# LATECOMER FIRMS, TECHNOLOGY LEARNING AND THE CHANGING DIVISION OF LABOUR IN TAIWAN'S ELECTRONICS INDUSTRY

by

Chia-Wen Lee
B.A., National Taipei University, 1996

THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF ARTS

In the
Department of Geography



SIMON FRASER UNIVERSITY

Summer 2005

## APPROVAL

**Name:** **Chia-Wen (Lydia) Lee**

**Degree:** **Master of Arts**

**Title of Thesis:** **Latecomer Firms, Technology Learning and the Changing Division of Labour in Taiwan's Electronics Industry**

**Examining Committee:**

**Chair:** **Dr. Nicholas Blomley**
Professor

---

**Dr. R. Hayter,** Professor
Senior Supervisor
Department of Geography, SFU

---

**Dr. David W. Edgington,** Associate Professor
Committee Member
Department of Geography, UBC

---

**Dr. T. Kawasaki,** Associate Professor
Committee Member
Department of Political Science, SFU

---

**Dr. Thomas A. Hutton,** Associate Professor
External Examiner
School of Community and Regional Planning, UBC

**Date Approved:** May 19, 2005

# ABSTRACT

This thesis examines the role of 'latecomer' firms in the development of the Taiwanese electronics industry, especially from the perspective of technology transfer. Latecomer firms are indigenous firms that are large, able to challenge the competitive power of multi-national corporations, and originally conceived in East Asian contexts. Conceptually, latecomer firms are examined as mechanisms of technology transfer within the framework of the (reverse) product cycle model and the changing international division of labour (IDL). Empirically, the analysis draws on in-depth personal interviews with representatives of three latecomer firms in Taiwan's electrical industry, as well interviews with government and association officials. The analysis reveals the importance of latecomer firms as a source of learning and skill formation in Taiwan along the lines of the reverse product life cycle model and variations among latecomer firms in the nature of learning. Implications for Taiwan's role in the IDL are also noted.

# DEDICATION

*This thesis is dedicated to the memory of my mother.*

ACKNOWLEDGEMENTS

It has been a long journey for me to finish this thesis. I feel an immense gratitude to many people who offered me a lot of help along the way. Without them, this thesis would not be completed so smoothly.

First, I want to express my gratitude to my senior supervisor, Professor Roger Hayter for initially turning me on to economic geography and for all the guidance, support and inspiration throughout the duration of my research.

I must offer my thanks to Professor David Edgington and Professor Tsuyoshi Kawasaki for their constructive criticism during my research as well as the writing of my thesis. Thanks also go to my external examiner, Professor Thomas Hutton for his patience and support of my research.

My Thanks go to all at the geography department of SFU, in particular my office colleagues, Tomasz and Julia, thank you for your friendship and for all the great advice and encouragement over the past two years.

I also want to thank the managers of all the firms who granted me interviews and provided me with a lot of great information.

Thank-you to all of my school fellows, especially Jenny, Taskin and Catherine, thanks for your friendship, and for always being there for me. Special thanks to Hsien-Ming and Tom for your encouragement and support along the way.

Last but not least, my biggest thanks go to my family and friends in Taiwan. Their endless care and moral support allowed me to stay focused on my research for the past three years.

# TABLE OF CONTENTS

# LIST OF FIGURES

# LIST OF TABLES

# CHAPTER 1:
# THE INTERNATIONAL DIVISION OF LABOUR AND LATECOMER FIRMS IN ASIA

During the past few decades, increasing global economic integration has become a notable trend. Underlying this trend are continuing changes in the spatial/international division of labour. As globalization has increased openness of national markets, shifts in international production and mobility of capital flows have created more complex exchanges between and within core and peripheral areas. As a result, the traditional view of the international division of labour (IDL), namely the core-periphery scheme, has become inadequate to explain the changing global economy (Gereffi, 1996; Dicken, 2003). Thus Scott and Storper (1992: 11) emphasize the increasing importance of the regional economic development in the global context, and they delineate the economic geography of the contemporary world as a 'global mosaic of regional economies' rather than a core-periphery system. In Gereffi's lexicon (1994), cores and periphery define a continuum of possibilities, including semi-peripheries.

The so-called 'new international division of labour' (NIDL) was first promoted in the 1980s (Fröbel et al., 1980; Scott, 1987), particularly with respect to the rise of newly industrialising countries (NICs) in peripheral regions, such as Latin America and East Asia. Whereas Scott (1987) emphasised the increasing complexity of the NIDL by illustrating the formation of an intra-regional division of labour within peripheries which are closely intertwined with the broader division of labour in the global scale, he also recognised that the NIDL does not define a static situation. In this regard, multinational corporations (MNCs) remain the major economic actor emphasized in the literature in understanding the evolving NIDL (Bellak and Cantwell, 1998). However, there has been increasing recognition that indigenous firms have also become important. Within the context of Asian newly industrialising countries (NICs) of Taiwan, South Korea and Singapore, for example, so-called 'latecomer firms' (Hobday, 1995) are indigenous firms which have grown rapidly to challenge MNCs, with important implications for the division of labour. In this regard, it is important to recognise that domestic capabilities in the promotion of entrepreneurship vary around the world. The Asian NICs have been considered remarkable examples with respect to fostering latecomer firms (Hobday, 1995; Mathews and Cho, 2000).

While some literature examines the notion of latecomer mostly at the firm level (Hobday, 1995; Mathews and Cho, 2000), other literature looks into the subject at the national scale (Storper, 1998; Bellak and Cantwell, 1998). Latecomer countries which are late in the sense of developing a sophisticated industrial structure within the global economy have followed various trajectories to catch up with the leading countries and adopted different strategies to develop higher value commodity chains (Storper, 1998; Gereffi, 2002). Whereas there are several factors that shape latecomer's competitiveness, including "innovation, technology, trade and foreign direct investment (FDI), size and resource endowments, and institutional factors" (Bellak and Cantwell, 1998: 40), innovation and technology are especially crucial. More specifically, technological learning capability is a major factor which determines the rate of catching up for latecomer countries and firms (Hobday, 1995; Storper, 1998). In this regard, latecomer firms can acquire technology from leading firms in highly developed countries through a variety of channels, including FDI, licensing, subcontracting and original equipment manufacture (OEM) arrangement (Hobday, 1995). Available evidence suggests that MNCs in the core countries have retained the leading position as the main source of advanced technology. However, the peculiar role of latecomer firms for promoting industrialization in latecomer countries has been recognized and has attracted a considerable research literature which spans several disciplines, notably economics, politics, and sociology (Hobday, 1995; Storper, 1998; Bellak and Cantwell, 1998; Amsden and Chu, 2003). Yet it remains a rather untouched subject in economic geography even some studies have focused on the role of late-industrialising countries and the evolving NIDL (Scott, 1987). This thesis addresses this research gap by exploring the development of latecomer firms, specifically with respect to Taiwan's role in the IDL of the electronics industry.

