semi-governmental unit, the Committee for Aviation and Space Industry Development (CASID), which consists of members from government units, universities, research organisations etc. Financial support to CASID is provided by the Ministry of Economic Affairs. CASID has four main roles:

1. To act as a bridge between the local companies and the government.

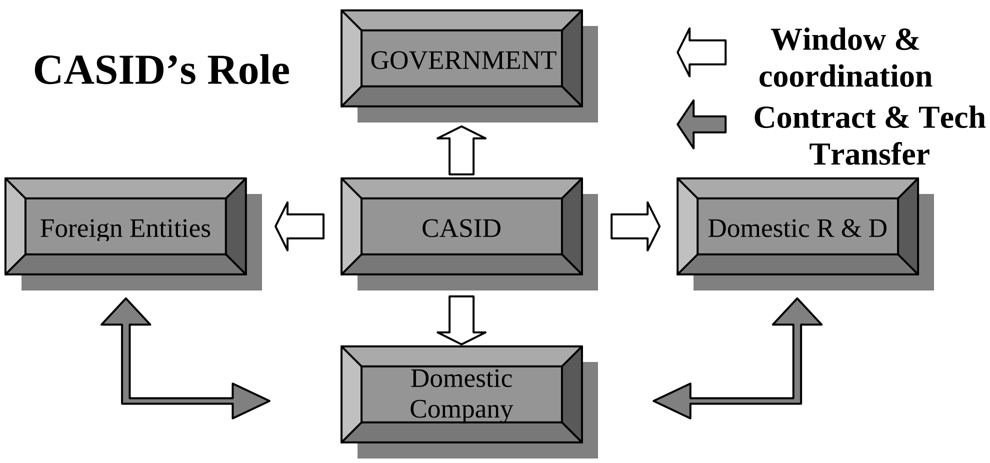
2. To act as a ‘window’ between foreign and local companies, assisting with market-surveys and various consultancy services.

3. As a semi-governmental organization, CASID has to implement government policy. CASID also has to make proposals about planning and future measures concerning the aerospace industry.

4. To handle offset credits. Offset deals were intended to be one of the main tools to build up the civil aircraft manufacturing capability, at least during the first phase. Insisting on offset agreements when buying aircraft abroad, the domestic industry has an opportunity to get access to aerospace technology by learning from its partners

Source: Interview with Vivian Wang, Project manager, CASID Head Office, Taipei, 6 August 1991.

Figure 3 CASID’s role in aerospace



Source*: CASID*

Previously the aircraft industry had been concentrated on the military sector. Nearly all resources had been allocated to the AIDC. As a result Taiwan had to build up an ‘infrastructure’ concerning suppliers. Companies making electronics, metals, and car parts were regarded as potential suppliers of aerospace components and materials, but there was a need to upgrade standards of precision, quality and management control.

Since only a small number of Taiwanese manufacturers were able to act as suppliers of aircraft components in the early 1990s, one important measure was to create a unit which could take the main responsibility for the integration of different subcontractors or suppliers. This unit was also to become the focal point of business transactions for Taiwan’s aerospace industry.

To fulfil these purposes, a semi-governmental company, the Taiwan Aerospace Corporation (TAC), was officially established in 1990 and started working in July 1991. The government provided 29 per cent of the initial capital, and private investors, including banks and manufacturing firms, covered the rest (Eriksson, 1995).

From the initial stages big expectations were laid on the newly formed Taiwan Aerospace Corporation. On November 20, 1991, a sensational agreement was signed between McDonnell Douglas (MDC) and the newly established TAC. The signing of the MoU (Memorandum of Understanding) initiated negotiations to set up a new commercial aircraft consortium. The key to the relationships between MDC and TAC was the launching of the proposed MD-12 wide body airliner. It appeared that TAC would buy up to 40 per cent of MDC´s commercial transport business by raising 2 billion U.S. dollar. MDC was to retain at least 52 per cent control, while a share of up to 9 per cent was aimed at a consortium of companies from South Korea and Japan (ibid).

Wealthy Taiwan appeared to be an ideal partner, especially as the MD-12 was being targeted at airlines serving the Asia-Pacific market to and from Europe and North America. MDC estimated MD-12 development costs at up to 5 billion U.S. Dollars. Initially MDC was offering co-development of major airframe sections in return for cash investments from the Asian partners in the project. After several MoU deadlines had been passed, it was obvious that the negotiations were facing bigger hurdles than had been foreseen.

There was much criticism of the proposed deal, despite the knowledge that the long learning curve in the civil aircraft industry could be leapfrogged. In Taiwan questions were raised whether it was financially sound to enter the proposed consortium when there were concerns about the financial health of McDonnell´s civil aircraft division. Another aspect was that the launching of the MD-12 came at a wrong time, making it uncertain whether the new aircraft could be developed. The MD-12 project was never put into production.

Many Americans who have regarded aerospace industries as their special expertise feared that the MDC-TAC deal was yet another key industry to be caught up by Asian competitors. This prompted two U.S. congressional committees to hold hearings on the deal, the first in December 1991, and the second in March 1992. The interest in the deal became lukewarm following further rounds of talk. In the summer of 1992 the whole deal came to nothing.

Instead, a new deal turned up in mid-September 1992. British Aerospace (BAe) announced a joint-venture with TAC. The deal should see TAC become a risk-sharing partner when the BAe 146 regional jet was re-launched as the RJ family. The two companies signed a contractual agreement on January 1993. TAC was aiming at a 50 per cent share in a new independent business based around BAe's Woodford plant near Manchester in the U.K. During 1995 it was obvious that also this second attempt to enter a full-fledged aircraft industry would not bear fruit (ibid).

The first years after the decision to develop a commercial aircraft industry were disappointing. It was much more complicated than anticipated. Despite Taiwan's huge economic resources and its reputation as an economic and commercial hub, it was much more complicated than the development of the computer industry.