The remainder of this chapter comprises three main parts. The first part defines the notion of IDL, introduces the concept of the 'latecomer firm' in the context of global economy and subsequently delineates the emergence of latecomer firms in East Asian countries. The second section describes the importance of the electronics industry in Taiwan as a major force behind the national industrial development. Finally, the research questions and research design are discussed in the following section.

## 1.1 The International Division of Labour and Latecomer Firms

In the past few decades, the concept of IDL has become more intricate in the modern literature as it aims to integrate various ongoing processes, which include "the fragmentation of tasks, the routinization of production, the physical (spatial) decentralization of work and the reintegration of physically decentralized, part-processing operations for final assembly and marketing" (Caporaso, 1987: 34). Within economic geography and related literatures, the division of labour is interpreted in various ways. The social division of labour involves the differentiation of occupational categories among firms while the internal division of labour refers to the differentiation of occupational categories within firms (Hayter, 1997). On the other hand, the territorial division of labour, or the spatial division of labour (SDL) refers to how geographical regions specialize within and among firms in producing certain products, exchanging their surplus for goods produced elsewhere (Caporaso, 1987). More specifically, according to Massey's (1984) definition, the SDL can be understood from two aspects, namely sectoral and intra-sectoral division of labour. The sectoral division of labour takes place when "regions specialize in particular industries and all related skills...the intra-sectoral division of labour occurs when within industries firms choose to specialize tasks and occupations by location" (Hayter, 1997: 208).

The traditional view of the spatial division of labour was based on the core-periphery scheme which basically divided the world into core areas of skilled labour and technologically advanced industries and peripheral areas marked by low wages and low-skilled labour, and relatively technologically backward industries (Simon, 1960; Hayter, 1997). However, this core-periphery scheme has proven more dynamic in the context of the IDL as Gereffi (1994, 2002) observed the increasing tendency of shifts in international production between the core, semi-periphery and peripheral countries. In a few cases, especially in Asia, selected countries have been able to shift into relatively high value-added activities and more sophisticated segments within the commodity chains by means of product differentiation and technological upgrading (Scott and Storper, 1992). The relocation of most labour-intensive segments of the commodity chains and production of mature products to countries with lowest wages can be summarized by the product cycle model. During the course of the evolution of product cycle model, technology shifts from laboratory equipment and pilot plants to relatively small-scale operations to large-scale plants utilizing standardized machinery designed for mass production. That is, over time, products shift from (skilled) labour-intensive activities to capital-intensive activities employing unskilled labour (Hayter, 1997: 101). As the product cycle is repeated for increasingly sophisticated products, it predicts the shift of industries (and products) from the core to more peripheral countries (Vernon, 1966; Bernard and Ravenhill, 1995).

The globalization in the past fifty years has generated examples of late developing countries, especially from East Asia, catching up with established economic powers like the U.S. and Japan. Yet the striking success of those latecomers has prompted enormous interest in the strategies and policies which have led to this success and their increasing importance in the global economy. Most of the research literature examines the rise of latecomer on the national economic development basis and generally with specific reference to certain technology-intensive industries (Hobday, 1995; Mathew and Cho, 2000). However, Gereffi (1996) suggests that a network-centered perspective is required to examine East Asia as an interrelated regional economy.

On the other hand, the implication of the rise of latecomer in economic geography could be referred to as notion of NIDL which according to Scott (1987) has evolved into a complicated system that consists of hierarchical levels and sub-regional relationship. As Scott (1987) identifies a crudely internal core and periphery within the south-East Asian semiconductor industry, the concept of latecomer fits perfectly into the category of the internal core. Moreover, Scott and Storper (1992) suggest the core-periphery scheme from the IDL fails to capture the periodic shifts in the overall geographic configuration of the contemporary global economic activities, which lead to a restructuring of the relationships between core and peripheral areas. They further stress the significance of the regional economic development in the global context and suggest that the global economy consists of a set of specialized regional production systems (Scott and Storper, 1992). In this system, some successful latecomers have acted as 'core-like' countries in the regional division of labour which entwines closely with the broader division of labour at the global scale. In this way, the "core-periphery" configuration, among which the core and peripheries had standard centre-hinterland relationships within the production systems at a global level no longer exists (Veltz, 1991).

Whereas the global economy becomes more interdependent as a result of the intensification and improvement of the IDL as well as new forms of enterprise organization, it is necessary for latecomer to find its "niche of specific competence" in order to be able to catch up with the leading economies (Bellak and Cantwell, 1998). As the latecomers generally begin with the labour-intensive industries at their initial stages in the international division of labour, overtime they shift to the capital- and technology-intensive industries that are based on continuous learning (Storper, 1998). Thus the long-term driving force in this process is the progressive improvement of their technological capabilities, in combination with their productivity advantages.

The changes of the latecomer's position in the NIDL not only involve the shifts in international production networks but also depend on the development of specialized technological competencies. Thus a number of critical institutional arrangements, including FDI, the international subcontracting system, OEM/ODM arrangement, inter-firm strategic alliances and licensing agreements, play important mediating roles during this process. According to Hobday (1995), those institutional channels enable latecomers to obtain technology from foreign firms and enter export markets which later force the pace of progress.

Meanwhile, foreign MNCs from leading countries continue to exert great impact on the evolving IDL as well as on the latecomers especially with regard to the acquisition of their technology. As MNCs continuously raise control over global production activities, the spreading of MNCs activities also led to changes in the spatial and international division of labour (IDL). In the context of NIDL, MNCs differentially allocate the various phases of the production process across space in accordance with their technological and skill characteristics. Moreover, MNCs have established international networks coordinating their production operation as well as innovatory activities. These networks rely on intra- and inter-firm linkages, representing varying degrees of integration and specialization (Bellak and Cantwell, 1998; Giroud, 2003). Cantwell (1994) also states that the international networks which MNCs created to back up their own technological innovation activities may intensify the existing patterns of national specialization. As a result, MNCs activities could lead to spatial consequences of the international division of labour (Veltz, 1991).

In view of the need for specific production created by MNCs, a country can become specialised in certain production and thus develop its own competence in relation to the regional division of labour. Through FDI, the MNCs continually contribute to the creation and improvement of such comparative advantages in the host countries. Over time, each country would carry out specific tasks within an evolving international division of labour. The position of FDI host country within the global commodity chains driven by the MNCs thus varies in accordance with its international specialisation. Furthermore, as the role of FDI and MNCs activities in the global economy continues to grow, the degree of transnationalisation is rapidly increasing for both MNCs and the countries in which they operate (UNCTAD, 2004).

## 1.2 The Economic Growth in East Asia

Developed countries dominate global FDI flows. However, some developing countries have become increasingly important as a destination and source of FDI. While global FDI inflows reached a peak of US$1.4 trillion in 2000 and then experienced three years of decline, falling to US$560 billion in 2003, the share of developing countries in global FDI inflows rose by 8%, to 31% in 2003 (UNCTAD, 2001, 2004). Although varied by region, FDI flows to developing countries grew continuously and rose by 9% to US$172 billion in 2003. China was the largest host country and inward FDI to the Asia-Pacific region reached US$107 billion in 2003. Further, annual FDI outflows from developing countries have grown faster over the past 15 years than those from developed countries, and in 2003 outward FDI from developing countries accounted for 6% of world total flows (US$36 billion) (UNCTAD, 2004).

East Asian countries have attracted important shares of FDI in the last few decades, and some of them have become major sources of outward FDI. According to the data from UNCTAD (2004), if FDI outflows are viewed with respect to the growth in fixed capital formation, a number of developing countries, such as Taiwan and Singapore, rank higher than certain developed countries as Japan and the USA. Relatively speaking, certain developing countries in East Asia are already among major sources of outward FDI. In 2003, the large donor economies in East Asia included South Korea, Taiwan, and Singapore, and these countries were previously the major FDI recipients (host economies) whereas China and Malaysia are currently the main FDI host economies in East Asia (UNCTAD, 2004). The major sources of Asian-based FDI flows are thriving Asian firms which are highly export-oriented and demand access to technology and strategic assets abroad. Before turning into foreign investors themselves, many Asian firms upgraded their manufacturing industries by obtaining advanced industrial knowledge from foreign MNCs through FDI as well as subcontracting, licensing and OEM/ODM arrangement (Hobday, 1995). As a result, more and more local enterprises have absorbed the technology expertise of established MNCs to become international firms and have grown to compete directly with MNCs from leading developed countries in the global market (Hobday, 1995; Urata, 1998). These firms illustrate the idea of latecomer firms. Typically, latecomer firms are manufacturing companies in developing countries which have been at a disadvantage in catching-up with cutting-edge industry, and who have successfully developed their own technological capabilities through learning strategies that differ from the traditional manner in which developing countries obtain advanced technology (Hobday, 1995).

The process of East Asia's growth has witnessed a rapid uptake of existing technological opportunities (Bell and Pavitt, 1993). Amsden (1989) suggests that the East Asian industrialisation experience has essentially been a process of 'catch-up', in which replication of industrial techniques has been achieved through 'learning', more specifically, through acquisition and adaptation of product and process technologies. With respect to their technological learning experiences, Hobday (1995) illustrates how latecomer firms in East Asia derived advanced technology from foreign MNCs from the USA and Japan through various channels. Furthermore, latecomer firms have coupled technology development to export market needs under sub-contracting arrangements, the OEM system, licensing and other mechanisms, in order to overcome entry barriers to the global market. These strategies have enabled them to learn from foreign companies and to rapidly expand their exports. Latecomer firms have not just imported technology but have learned how to absorb, adapt, diffuse and ultimately improve it (Kim, 1997).

According to Hobday (1995), the latecomer firms tend to enter at the mature, standardized end of the product life cycle and gradually assimilate technology by learning. As they gradually accumulate their technological capabilities, they narrow the technology gap between themselves and the market leaders. In this sense, the latecomer firms travel backwards along the product life cycle, reversing the normal path. Hayter and Edgington (2004) also observe that some East Asian latecomer firms have followed this trajectory with respect to their economic development and moved along the reverse product cycle.

## 1.3 The Electronics Industry in Taiwan

Since the 1970s, there has been an increasing concentration of activities in the electrical and electronics sector in Asia, with operations from Western and Asian firms highly concentrated in a few Asian countries, particularly the Asian NICs (Borrus, 1993, Hobday, 1995). In this period, East Asian NICs have developed extensive, technologically-sophisticated industries and certain production in the electronics industry and begun to compete directly with the dominant Japanese, USA and European manufacturers (Henderson, 1997; Mathew and Cho, 2000; Guerrieri, 2000).

In the past few decades, Taiwan has been an especially notable performer in the electronics sector among Asian countries and indigenous latecomer firms have played an important role in this growth. Before the rise of the indigenous latecomer firms, FDI, specifically from Japan, stimulated Taiwan's electronics industry. From 1970 well into the 1980s, Taiwan was one of the major recipient countries of Japanese FDI (Hayter and Edgington, 2004). Many Taiwanese firms upgraded their manufacturing industries by obtaining advanced industrial knowledge from Japanese MNCs. Subsequently, by the late 1980s, several enterprises expanded internationally in their own right (Urata, 1998).

During the 1970s, FDI flows into the electronics sector accounted, on average, for 39% of total approved FDI (MOEA, Taiwan). Although FDI in electronics sector then experienced a slow decline into the 1980s and accounted for only 20.5% of total approved FDI in 2002, the electronics sector remained the largest recipient of FDI in Taiwan. Indeed, foreign firms in the electronics sector have continued to play a significant role in the development of local economy. Meanwhile, local firms have upgraded their capabilities in the industry and narrowed the technological gap between themselves and the foreign market leaders (Wang, 2002; Amsden and Chu, 2003)

**Table 1.1: Exports of Taiwanese electronics: selected years 1980 to 2002 (US$ billions)**

| Year | Exports | % of total exports |
|---|---|---|
| 1980 | 4.1 | n/a |
| 1985 | 4.9 | n/a |
| 1987 | 10.5 | 19.48 % |
| 1990 | 13.6 | 20.31 % |
| 1995 | 27.1 | 24.21 % |
| 1996 | 30.1 | 25.93 % |
| 1997 | 33.3 | 27.27 % |
| 1998 | 31.3 | 28.32 % |
| 1999 | 37.6 | 30.98 % |
| 2000 | 51.8 | 34.98 % |
| 2001 | 39.9 | 32.43 % |
| 2002 | 42.4 | 32.49 % |

Data source: Ministry of Finance in Taiwan, MOF [http://www.mof.gov.tw/statistic/]

Many Taiwanese firms progressed from simple assembly operations in the 1960s to engage in more sophisticated activities which require software and precision engineering skills in the 1990s. Since the late 1980s, electronics has constituted the largest export sector in Taiwan and the sector accounted for 32.49% of its total exports in 2002 (MOF, Taiwan, 2004). Taiwanese electronics exports grew from just US$4.1 billion in 1980 to US$42.4 billion in 2002, overtaking textiles, chemicals and plastics industry to become the largest single export sector (MOF, Taiwan, 2004; MOEA, Taiwan). As shown in Table 1.1, exports in the electronics sector grew continuously throughout the 1990s. The thriving electronics sector in Taiwan, however, experienced an abrupt decline in 2001 as a result of the great recession of the global electronics market at the same year (Reed Electronics Research, 2003).