It is obvious that Taiwan wanted to leapfrog the learning curve by taking equity and risk-sharing stakes in foreign companies, but the overseas firms main reason for engaging Taiwanese counterparts was the prospects of obtaining investment resources for extremely expensive aircraft projects.

After discussions (the author) with several high-ranking officials in Taiwan's aerospace industry, one obstacle in the early 1990s was the obvious difference in business culture between foreign and domestic actors. In retrospect, a lack of experience in commercial aerospace business on Taiwan's part was a factor which complicated the discussions with foreign companies.

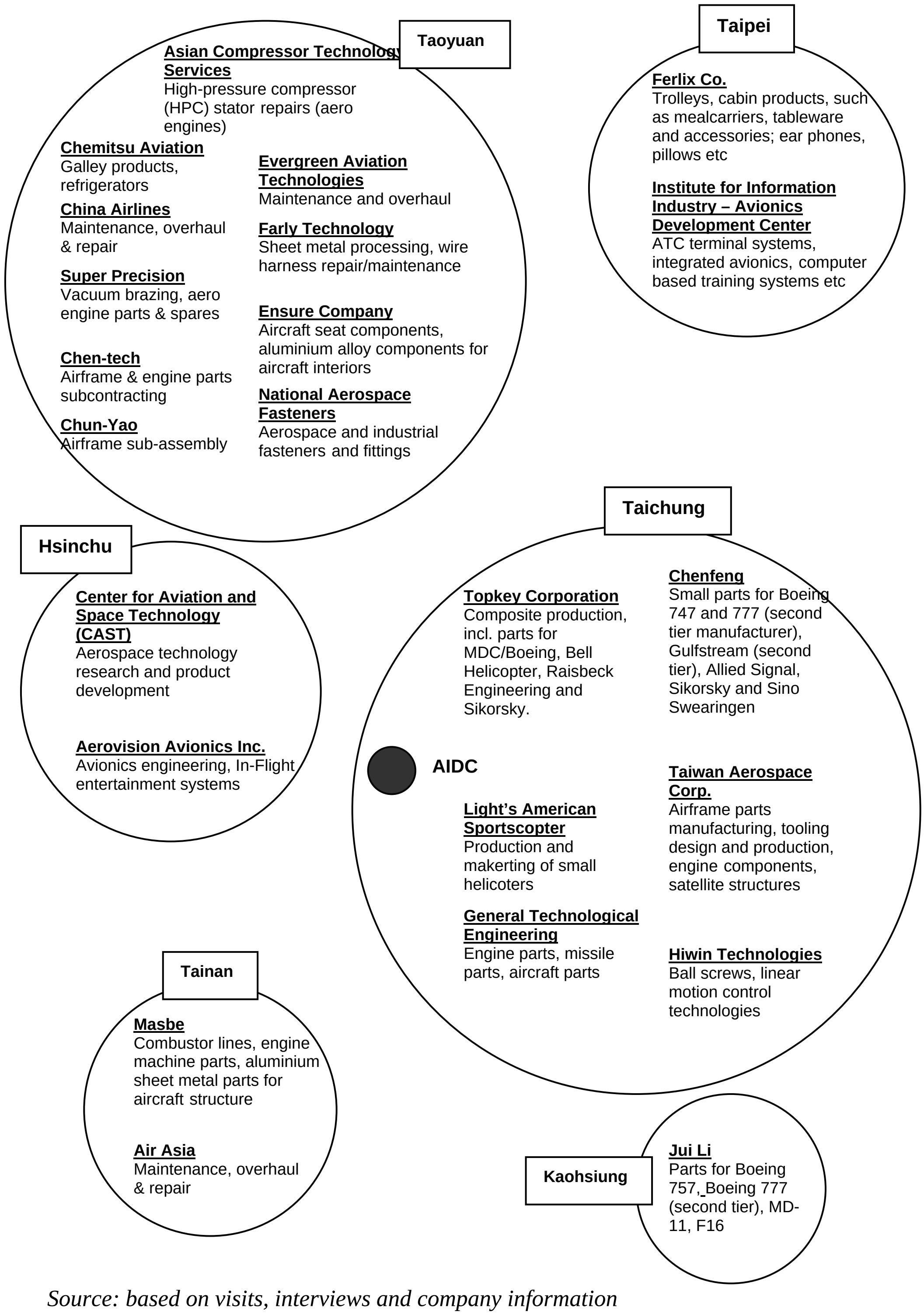
The failure to move into main airliner projects with American and European companies has not dampened Taiwan's ambitions to achieve a developed status in aerospace business. The government as well as private companies still aim at moving into the industry. When the original strategy to developed TAC into a major aerospace company failed, it was taken over by AIDC, almost the only representative of Taiwan's entire aircraft industry. In 1996 AIDC was transformed from a military enterprise directed by the Ministry of National Defence into a government-owned corporation supervised by the Ministry of Economic Affairs. In terms of new operation strategy, AIDC placed its emphasis on both the military and civil sectors (AIDC, 2000). In May 2000 AIDC employed a work force of approximately 4000. The first international subcontracting was the manufacturing of 7 components (offset) for the G.D./Lockheed F-16.

During the second part of the 1990s AIDC obtained a number of foreign commercial subcontracting work from Airbus, Aero Vodocody, Alenia, Bell Helicopters, Bombardier and Dassault.

Another way to support future technology development within the civil aerospace sector has been the establishment of the Centre for Aviation & Space Technology (CAST) integrated into the Industrial Technology Research Institute (ITRI). The main purpose is to develop aerospace technology and transfer it to local companies. As small and developing firms have small resources to deal with R&D, ITRI give them support. Although ITRI is not a manufacturing/company, it has set up a 'demo-factory', but will not be involved in any 'mass-production'. The fruits of research and development would then be passed on to privately and publicly-owned institutions and companies. The main funding comes from the Ministry of Economic Affair's (MOEA) 'Industrial Technology Development Program' and the 'Technology Transfer Program' (inf. CAST). The first five-year program ran between 1993 and 1997. CAST has also supported a number of companies with investments for developing new products.