The Taiwanese government has played an important role in promoting the electronics industry through interventions that went beyond the market model (Amsden and Chu, 2003). Since the 1980s the government has worked in close cooperation with the private sector and has helped reinforce the efforts of firms that were already engaged in the electronics industry, particularly the semiconductor industry. The government also strengthened local technological capabilities by organising technology alliances between national research institutes and local firms. The state has exercised pressure on private firms to develop public-private projects that targeted certain electronics products since 1990s. An example is, the 1991-1995 National Science Council Plan, gave priority to the development of integrated circuits, liquid crystal display (LCD), and dynamic random access memory (DRAM) in order to reduce the trade deficit with Japan for components (Chaponnière and Lautier, 1998; MOEA, Taiwan, 2003).

## 1.4 Research Questions

The idea of the spatial and international division of labour has been widely incorporated in the economic geography literature for several decades. The notion of NIDL may be considered a key factor that connects economic geography's long-standing interest in regional development and employment with the role of business strategies and structures. The NIDL has largely been associated with MNCs activities, particularly with regard to technological transfer. However, within the context of Asia's NICs of Taiwan, South Korea and Singapore, latecomer firms are domestic firms that have grown rapidly to challenge MNCs, with important implications for the international division of labour. In this regard, while economic geography has recognized the increased complexity of the IDL within Asia not much attention has been paid to latecomer firms themselves.

This thesis focuses on the development of latecomer firms and its implication for the IDL within the context of the electronics industry in Taiwan. An important goal of this thesis is to understand how Taiwanese latecomer firms acquire technology and develop their own technological capabilities. This thesis attempts to answer the following question:

- **To what extent have foreign MNCs led to technology transfer to Taiwanese electronics later-comer firms in the period from the 1975 to 2004, and to what extent have `internal' factors, such as government research institutions and indigenous R and D, as well as technical training been important?**

In pursuing this central theme, this thesis provides insights into two related research questions:

1. Has the growth of electronics latecomer firms in Taiwan since 1975 impacted on the international division of labour, particularly among core countries (e.g. Japan, and the USA), Taiwan, and the rest of Asia?

2. What contributions have latecomer firms made to skill formation in Taiwan and further its influence on the division of labour?

Empirically, this thesis makes a partial contribution towards answering these research questions within the limitations of its research design.

## 1.5 Research Design

The research for this thesis features a case study and in-depth interview approach. Such a methodology provides the necessary depth of information required to understand the development of technological capabilities of the latecomer firms and its impact on the spatial division of labour. The general purpose of this research is to collect original data on how electronics firms in Taiwan have learnt and adapted new technology from various sources over time. As I attempt to draw a complete picture of technology transfer mechanism from the firm's perspective, a comprehensive understanding of the complex process of technological capability is critical. Thus the case study approach serves this research quite well. Feagin et al. (1991) suggest that a case study approach is an ideal methodology when a holistic, in-depth investigation is needed. Moreover, according to Yin (1993, 1994), the use of case studies helps to completely describe a phenomenon in its own context and further to explain linkages between causes and effects.

These in-depth studies of individual firms were complemented by archival research. Information on specific characteristic of each case study firm, including the development history of the firms, location, value of outputs, products produced and market services, and associated changes including plants openings, closings and changes in location, was collected from the firms' annual reports and websites. A number of government reports and research reports published by private consultancy also provide aggregate date on the electronics industry as a whole. Aggregate data were obtained on the significance of the electronics sector in Taiwan, on specific characteristics such as value of exports, approved inward FDI, products produced as well as relevant government policy. The information gathered from these reports is presented in Chapter three which gives a broad description of the electronics industry in Taiwan as a whole.

As a key feature of the research design, a series of interviews were conducted to obtain more in-depth data to be analysed in a qualitative way following a case study format. Interviews are one of the most important sources of case study information (Yin, 1994), and a semi-structured interview format was utilised to gather information. Semi-structured interview provided a flexible but systematic approach. Unlike a list of closed questions, the respondent was left free to discuss and answer each question during the semi-structured interview. As Saunders et al. (1997: 243) suggest that in semi-conductor interviews, researcher may "omit some questions in particular interviews, given the specific organisational context which is encountered in relation to the research topic". The order of the questions may also be varied depending on the flow of the conversation. On the other hand, additional questions may be required to explore your research question and objectives given the nature of events within particular organisation". It is believed that semi-structured interview technique can lead to a better understanding of the topic being studied as the interviewee is encouraged to emphasize more significant issues affecting the industry and to lay stress on the specific aspect involved in the process of developing technological capability. The merits and drawbacks of this methodology are well documented in the literature (Valentine, 1997; Seidman, 1998).

Case study firms were chosen through consultation with representatives of key government organisations (Industrial Development Bureau, Ministry of Economic Affairs in Taiwan) and from the information provided by industry agencies. As the electronics firms in Taiwan have experienced various mechanisms regarding the development of their technological capabilities as well as their origins, it is necessary to collect information from firms which exhibit a range of experience, size and strategy. As a result of the depth of information required and the limitations imposed by time and financial, three electronics firms were chosen as the case study firms.

The selected firms are Taiwan Semiconductor Manufacturing Company (TSMC: Mr. Feng Wei-Zhong, General Secretary in Human Resource department), Chunghwa Picture Tubes (CPT: Mr. Lin Yen-Chung, General Manager of Corporate Management Division) and Kinpo Electronics (Mr. Pearce Chiu, Vice president & special assistant to chairman). In addition to those three major local firms, a supplier firm of TSMC, Topco, was also interviewed to gather information on the inter-firm network associated with the technology learning. TSMC is the largest and best known electronics (semiconductor) firm within Taiwan and beyond. Whereas TSMC was established in 1987 as a joint venture between the government and a foreign MNC (Philips), CPT and Kinpo were among the first firms in Taiwan to become established in the 'new' electronics industry in the 1970s. Moreover, TSMC is a leading silicon chip manufacturer in the global market while both CPT and Kinpo manufacture final consumer goods in addition to acting as suppliers to other electronics firms, locally and abroad. All three local firms have made investments abroad; most of their subsidiaries are located in Asia.

As all the firms chosen are predominantly large firms, each with more than 10,000 employees globally, for each case study an attempt was made to interview management personnel in the firm to gain an in-depth understanding of their policies regarding technology transfers from foreign MNCs or other sources.