One may ask what has been achieved after a decade of efforts to develop and establish an aerospace manufacturing system? Was it successful in its endeavour? According to CASID there were more than 60 companies involved in aerospace manufacturing in 2000, but a study (Eriksson, 2002) reveals that it is an exaggeration: field visits and first-hand information show that many of these companies are not yet involved in any manufacturing activities and if they do their aerospace related production is very limited. These companies should be looked upon as future potential suppliers in the aerospace industry. The study (ibid) shows that there has been development of new firms in the aerospace manufacturing sector as well as ”old” companies moving into this industry. The main locations for these new firms are Taichung and Taoyuan. AIDC is still the only company that has a real system integration capability (military aircraft), but there are signs that limited systems integration knowledge are under development through CAST, at least some sub-systems. It is clear that most of the new firms focus on specializing in certain niches, namely metal processing/aircraft components, avionics, galley products and maintenance.

Figure 4 Taiwan's 2000-2001 aerospace cluster



Source: based on visits, interviews and company information

A view of the firms, which have entered the aerospace sector, shows that *AIDC* acts as a spill over source for new firm formation. The author gathered from his visits to these companies that many employees and executives, in the new firms as well as old ones entering into this business, had experience from AIDC. This is a spill-over where competent people carry with them technical and management and other kinds of knowledge. AIDC is also the main source of production and other technology knowledge. Some of these companies have worked as subcontractors to AIDC thus learning production and technology from the main firm.

CAST is a new source of technology spill over, support and start-ups of new activities, although its impact seems to be very limited. The Cheng-Kung University, Tainan, is a university with a dedicated aerospace education, and supplies the firms with engineers.

More Taiwanese firms now work directly with foreign companies than a decade ago, especially those not linked to the AIDC "network". This gives them new access to markets and technology information/knowledge, and in the future enable them to work as domestic diffuser of knowledge. During visits to Taiwan it was also evident that a number of students studying abroad, mainly in the USA, had returned home to take part in the process to develop the domestic aerospace industry.

Other conclusions of the Taiwanese efforts to develop the aerospace sector are:

- The main strategy was to leapfrog the learning curve by taking equity stakes and risk-sharing deals with foreign companies. Although Taiwan boasts a unique economic and industrial development and large economic resources, it is obvious that the development of a successful civil aerospace industry was much more difficult than expected. With the astounding success of Taiwan's electronics and computer industry in mind, the government and organizations had no misgivings that it was possible to enter a similar path in commercial aerospace.

- The aerospace industry is characterized by extremely high-value products in relatively small quantities, produced by relatively few players. Products in this industry have long development cycles, skyrocketing development costs and low company turnover. In the case of Taiwan, the industry had no experience in the civil aerospace, which often takes a very long time to develop. There was a very limited capability in the Taiwanese innovation system to support such a complicated task. Taiwan's industry has profound experience in electronics- and computer industries with many competitors, short product life cycles and rapid company turnover. Most of Taiwan's firms are SMEs, while the system integrators in the world aerospace markets are large or huge companies, such as Airbus and Boeing.

- The aerospace industry is extremely complex and the most demanding in terms of system integration. A large number of different technological subsystems must work in an integrated way. This differs a lot from modularisation and disintegration, used by Taiwanese companies as a way to lower the entry barriers, for their semiconductor industry. Even the development of Taiwan's military aircraft industry was to a very large extent dependent on technology inflow (vertical inflow) of knowledge from foreign aerospace companies, mainly from the U.S. The domestic flows of knowledge and technology (horizontal) was more or less non-existent.

- After discussions with high-ranking officials in Taiwan's aerospace sector one obstacle has been the obvious difference in business culture between foreign and domestic actors. A lack of experience in commercial aerospace business was a factor which complicated the discussions with foreign companies.

- In recent years the overall processes in the aerospace industry are characterized by an increasing number of mergers, both domestic and cross-national. This implies a steady decline in the number of systems integrators. The reasons are high technological requirements, increasing development costs and international competition. It also means that functional and design standards are decided by the integrators, which in turn reduces options for the lower-tier companies, such as the Taiwanese ones. Put together, the entry barriers are extremely high, and have increased in recent years. On the other hand, an increasing number of cross-border activities in aircraft/aerospace development and production open up possibilities for emerging economies to enter new projects.

- The early emphasis to enter the group of system integrators, i.e. McDonnell Douglas and BAe, was never realized, and it is unlikely to be considered an option by Taiwanese actors. To develop the commercial aerospace competence, and thus create new possibilities for these firms, there is a need to join large international aerospace design and manufacturing networks. During the last few years several new linkages have been made to foreign aerospace companies as well as new innovation and manufacturing networks within Taiwan itself. Still some serious disadvantages remain: a limited infrastructure of supplier and related industries, and lack of business practices.

- To be able to enhance an internationally competitive aerospace cluster Taiwanese firms must develop unique competences or competitive advantages in an international context. Today much of the production includes components and parts manufacture, which are internationally replaceable, due to the existence of many locations around the world with a surplus in manufacturing capability. The excess does not only come from the mature aerospace actors within the EU and North

America, but also from countries of Eastern Europe, such as Russia, Czech Republic and Poland. Many developing and newly industrializing countries have also invested heavily in this sector and suffer from surplus manufacturing capacity.