The interview questions comprised three sets of questions; each set focused on a specific subject with regard to my main research questions. The three categories were:

*(a) The development of the firm and information on its subsidiaries;*

*(b) Sources of technology learning and in-house R&D;*

*(c) Skill formation within the workforce and links with overseas investments*

Information was collected on the location and age of each firm, the size of the firm, both in employment and output values, and the investment and geographical distribution of their plants, locally and abroad.

In order to the ascertain the mechanism of technology learning of each firm, each firm was questioned on the major source of its technology learning over time, linkages with customers and suppliers regarding the technology assistance, as well as the firm's strategy to advance its own technological capability. Information was also gathered on annual expenditures made in in-house R&D, the number of R&D workers and the nature of R&D, namely innovative or problem-solving. Questions about their linkages with supplier firms helped determine how effectively knowledge was diffused within the local industry and overall contributions to skill formation in Taiwan. Case study firms were also asked to what extent they have helped skill formation among their supplier firms and the extent to which they relied upon specialised expertise among these suppliers firms.

With respect to workers and management within firms, questions focused on identifying various forms of on-the-job training and off-the-job training. Relationships between management and workers were assessed to further understand the diffusion of knowledge within the corporate organisation. Questions about the workforce started with the primary characteristics of the labour force, such as its functional composition, level of education and skills. Attempts were made, based on norms within firms and interview data, to classify workers as skilled, semi-skilled and unskilled, and changes in these categories over time. Finally, firms were asked about their future plans in terms of products, technology, markets, location, investment and employment, so as to assess the effects of on-going plans which may change the operation of the firm that might affect the division of labour.

## 1.6 Thesis Organisation

This thesis is structured by the objectives of the research in order to clearly present the findings from the research and the nature of the changing international division of labour with the example of the electronics industry in Taiwan. Chapter two reviews the idea of the international division of labour, especially in regard to the NIDL, and gives especial attention to the role of MNCs and latecomer firms. Chapter three reveals the importance of the electronics industry for the latecomer firms by describing the evolution of Taiwanese electronics industry, along with the related government policy and highlights the contribution of foreign MNCs. Information was gathered from secondary sources in the form of government agency reports and private consultancy reports published over the past few years, and information from industry associations, as well as from existing academic research. These reports provided valuable data on the development of Taiwanese electronics industry. The subsequent two chapters present the results of case study interviews with individual firms in order to understand the evolution of the local latecomer firms and the variety of sources and strategies for their technology learning. Chapter four focuses on the technological transfer and learning processes in Taiwan's electronics industry from the perspective of the leading latecomer firm, namely Taiwan Semiconductor Manufacturing Company (TSMC). Chapter five concentrates on two other important latecomer firms, Chunghwa Pictures Tubes (CPT) and Kinpo Electronics. Each of these three main case studies are all latecomer firms and in the same broadly based business segment classified as locally based 'large firms'. They provide key insights into the evolving division of labour within Taiwan's electronics industries (chapter three). Each firm also reveals interesting differences in corporate origins and processes of technological learning, as well as in product mix. Concluding thoughts are presented in chapter six, evaluating the significance and contribution of latecomer firms with respect to their technology learning routes, and the implication of their development for the changing IDL.

# CHAPTER 2:
# THE CHANGING INTERNATIONAL DIVISION OF LABOUR: MULTINATIONAL AND LATECOMER FIRMS

The idea of the spatial and international division of labour has been widely incorporated in the economic geography literature for several decades. Indeed, it may be considered a key theme that connects economic geography's long-standing interest in regional development and employment with the role of business strategies and structures. To a considerable degree the idea of the international division of labour has evolved in close association with models of the behaviour of multinational corporations (MNCs) especially with respect to technological transfer. Thus the so-called 'new international division of labour' (NIDL) promoted in the 1980s was associated with new development in the behaviour of MNCs.

Understanding the NIDL is complicated because MNCs are dynamic organisations. Moreover, the NIDL is not just driven by what MNCs do and how they wish to transfer technology and job skills around the world. Domestic firms are also relevant, as is government policy both in stimulating domestic firms and in attracting and bargaining with MNCs. Within the context of Asia's so-called newly industrialising countries (NICs) of Taiwan, South Korea and Singapore, for example, latecomer firms are domestic firms which have grown rapidly to challenge MNCs, with important implications for the division of labour. In this regard, it is also important to recognise that domestic capabilities vary around the world; the Asian NICs have been usually successful in promoting latecomer firms.

This chapter reviews the idea of the international division of labour, especially in regard to the NIDL, and gives especial attention to the role of MNCs and latecomer firms. The first part of the chapter reviews some basic definitions of the international division of labour and explains the NIDL by reference to the original product cycle model of foreign direct investment (FDI). The next part of the chapter elaborates on how MNCs can directly and indirectly stimulate the transfer of skills and so shape the evolving NIDL. One of these ways is by the stimulation of latecomer firms and the last part of the chapter examines these firms and their impacts on the division of labour.

## 2.1 The New International Division of Labour and Product Life Cycle

During the 1980s, a 'new international division of labour' (NIDL) made its appearance particularly in certain sectors of manufacturing. The words 'NIDL' was introduced, or at least popularised by Fröbel et al. (1980) to illustrate the trend towards the increasing mobility of capital. They examined in great detail the ongoing transformations in industrial production, the move of capital from core countries to peripheral countries, the rise of the industrialising semi-periphery (in reference to selected countries in Africa, Asia and Latin America), and the limitations of this style of industrial growth for those countries. As Skak (1987: 123) suggests, "The emergence of NICs capable of penetrating the markets of 'Northern', (i.e., the Organisation for Economic Cooperation and Development or OECD) countries with manufactured goods, chemicals and steel was a qualitatively new trend in world economic exchange later referred to as the new international division of labour". In this context, the NIDL is seen as the internationalisation (or disaggregation) of the production process brought about by advances in technology and the ability of capital to relocate to peripheral and semi-peripheral countries (Higgott 1987; Fröbel et al., 1980). Even so, Fröbel et al observed that NIDL processes would not change the core-peripheral scheme and that "the development of the underdeveloped countries will manifest itself as continued underdevelopment" as the actual control functions would remain the responsibility of the head offices of the foreign companies (Fröbel et al. 1980: 403).

Since Fröbel et al. (1980), the acronym NIDL has become a 'catch-phrase' that is extensively used in modern literature. Indeed, the NIDL has then been frequently employed specifically in relation to the rise of the Asia-Pacific region as a new global economic power. Despite extensively citations in the literature, however, the term NIDL remains an ambiguous concept that is often used without precise definition or at least little elaboration. Thus most studies refer to the NIDL in a rather superficial way, "often incautiously drawing conclusions not warranted by the sources used" as Caporaso (1987) suggests. As a result, the interpretations of the NIDL are confused, and it is not always clearly distinguished from the IDL. For Wilkinson et al (2000) the NIDL is considered an exclusive Asian version of the IDL.

The processes underlying the geographical shift of manufacturing tasks from core to peripheral countries have been explained frequently by the product life cycle (PLC) model. The PLC model was developed by Vernon (1966) and associates (Hirsch, 1967) to interpret the expansion of branch plants owned by US-based MNCs in foreign countries. Vernon focused on how the life cycle of individual products affects the competitiveness of firms, especially with respect to the locus of manufacturing production (Vernon, 1966; also see Bernard and Ravenhill, 1995: 173). The PLC has been widely adapted to "link product cycle and location dynamics with respect to in situ employment changes in advanced countries and non-metropolitan industrialisation" as well as to model direct foreign investment from Western developed countries in peripheral regions (Hayter, 1997:101). As Vernon suggests (1966), products evolve through a cycle of initiation, exponential growth, slowdown and decline- a sequence that corresponds to the process of introduction, diffusion, maturation and senescence. During this life cycle, as products mature the structure of input conditions change, especially in regards to labour. Thus in the early stages of product development labour inputs are dominated by scientists, engineers and skilled labour, supplies of which are dominated by rich advanced countries. As products mature and technology more routinized, however, plentiful supplies of lesser skilled, low cost labour become the main labour input condition. At this stage the PLC model predicts relocation to low wage regions and countries (Hayter, 1997).

## 2.2 Technology Transfer and Learning

The notion of the IDL is closely associated with the behaviour of multinational corporations (MNCs) especially with respect to technological transfer. From the perspective of developing countries, the rapid growth of foreign direct investment (FDI) reflects in part the importance attached to FDI in local development. According to Hayter (1997), "FDI comprises activities that are controlled and organised by firms (or groups of firms) outside of the nation in which they are headquartered and where their principal decision makers are located. In the context of the manufacturing sector, FDI is conventionally thought of in terms of branch plants or subsidiary company operations that are controlled by parent companies based in another country" (ibid). FDI also has important developmental implications.

The process of FDI involves the transfer of financial capital, technology and other skills (managerial, marketing, accounting, etc). This process gives rise to costs and benefits for the donor country (the source of the investment) and the host country (the recipient of the investment). For many developing countries, FDI is considered to be a major channel for access to advanced technologies (Kumar, 1998; Urata, 1998). Most countries in the Pacific-Asia region have actively sought to 'catch up' economically and technologically with advanced countries by attracting FDI. Particularly for developing countries in the Pacific-Asia region, Japanese MNCs have been the main source of FDI which continues to be justified in terms of technology transfer. The transfer of technology has thus become the predominant issue around which discussions of MNCs and their dealings with developing countries evolve (Moosa, 2002; Hobday, 1995; Hayter and Edgington, 2004). Technology is a vital source of economic growth, capital accumulation, trade, and has important implication for the division of labour. Kumar (1998) suggests that technology is a crucial input in the industrialisation and development of countries. A considerable proportion of technological inputs are sourced from abroad in the early stages of a country's development. An important issue is whether this technological dependence changes over time, specifically the extent to which host countries absorb and develop technological capability. In this context technology transfer implies technological learning within host countries.

As Hobday (1995: 32) suggests, "technology represents the capacity to create and extend the existing pool of industrial skills and knowledge", and it is a dynamic capability used to absorb, adapt and advance existing know-how and skills. Hobday (1995: 32) further defines the nature of technology as "a resource embodied not only in physical capital but, equally importantly, in human skills, institutions (especially firms) and social structures". Thus technological learning can be considered a process by which firms obtain technology. Technological learning is a dynamic, difficult and costly process; it normally involves substantial and deliberate effort and investment on the part of the firm. As Malerba (1992) shows, learning is central to productivity growth and different types of product and process improvement. The process of technology learning helps firms acquire knowledge about products and manufacturing processes, further enhances their abilities to use their various resources (such as labour, capital and natural resources) and leads to improvements in their facilities, equipment, manufacturing, management, and marketing methods (Cooke and Mayes, 1996; Gee, 1981). In other words, via this learning process, firms advance their 'technological capability' which refers to "the whole range of skills needed to operate industry, and any gain in these skills is regarded as technological progress" (Lall, 1990: 19).

Technology learning occurs when some or all of the skills needed to absorb and adapt a specific production process or product have been developed. These learning processes, as Rodrigo (2001: 102) suggests, are highly 'technology-specific' and the pace and efforts which are required for effective learning would vary by the complexity of the knowledge involved and the initial capabilities of the learner. Lall (1990: 20) states that simple technologies require investment in basic technology mastery while complex technologies require minor innovation capability as well as formal R&D to absorb or imitate advanced technology necessitate.

### 2.2.1 Mechanisms of technology transfer

Technology is transferred or traded internationally through various means or paths. In this context, technology that is 'embodied' in capital refers to the know-how that has been used to design and build machinery but is not directly accessible to users of the machinery. Similarly, components that are used in the assembly of products may involve embodied technology. Knowledge may also be embodied in migrant engineers, managers and workers. In general, embodied knowledge is not automatically transferred to the local or host economy by FDI (Kumar, 1998). Rather it has to be taught and learnt, thus becoming 'disembodied' from equipment and 'embodied' within local workforces and institutions. For sustained foreign technology transfer to occur and to further enhance technological capabilities of local firms, various learning mechanisms and channels need to function effectively (Hobday, 1995). Three channels of technology transfer from MNCs of particular importance to this thesis may be highlighted. First, MNCs can directly provide technology and skills to their subsidiaries or to the indigenous firms through special arrangement, and over time they can deepen and extend these skills. Second, MNCs can develop linkages with local suppliers who in turn can develop progressively increasing skills and expertise. These suppliers may be local or foreign owned. Third, MNCs can help stimulate the skills and expertise of locally based or indigenous 'rivals' and other types of companies either directly, for example, via patents licensing arrangements, or indirectly via so-called 'demonstration' and 'spill-over' effects. These indigenous companies can in turn pass on skills to suppliers (Li, 2001).

With respect to technology transfer and skill formation within foreign owned subsidiaries, MNCs can enhance local technological capabilities by training local personnel, assisting product manufacturing and management, and transferring information about R&D from the parent company or by permitting the utilisation of new technology (Tang, 2001). MNCs can invest internally in labour and management training and even R&D activities in foreign subsidiaries. Improvements in ability of workers can occur through on-the-job training programmes and via various kinds of vocational and apprenticeship programmes that are off-site. Koike and Inoki (1990) interpret internal skill formation within firms in terms of 'enterprise specific skills' (ESS) which they define as "skills [that] are acquired by an employee over time and tie firm and employee together according to the unique characteristics of that skill" (quoted in Patchell and Hayter, 1995: 344). This concept implies that the degree of worker ability gained is determined by the width (e.g. workers switch among their range of usual or routine tasks) and depth (e.g. workers deal with unusual or difficult situations within tasks) of career experiences. It should also be noted that indigenous firms can develop ESSs in the same way. Moreover, Stopford (1995: 16) suggests that firms progress over time from simplest to more complex forms of international production networks as they learn how to manage them, and such learning occurs with foreign subsidiaries: "As skills and resources accumulate within the various foreign units, new options and more complex projects can be undertaken without relying heavily on the parent organisation for help and guidance".