- The domestic aerospace innovation system is still rather weak and cannot support Taiwan's wishes to develop a strong aerospace industry. The dependence on technology and business links to leading international firms is of outmost importance to develop a competitive aerospace cluster and innovation system. Although such links have increased in recent years, most of them are not of the kind that will have any major impact on the Taiwanese innovation system in a short term perspective.

5 CONCLUSIONS

South Korea and Taiwan both belong to the small group of first generation ”Asian tigers” also including Hong Kong and Singapore. The two economies which are subject of this study share a number of common features. First, like Korea, Taiwan was a Japanese colony and was tightly integrated into the Japanese economic system. A substantial industrialized base and physical infrastructure was established by the Japanese to utilize local labour and materials. Second, both South Korea and Taiwan have a difficult external political situation. In the case of Taiwan, there is claim by the P.R.C. of it being an integral part of the mainland, and in the case of Korea there is external threat from the unstable North Korea.

Both South Korea and Taiwan can also be described, at least in earlier periods, as being authoritarian corporatist states. They also share common features in the development path, going through primary-substituting industrialization, primary export-oriented industrialization and secondary import-substituting industrialization as well as secondary export-oriented industrialization.

In the early phase of development much of industrial production took advantage of abundant labour supply and later moved into consumer goods industries and more capital-intensive industries. These stages in industrial development correspond rather well to the notion of technological learning found in the sequences of industrial development, implying successively higher capital-ratios and higher levels of technological sophistication (Tier 1 to Tier 4), although there are still impediments for these economies to be looked upon as fully-fledged ”Schumpeterian” ones.

The role of the state has been fundamental both in Korea’s and Taiwan’s economic and industrial development. In general the government influence on industry and trade has been stronger in South Korea than in Taiwan. This is especially true when looking into the strong ties between the chaebols and the state. Although the large diversified family-controlled chaebols are pure private companies, the state deliberately created and nurtured them as locomotives for economic development. These business groups were the backbone of industrialization in the labour-intensive industries and played a major role in expediting technology learning in the industry. The chaebol has been the greatest strength of South Korea’s innovation system, but due to the recent developments perhaps these business groups have become a serious liability since the Asian crisis.

The Taiwanese industrial structure is different from that in South Korea. In Taiwan there is huge dominance of SMEs, with a strong entrepreneurial spirit, flexibility and where the industrial structure is based on business groups structured around the family, although they are much smaller than such groups in South Korea. In Taiwan the guanxichiye typically occupy a niche within part of one or several commodity chains, supplying intermediate products and services to other Taiwan businesses for eventual incorporation within export sectors. In South Korea the large business groups are much more involved in producing end products aiming at the domestic and international consumer markets.

The role of the state in Taiwan has concentrated more on creating supporting institutions that have focused on building human resources, acquiring technology from abroad, creating science and technology capacities and supporting development of commercial products.

Despite an impressing long-term economic and industrial development, both economies have weaknesses in the their innovation systems. In South Korea it seems that research at universities is relatively weak with a serious lack of interplay between universities and the private sector and a dearth of diffusion mechanisms to transfer research results from public research establishments to industry and particularly SMEs . On the other hand one report states that the SME-oriented innovation policies are more strongly developed than one would expect after reading literature on South Korea. South Korea's SME-oriented support is judged variously in the literature. Some have negative views. while others are more positive. Another study expresses the opinion that different judgements depend on lack of systematic evaluation. In general there are signs that South Korea's technology policy is moving from a mission-oriented to diffusion-oriented one.

As in South Korea, research at universities in Taiwan is relatively weak, but it seems that in Taiwan there are more developed mechanisms to transfer research results from public research establishments to industry, especially SMEs, through establishments such as ITRI and science-based industrial parks. The industrial and technology policies in Taiwan have supported a rather close cooperation between the state and industry, and increased connection between universities and the state. The weakest links seem to be between universities and industry. Reasons for the weak linkages are shortage of human resources in the engineering faculties of universities and Taiwan's industrial structure, with the domination of SMEs with very limited resources for research, both in terms and capital and human resources. An aggravating circumstance are the difficulties for leave of absence for researches to work in the industry.

An important reason for Taiwan's success in the IT-industry is the modular architecture of the products manufactured as modularization can reduce product complexity, lower entry barriers and increase industrial flexibility. This industry also fits well into the experience of most Taiwanese companies, with an emphasis on many competitors, short product life cycles and rapid company turnover. The emergence of new centres of technology, like Taiwan, has been possible due to a radical transformation in the structure of the IT-sector. The rise of Silicon Valley industrial model initiated a radical shift to a more fragmented industrial structure organized around networks of increasingly specialized producers.

Another important reason for the emergence of innovative regions such as Hsinchu is the importance of a transnational community that shares information, trust and contacts. From an innovation perspective this force is perhaps as important, or even more important, than government policies and TNCs. The connection to Silicon Valley, in particular, explains clearly how Taiwan's producers innovated technologically independence of their OEM customers.

South Korea was one of few countries with restrictions on FDI when technology was not a critical element and necessary mature technologies could be acquired through mechanisms other than FDI, such as reverse-engineering. As a consequence, the size of FDI was significantly lower in South Korea compared with most other newly industrializing economies. This implies that FDI had a much smaller effect on the Korean economy compared with the effects from FDI in other NIEs.

The technology transfer promotion through procurement of turnkey plants and massive imports of foreign capital goods became a major source of learning through reverse-engineering until the 1970s and probably even much later. After two decades of restrictive policy toward foreign direct investment and foreign licensing, South Korea liberalized its technology transfer policies in the 1980s and 1990s. The U.S. and Japan have been the major sources for technology transfer and learning.

As in South Korea, much of technology input in Taiwan has come from Japan and the U.S. Through much of its early industrialization, Taiwan employed older machinery and manufactured standardized products that were not subject to propriety restrictions. Knowledge about how to improve the utilization of this equipment as well as modifications of product specifications were readily available at low cost in trade literature and engineering publications. Up to the early1990s it seems that reverse engineering was still the most common means of acquiring technology. Since the 1990s the return of nationals who were educated or worked abroad had been an important mode of technology transfer as industrialization proceeds with more emphasis on capital and technology intensive sectors.