Skills can be transferred by foreign subsidiaries through linkages with local suppliers. As Moosa (2002: 87) argues, "FDI can influence the economy of the host country via inter-industry linkages". To the extent that foreign subsidiaries establish links with local suppliers for locally produced materials and components, FDI helps provide indigenous firms with increased opportunities that in turn affect their employment and income positions. Within Japan the linkages between core firms and their suppliers is interpreted by the concept of 'relation specific skill' (RSS) developed by Asanuma (1989). Asanuma uses the inter-firm relations in Japan to illustrate how technological (innovation) capability is developed on the basis of the RSS. For Asanuma, RSS is defined as "the skill required on the part of the supplier to respond efficiently to the specific needs of a core firm…Formation of this skill requires that learning through repeated interactions with a particular core firm be added to the basic technological capability which the supplier has accumulated" (Asanuma, 1989: 28). Since the RSS refers to the constant exchange of information between firms and collaboration that proves mutually beneficial over time, it is regarded as an external channel for technology learning (Patchell and Hayter, 1995).

Moreover, technology and skills transferred from MNCs to subsidiaries may 'leak out' to the host country, giving rise to learning-based positive externalities or 'spillovers' (Blomstrom and Perron, 1983; Moosa, 2002). Indeed, these spillover effects are likely to be crucial for sustained local development since they define the extent to which technological capability has been diffused and absorbed throughout host economies. There are various possibilities by which spillover effects can occur in this context. For instance, the introduction of new technologies in foreign subsidiaries may stimulate indigenous firms to hasten access to similar technologies. Local firms may not have been aware of the existence of the technology prior to FDI and they may feel its adoption will enhance profitability (Blomstrom, 1986: 100). Hou and Gee (1993) found labour mobility from foreign subsidiaries to indigenous firms to be a key variable for technology diffusion in local economies (see also Moosa, 2002; Tang, 2001). As a result of labour migration, human capital investments made by foreign MNCs are ultimately utilised within domestic owned firms.

As Schive (1990) and Fok (1991) shows, foreign MNCs act as demonstrators for local firms to imitate either through formal understandings or more informally. Under licensing arrangements, for example, indigenous firms pay for the right to manufacture products usually for the local market, and MNCs transfer the required technology for manufacture. Strategic partnerships (i.e. joint ventures on a more equal footing) also enable local firms to enhance their technological capabilities by developing a new product or process jointly with a foreign company (Hobday, 1995). Alongside formal mechanisms for technology transfer, there are many informal channels. These informal sources of technology for indigenous firms include the copying of products, reverse engineering, visits to foreign factories, hiring of foreign engineers and returnees and the widespread training of engineers abroad (Chiu, 2002; Hobday, 1995).

The application of different transfer methods depends on the nature of the technology and the specific circumstances of each case. In some cases, indigenous firms rely on different sources of technology learning according to their size. Most large firms generally approach technology transfer through formal mechanisms such as joint ventures, FDI (reverse engineering via FDI) and licensing agreements whereas SMEs (Small and Medium sized enterprises) relied more heavily on informal channels such as copying and business liaisons (Athukorala and Hill, 2002). Moreover, the effectiveness of the different approaches differs in terms of the ability of the technology recipient to learn and to acquire increased technological know-how (Gee, 1981). In this regard, latecomer firms offer particular potential.

According to Hobday's research in East Asia, some latecomer firms gain direct access to training and engineering support within the framework of joint ventures with foreign partners (Hobday, 1995: 36). Foreign and local buyers are also important sources of technology and market information for indigenous firms. Wortzel and Wortzel (1981) suggest that buyers provide firms with information on production designs as well as advice on quality and cost accounting procedures. Some buyers assist with the purchase of essential materials, capital goods and components (see also Hobday, 1995: 36). Furthermore, governments can be of great assistance in the building of R&D departments by indigenous firms, especially when indigenous firms lack capital to invest and to develop their own R&D. Some firms also attempt to promote their technological capabilities by means of cooperating with local universities. The strong public intervention has been emphasized with respect to the success of latecomer firms, particularly with respect to the East Asia NICs. Mody (1990) sees state intervention as critical, especially where the institutional support of a powerful industrial combine is lacking. For instance, he argues that Taiwanese firms have little incentives to upgrade quality individually because they do not have strong company/brand identities.

Moosa (2002) suggests that the impacts of FDI on skill formation and technology transfer in host countries may not be obvious, and may turn out to be negligible or even negative. Thus in some cases, powerful MNCs might grow to dominate the host market or truncate regional economic structures that in the long run results in large outflows of capital. In this context, of "truncated branch plants" merely manufacture large volumes of a low-value commodity for a parent firm and without any independent marketing or R&D capability (Hayter, 1982; 1997: 396). Thus host countries may not be able to absorb foreign technology efficiently and properly. Moosa (2002: 89) further suggests that "while FDI may in theory be the fastest and most efficient way of gaining access to the latest technology, some costs arise because the monopolistic power of MNCs allows them to extract rents". Indeed, MNCs may not be willing to transfer all aspects of their technological capability. Within Asia-Pacific, for example, the transfer of technology has had highly varied impacts on developing countries. While Taiwan and South Korea are considered to be leaders other countries such as Malaysia and Indonesia have been less successful. In the future all Asia-Pacific countries are likely to be affected by what happens in China (Hayter and Edgington, 2004).