Like Korea, Taiwan has controlled the inflow of foreign direct investments into the domestic economy, although much less strictly. Compared with Korea, the role of FDIs in Taiwan has been more important as a source of learning and technology transfer. According to one limited study, the largest impact on the Taiwanese knowledge flow system was made by an International Interdependent Laboratory. In general there is consensus that foreign investment from the 1960s throughout the last century had a major influence on the development of knowledge and innovation capability in Taiwan. These industrial connections have provided opportunities for an agile manufacturing system that is capable to cope with the market fluctuations of cost-competitive and fashion-conscious industries.

In 1990 Taiwan's government decided to embark on the development of a civil aerospace industry in an effort to upgrade its industrial and technological capabilities, with the explicit expectations to foster more of an innovation-driven economy. Although Taiwan boasts a unique economic and industrial development, it is obvious that the development of a successful civil aerospace industry has been much more difficult than expected. The main reasons for this are:

- The aerospace industry is characterized by extremely high-value products in relatively small quantities, produced by relatively few players. Products in this industry have long development cycles, skyrocketing development costs and low company turnover. Taiwan's industry has profound experience in electronics- and computer industries with many competitors, short product life cycles and rapid company turnover. Most of Taiwan's firms are SMEs, while system integrators in the world aerospace markets are large or huge companies, such as Airbus and Boeing.

- The aerospace industry is extremely complex and the most demanding in terms of system integration. A large number of different technological subsystems must work in an integrated way. This differs a lot from modularisation and disintegration, used by Taiwanese companies as a way to lower the entry barriers, for their semiconductor industry. Even the development of Taiwan's military aircraft industry was to a very large extent dependent on technology inflow (vertical inflow) of knowledge from foreign aerospace companies, mainly from the U.S. The domestic flows of knowledge and technology (horizontal) were more or less non-existent. During the last few years several new linkages have been made to foreign aerospace companies as well as new innovation and manufacturing networks within Taiwan itself. Still some serious disadvantages remain: a limited infrastructure of supplier and related industries, and lack of business practices.

- In recent years the overall processes in the aerospace industry are characterized by an increasing number of mergers, both domestic and cross-national. This implies a steady decline in the number of systems integrators. The reasons are high technological requirements, increasing development costs and international competition. It also means that functional and design standards are decided by the integrators, which in turn reduces options for the lower-tier companies, such as the Taiwanese ones. On the other hand, an increasing number of cross-border activities in aircraft/aerospace development and production open up possibilities for emerging economies to enter new projects. To develop the commercial aerospace competence, and thus create new possibilities for these firms, there is a need to join large international aerospace design and manufacturing networks.

- Today much of the production includes components and parts manufacture, which are internationally replaceable, due to the existence of many locations around the world with a surplus in manufacturing capability. The excess does not only come from the mature aerospace actors within the EU and North America, but also from countries of eastern Europe, such as Russia, Czech Republic and Poland. Many developing and newly industrializing countries have also invested heavily in this sector and suffer from a surplus manufacturing capacity.

The Asian crisis appears to have catalyzed restructuring of South Korea's economy. Reforms in the public sector, the financial sector, chaebols and labour market, will probably have major future effects on South Korea's economy, also implying long-time changes in the innovation system. The down-sizing and the new focus of core business for chaebols, and promotion of SMEs, will also have major future implications of the country's innovation structure, as well as increasing foreign ownership in the industry and banking sector, implying introduction of new technologies and management knowledge.

Taiwan remained relatively well-insulated, in comparison to South Korea, from financial turbulence that hit the region due to the 1997 East Asian crisis.

Although Taiwan's economy has prospered in the past decades, its economy now faces a number of obstacles, such as increasing wages, industries moving out of Taiwan and slow down of industry growth. Another problem is Taiwan's political status in the international community. On the one hand, the 50-year rule of the authoritarian KMT came to an end in early 2000, when the Democratic Progressive Party (DPP) was elected into government. On the other hand, the DPP is a long-established advocate of independence from P.R.C. and this creates further political tensions. All these changes can have an influence on the future of Taiwan's innovation system.

6 References

Aeronautics and Space Industries Development Program (1990) *Ministry of Economic Affairs*, Taipei.

Amsden, H. (1989*) Asia's Next Giant, South Korea and Late Industrialization*. New York, Oxford University Press.

Aoki, M. (2000) Innovation in the Governance of Product-System Innovation: The Silicon Valley Model. Stanford Institute for economic Policy Research, *Policy Paper no. 00-003,* October.

Berger, S. and Dore, R. (eds) (1996*) National Diversity and Global Capitalism*. Ithaca, NY, Cornell University Press.

Breshnahan, T. (1998) New Modes of Competition: Implications for the Future Structure of the Computer Industry, Conference paper, March.

Callon, S. (1995) Different Paths: The rise of Taiwan and Singapore in the Global Personal Computer Industry, Asia/Pacific Research Centre, Stanford University, January.

Carlsson, B. & Jacobsson, S. (1994) Technology systems and economic policy: the diffusion of factory automation in Sweden. *Research Policy* 23, pp. 235-48.

Chang, H.-J. (1998) South Korea: the misunderstood crisis. In K.S. Jomo, *Tigers in trouble: Financial Governance, Liberalization and Crises in East Asia*. London, Zed Books, Chapter 10.

Chen, S.-H. and Liu, M.-C. (2003) Taiwan's Transition from an Industrializing Economy to a Knowledge-based Economy. In Masuyama, S. & Vandenbrink, D. (2003) *Towards a Knowledge-based Economy – East Asia's Changing Industrial Geography*, Tokyo and Singapore, Nomura Research Institute & Institute of Southeast Asian Studies.

Chesnais, F. (1986) Science, technology and competitiveness. *Science Technology Industry Review* 1, pp.85-129.

Chiang, J.-T. (1989) Technology and alliance strategies for follower countries*. Technology Forecasting and Social Change*, 35:339-49.

Chung, S. (1999) Korean innovation policies for SMEs. *Science and Public Policy*, 26, pp.70-82.

Chung, M.K. (2000) One Best Way? Niche Market Player or Global Market Player: The Case of the Korean and Taiwanese Electronics Industries. Paper presented at the International Conference on Business Transformation and Social Change in East Asia. Tunghai University, Taiwan, June 2-3.

Council for Economic Planning and Development (CEPD) (1996) Input-Output Tables Taiwan.

Crotty, J. and Lee, K.-K. (2002) A political-economic analysis of the failure of neo-liberal restructuring in post-crisis Korea. *Cambridge Journal of Economics*, 26, pp. 667-678.

Delapierre, M. and Mytelka, L.K. (1998) Blurring boundaries: New Interfirm Relationships and the Emergence of Networked Knowledge-based Oligopolies. In M.G. Colombo (ed.), *The Changing Boundaries of the Firm: Explaining Evolving Inter-Firm Relations*. London and New York, Routledge.

Deyo, F.C. (1992) The political economy of social policy formulation: East Asia's newly industrialized countries. In Applebaum, R.P. & Henderson, J. (eds), *States and Development in the Asian Pacific Rim*. London, Sage, chapter 11.

Dicken, P. (1998) *Global Shift – Transforming the world economy*, London, Paul Chapman Publishing.

Dicken, P. (2003) Global Shift – Reshaping the Global Economic Map in the 21st Century. London, Thousand Oaks, New Delhi, SAGE Publications.

Doremus, P.N., Keller, W.W., Pauly, L.W. and Reich, S. (1998) *The Myth of the Global Corporation*. Princeton, NJ, Princeton University Press,

Eriksson, S. (1995) *Global Shift in the Aircraft Industry: A study of airframe manufacturing with special reference to the Asian NIEs*. Gothenburg, Publications edited by the Departments of Geography, University of Gothenburg, Series B, no. 86.

Eriksson, S. (2000) Technology spill over from the aircraft industry: the case of Volvo Aero. *Technovation* 20, 653-664.

Eriksson, S. (2002) The efforts to create a high-technology aerospace cluster in Taiwan: impediments and prospects. Paper presented at a special invitation seminar "Clusters in High-technology" Montreal UQAM, November 1, 2002.

Eriksson, S. (2003a) Indonesia's aircraft industry: technology and management impediments. *International Journal of Technology Transfer and Commercialisation*, Vol. 2, No.2, pp. 207-226.

Eriksson, S. (2003b) Technology policies in East and Southeast Asia: Creating a new global structure in the aircraft industry. *Asian Geographer*, Vol 22, pp. 179-195.

Etzkowitz, H., Webster, A., Gebhardt, C., Cantisano Terra, B.R. (2000) The future of the university and the university of the future: evolution of ivory tower to entrepreneurial paradigm. *Research Policy*, Volume 29, Issue 2, February 2000, pp. 313-330.

Etzkowitz, H. and Leydesdorff, L. (2000) The dynamics of innovation: from National Systems and "Mode 2" to a Triple Helix of university-industry-government relations. *Research Policy* 29, Vol. 2, pp. 109-123.

Evans, P.B. (1995) *Embedded Autonomy: States and Industrial Transformation*. Princeton, Princeton University Press

Fang, S.-C., Lin, J.L., Hsiao, L.Y.C., Huang, C.-M. Huang, Fang, S.-R. (2002) The relationship of foreign R&D units in Taiwan and the Taiwanese knowledge-flow system. *Technovation* 22, pp. 371-383.

Freeman, C. (1988) Introduction, in G. Dosi, C. Freeman, R. Nelson, G. Silverberg, and L. Soete (eds) *Technical Change and Economic Theory*. London, Pinter, Chapter 1.

Freeman, C. (1995) The ‘national system of innovation’ in historical perspective. *Cambridge Journal of Economics* 19, pp. 5-24.

Freeman, C. & Lundvall, B.-Å. (eds) (1988) *Small Countries Facing the Technological Revolution*. London, Pinter.

Gerybadze, A. and Reger, G. (1999) Globalisation of R&D: Recent Changes in Management of Innovation in Transnational Corporations. *Research Policy* 28 (2-3), pp. 251-74

Griffin, K. (1978) *International Inequality and National Poverty*. London, Macmillan.

Guerrieri, P. and Tylecote, A. (1994) National competitive advantages and microeconomic behaviour. *Economics of Innovation and New Technology* 3, pp. 49-76.

Hagedoorn, J. (1995) Strategic technology partnering in the 1980s: trends, networks and corporate patterns in non-core technologies, *Research Policy* 24:207-31

Hamilton, G. (1998) Culture and organization in Taiwan’s market economy. In Hefner, R. (ed.) *Market Cultures: Society and Morality in the New Asian Capitalisms*. Boulder, Colorado, Westview Press.

Hassink, R. (2001) Towards Regionally Embedded Innovation Support Systems in South Korea? Case Studies from Kyonk-Taegu and Kyonggi. *Urban Studies*, Vol. 38, No. 8, pp. 1373-1395.

Henderson, R.M. & Clark, K.B. (1990) Architectural innovation: the reconfiguration of existing product technology and the failure of established firms. *Administrative Science Quarterly*, 35:9-30.

Hou, C-M & Gee, S. (1993) National systems supporting technical advance in industry: the case of Taiwan. In Nelson, R.R. (ed.), *National Innovation Systems: A Comparative Analysis*. New York, Oxford University Press.

Hsu, C.-W. & Chiang, H.-S. (2001) The government strategy for upgrading of industrial technology in Taiwan. *Technovation* 21, pp. 123-132.

Justman, M. & Teubal, M. (1995) Technological infrastructure policy (TIP): creating capabilities and building markets. *Research Policy* 24, pp.259-81.

KDI (1975) *Korea’s economy: Past and present*. Seoul.

Kim, B.K. (1987) *Bringing and managing socioeconomic change: the state in Korea and Mexico*. PhD dissertation, Department of Government, Harvard University.

Kim, L. (1980) Stages of development of industrial technology in a developing country: a model. *Research Policy* 9: 254-77.

Kim, L. (1997) *Imitation to Innovation*. Boston, Harvard Business School Press.

Kim, L. (1997b) *Toward re-engineering Korea’s national innovation system in transition*. Seoul, STEPI (unpublished manuscript).

Kim, L. (2000) Korea’s National Innovation System in Transition. In L. Kim and R. Nelson (eds) *Technology, Learning and Innovation: Experiences of Newly Industrializing Economies*. Cambridge, U.K., Cambridge University Press, pp. 335-360.

Kim, L. (2001) Crisis, National Innovation, and Reform in South Korea. *MIT Working Paper* 01.01.

Kim, L. & Kim, Y. (1985) Innovation in a Newly Industrializing Country: A Multiple Discriminant Analysis. *Management Science* 31, no. 3, pp. 312-322.

Kim, L. & Nugent, J.B. (1994) *The Republic of Korea's small and medium-size enterprises and their support system*. Policy Research Working Paper 1404, Washington, The World Bank.

KITA (Korea Industrial Technology Association) (1994) *Sanup Gisul Baegseo* (Industrial technology white paper, 1994). Seoul, KITA Press.

Kogut, B. & Bowman, E. H. (1995) Modularity and permeability as principles of design. In Bowman & Kogut (eds), *Designing the firm*. New York, Oxford University Press.

Koo, H.& Kim, E.M. (1992) The developmental state and capital accumulation in South Korea, in R.P. Appelbaum and J. Henderson (eds), States and Development in the Asian Pacific Rim. London, Sage, Chapter 5.

Korea Exchange Bank (1987) Direct Foreign Investment in Korea. *Monthly Review*, October 1987, pp. 18-19.

Krause, L. (2000) The Aftermath of the Asian Financial Crisis for South Korea. Paper presented at the East West Centre, Honolulu, January.

Krugman, P. (1991*) The Geography of Trade*. Cambridge, MA, MIT Press.

Krugman, P. (1992) Technology and international competition: a historical perspective. In Harris, M.C., Moore, G. E. (eds) *Linking Trade and Technology Policies*. Washington, National Academy Press, pp. 13-28.

Lall, S. (1994) Industrial policy: the role of government in promoting industrial and technological development, *UNCTAD Review* 1994, pp. 65-90.

Lau, L.J. (1994) The Competitive Advantage of Taiwan, *Journal of Far Eastern Business*, Autumn, pp. 90-112.

Lehmann, J.-P. (1998) Asian tigers make way for the bamboo network, Mastering Global Business 10, pp. 2-4, Financial Times.

Levy, B. & Kuo, W.-J. (1991) The strategic Orientation of Firms and the Performance of Korea and Taiwan in Frontier Industries: Lessons from Comparative Case Studies of the Keybord and Personal Computer Assembly. *World Development*, 19 (4), pp.363-375.

Lin, O. (1998) Science and technology policy and its influence on economic development in Taiwan. In Rowen, H.S. (ed*.), Behind East Asian Growth*. London, Routledge.

Lundvall, B.-Å. (1985) *Product Innovation and User-Producer Interaction*, Aalborg, Aalborg University Press.

Lundvall, B.-Å. (ed) (1992) *National Systems of Innovation*. London, Pinter.

Lynn, L.H., Reddy, N.M. & Aram, J.D. (1996) Linking technology and institutions: the innovation community framework. *Research Policy* 15, pp. 91-106.

Malecki, E.J. (1997*) Technology & Economic Development (Second edition): The Dynamics of Local, Regional and National Competitiveness*. London, Longman.
Mathews, J.A. (1997) A Silicon Valley of the East: Creating Taiwan's Semiconductor Industry, *California Management Review*, 39 (4), pp. 26-54.
Mathews, J.A. & Cho, D-S (2000*) Tiger Technology – The creation of a semiconductor industry in East Asia*. Singapore, Cambridge University Press.
Metcalfe, J.S. (1995) Technology systems and technology policy in an evolutionary framework. *Cambridge Journal of Economics* 19, pp. 25-46.
Michell, T. (1988) *From a developing to a newly industrializing country: The Republic of Korea, 1961-82*. Geneva, International Labour Office.
Ministry of Science and Technology (1994) *1994 Report on the Survey of Research and Development in Science and Technology*. Seoul, MOST, December.
Mowery, D.C. & Rosenberg, N. (1989) *Technology and the Pursuit of Economic Growth*, Cambridge, Cambridge University Press.
National Science Council Executive Yuan, R.O.C. (NSC) Science and Technology Indicators, 1998.
Nelson, R.R. (1993) *National Innovation Systems: A Comparative Analysis*. New York, Oxford University Press.
Niosi, J. (1999) The Internationalisation of industrial R&D from Technology Transfer to the Learning Organization. *Research Policy* 28 (2-3), p. 107-17.
OECD (1988) *The Newly Industrializing Countries*. Paris, OECD.
OECD (1991) *Strategic Industries in a Global Economy: Policy Issues for the 1990s*. Paris, OECD.
OECD (1996*) Reviews of National Science and Technology Policy: Republic of Korea*. Paris, OECD.
OECD (1999) *OECD Science, Technology and Industry Scoreboard 1999: Benchmarking Knowledge-Based Economies*. Paris, OECD.
Ozawa, T. (1995) Structural upgrading and concatenated integration: the vicissitudes of Pax Americana in tandem industrialization of the Pacific Basin. In Simon D.F. (ed.*) Corporate Strategies in the Pacific Rim: Global versus Regional Trends*. London, Routledge: 215-46.
Pack, H. (2001) The Role of Acquisition of Foreign Technology in Taiwanese Growth. *Industrial and Corporate Change*, Vol. 10, Nr 3. Oxford University Press.
Park, S.O. (1998) *Local innovation systems of small and medium-sized enterprises in Korea*. Paper presented at the Annual Conference of the IGU Commission on the organization of Industrial Space. Seville, August.
Patel, P. & Pavitt, K. (1994) National innovation systems: why they are important, and how they might be measured and compared. *Economics of Innovation and New Technology* 3, pp.77-95.

Perkins, D.H. (1994) There are at least three models of East Asian development. *World Development* 22, pp. 655-61.
Perry, M. (1999) *Small Firms and Network Economies*. London and New York, Routledge.
Porter, M. (1990*) The Competitive Advantage of Nations*. New York, Free Press.
Portes, A. (1996) Global Villagers: The Rise of Transnational Communities. *American Prospect*, March-April, pp. 74-77.
Ranis, G. (1979) Industrial Development. In W Galenson (ed.), *Economic Growth and Structural Change in Taiwan*. Ithaca, NY, Cornell University Press.
Ranis, G. (1998) 'Miracles that don't cease', *Financial Ti*mes, 19 February.
Rankin, L.J. (1995) The role of users in information technology standardisation. *STI Review 16*, pp.177-94.
Roobeek, A.J.M. (1990) *Beyond the Technology Race: An Analysis of Technology Policy in Seven Industrial Countries*. Amsterdam, Elsevier.
Samuels, R.J. (1994) '*Rich Nation, Strong Army': National Security and the Technological Transformation of Japan*, Ithaca, New York, Cornell University Press.
Saxenian, A.L. & Hsu, J.-Y. (2001) The Silicon valley-Hsinchu Connection: Technical Communities and Industrial Upgrading. *Industrial and Corporate Change*, Vol. 10 (4), pp.893-920.
Schumpeter, J. (1934) *The Theory of Economic Development. Oxford*, Oxford University Press.
Schumpeter, J. (1943) *Capitalism, Socialism and Democracy*. London, Allen & Unwin.
Sen, A. (1979) Followers' strategy for technological development. The *Developing Economies* 17: 506-28.
Shyu, J,C, & Chiu, Y.-C. (2002) Innovation policy for developing Taiwan's competitive advantages. *R&D Management* 32, 4, pp. 369-374.
Sigurdson, J. & Cheng, A. L.-P. (2001) Introduction: New technological landscape in Asia Pacific? *Int. J. Technology Management*, Vol. 22, Nos.5/6, 2001.
Simai, M. (1990) *Global Power Structure, Technology and World Economy in the Late Twentieth Century*. London, Pinter.
Singh, A. (1995) How did east Asia grow so fast? Slow progress towards an analytical consencus, *UNCTAD Bulletin*, Vo. 32, pp. 4-5, 8, 14.
Tassey, G. (1991) The functions of technology infrastructure in a competitive economy. *Research Policy* 20, pp. 345-61.
Todd, D. (1992) The internationalisation of the aircraft industry: substance and myth. In van Liemt, G. (ed.) *Industry on the Move: Causes and Consequences of International Relocation in the Manufacturing Industry*. Geneva, International Labour Office, pp. 117-148.
Turner, A. (2001) *Just Capital: The Liberal Economy*. London, Macmillan.
Ulrich, K. (1995) The role of product architecture in the manufacturing firm. *Research Policy*, 24: 419-40.

UNCTAD (1995) *World Investment Report 1995: Transnational Corporations and Competitiveness*. New York, United Nations.

UNCTAD (2001) *World Investment Report: Promoting Linkages*. New York, United Nations.

Wade, R. (1990) *Governing the Market: Economic Theory and the Role of Government in East Asian Industrialization*. Princeton, NJ, Princeton University Press.

Wade, R. and Evans, D. (1994) Comments on the World Bank's Study: The East Asian Miracle, *Working Paper, Institute of Development Studies*, University of Sussex.

Walsh, V. (1987) Technology, competitiveness and the special problems of small countries. *STI Review* 2: 81-133.

Whitley, R.D. (1999) Divergent Capitalisms: The Social Structuring and Change of Business Systems. Oxford, Oxford University Press.

Windrum, P. (1999) "The MERIT Report on Innovation Networks in E-commerce". Prepared for SEIN (Simulating Self-organising Innovative Networks), Workpackage 4. EU TSER (Targeted Socio-economic Research) Programme.

World Bank (1993) *The East Asian Miracle: Economic Growth and Public Policy*. New York, Oxford University Press.

Westphal, L.E., Kim, L. & Dahlman, C.J. (1985) Reflections on the Republic of Korea's Acquisition of Technological Capability. In Rosenberg, N. and Frischtak, C., *International Technology Transfer: Concepts, Measures, and Comparisons*. New York, Praeger.

Wu, R.-I. (2000) "Competive Analysis of Taiwan's Industrial Technology". Paper presented at the conference on the Measurement of Industrial Technology Competitiveness in the Knowledge-Based Economy, Taipei, 23-24 August.

Zysman, J. (1994) How institutions create historically rooted trajectories of growth. *Industrial and Corporate Change* 3, pp. 243-83

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VINNOVA´s mission is to promote sustainable growth
by developing effective innovation systems
and funding problem-oriented research

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