## 2.3 The Dynamic of the New International Division of Labour in Asia

As part of the NIDL on the global scale, Scott (1987) has identified an emerging IDL in the semiconductor industry within Southeast Asia. In contradistinction to the original account of the NIDL, which suggests the way FDI functions in peripheral countries is relatively static (Fröbel et al. 1980, Bluestone and Harrison 1982), Scott (1987) revealed a dynamic NIDL in the semiconductor industry within Southeast Asia. Based on his fieldwork in 1985, Scott (1987) observed that the semiconductor industry in Southeast Asia appeared to have evolved through a series of successive stages of development and became specialised along regional lines. This process has been accompanied by "the formation of a new international division of labour internal to the region and entwined with the broader division of labour at the world scale" (Scott, 1987: 153). This intra-regional division was roughly identified in terms of a 'core' of high-wage countries (Hong Kong, Korea, Singapore, and Taiwan) and a 'periphery' of low-wage countries (Indonesia, Malaysia, Philippines and Thailand). Moreover, this roughly identifiable internal core and periphery in the Southeast Asian semiconductor industry revealed that the NIDL no longer consists of "a simple bipartite split between the economies of the capitalist core and those of the world periphery" but has evolved into a complex spatial system with different hierarchical levels and sub-regional connections (Scott, 1987: 156; also see Lipietz, 1986). Most notably, although employment at semiconductor assembly plants in East Asia had been dominated by production workers who were considered relatively unskilled, Scott's research (1987) showed a trend towards increased reliance on highly skilled labour within the region as industry became more highly-developed and territorially differentiated. This conclusion contradicts the argument of Fröbel et al. (1980). Fröbel et al. (1980) concluded that 'world market factories' in the periphery countries were isolated from the local economy, and that skilled labour forces are not necessary.

By means of the development of South-East Asian semiconductor industry, Scott not only suggested that South-East Asian periphery was no longer "a subordinate and dependent terrain within the orbit of international capitalism as a whole" but also indicates that NIDL was not a constant process (Scott, 1987:157). It may also be suggested that Scott set a precedent to employ the NIDL in order to interpret economic patterns in East Asia. Since then, the NIDL has becomes a particular term which has usually implied the development of IDL in Southeast Asia (e.g. Takayasu and Ishizaki 1995; Wilkinsin 2001). However, according to Cohen and Kennedy (2000: 378), the NIDL "divides production into different skills and tasks that are spread across regions and countries rather than within a single company", and underdeveloped countries, particularly in the Asia-Pacific region, became rapidly drawn into the new international division of labour since 1970s. Indeed, for Scott (1987), the NIDL was not merely an Asian version of IDL but had a deeper insight which implied a changing IDL with different hierarchical levels and sub-regional connections within a more complex spatial system.

### 2.3.1 Latecomer countries and firms

Although Scott (1987) has observed that the NIDL is not a static progress and has suggested that it would lead to a more elaborate and unforeseen development patterns in the near future, the prospective role of Southeast Asia within an expanded and modified international division of labour remains an unanswered question in his paper. In practice, over the past two decades the rise of latecomer firms within the region has been a vitally important development shaping the division of labour.

The notion of the 'latecomer country' was proposed by Gerschenkron (1962) who studied the rise of 'late industrialising' countries in Europe in the 19th century (e.g., Germany, Austria) that "acted as a brake on the innovative potential of earlier industrialisers" (Mathews and Cho, 1999: 141). Gerschenkron pointed to the possibilities for latecomer nations to catch-up to early starters through the creation of appropriate institutional arrangements and suggested the critical role of the government in the industrialisation of latecomer countries (Mathews and Cho, 2000; Zhang, 2003). According to Zhang (2003), Gerschenkron developed the idea of latecomer countries partly based on the German political economist Friedrich List's notion of 'developmental state' which suggested that strong state protection was necessary for the late-industrialising countries, especially for their infant industries, in order to compete successfully with developed countries. Indeed, governments have played a central role and made a great contribution toward the rapid and sustained growth of Asia's NICs. It is well recognised that government played an active role in three of the four Asian NICs, namely in Taiwan, South Korea and Singapore (Appelbaum and Henderson, 1992; Amsden, 1989; Wade, 1990). These countries comprise a more recent set of latecomers.

According to Amsden (1989), the role of government has been an essential ingredient of the NIC's development strategy. Indeed, government policy is crucial both in stimulating indigenous firms and in attracting foreign MNCs, in order to accelerate the process of local development. As Wade (1990) suggests, in latecomer countries, such as Taiwan and South Korea, the government initially played a pivotal role in promoting the development of markets and the private sectors since markets in these countries were weak or poorly developed at the outset. These governments maintained a stable macroeconomic condition, promoted growth and employment and provided infrastructure and public goods, such as education, national security and basic research. Governments also helped to induce local entrepreneurs to invest in high-risk ventures as well as to compete in international markets by providing incentives, subsidies, protection and contingent rents (Yong, 2003). Aoki et al. (1997) also suggest that the state can help to enhance local market in developing countries by facilitating the development of private sector institutions. As the role of the government was regarded as the main driver of economic development for all the Asian NICs, this role differed in form and effectiveness in each country (Wade, 1990; Zhang, 2003).

The rise of East Asian countries in the 20th century, starting with Japan and then moving to the Asian NICs, provides a more recent example of Gerschenkron's idea as those countries have behaved in classic 'latecomer' manner and are regarded as typical latecomer countries (Mathews and Cho, 1999, 2000). Since the 1980s, the rise of East Asia, beyond Japan, as a global economic power has been one of the central dimensions of global transformation (World Bank, 1993). Although now dominated by China's industrialisation, the four Asian NICs have been on the leading role of this transformation. Led by firms from Japan, the four Asian NICs (Taiwan, South Korea, Singapore and Hong Kong), which are also designated 'four dragons', have forged their ways into high-technology markets to become internationally respected suppliers of a wide variety of products (Hobday, 1995). These countries have sustained the development process, and have moved toward the point of absolute technological advantage in certain areas, including the electronics industry. Moreover, other followers in the region, notably Thailand, Malaysia, Indonesia and China, have grown rapidly, largely as a result of export-led industrialisation. These countries have interacted with the global economy by progressive improvement of their technological capabilities and productivity advantages. Firms and governments within the region have devised an impressive variety of new routes to industrial development. The example of these countries suggests that there are possibilities for latecomers within the global economy (Storper, 1998: 22). The presence of latecomer firms provides an index of potentials in this regard.

Despite the continuing economic dominance Japanese firms in the region, some Asian-Pacific firms, for example, Samsung and Acer have learned to compete in manufacturing exports and have progressively generated the capacity to innovate to become remarkable rivals to MNCs from Japan, North America and Europe (Hobday, 1995; Mathews and Cho, 2000). These firms illustrate the idea of 'latecomer firm' (hereafter termed as LCF). Hobday (1995: 33) defines the LCF as "a manufacturing company (existing or potential) which faces competitive disadvantages in attempting to compete in exports markets". According to Mathews and Cho (1999, 2000), the LCF typically starts with meagre resources and competitive disabilities, but manages to turn these disadvantages around by devising learning strategies to develop and continuously upgrade their own technological capabilities and thus brought themselves to the world's technological frontier. Moreover, the success of LCFs is largely due to world economy integration through exports, technology transfer and access to foreign capital (Mathews and Cho, 2000). Thus to slightly modify Hobday's definition, LCFs are manufacturing companies that have overcome competitive disadvantages in export markets to rival established MNCs in substantive product market areas.

Hobday (1995) has established a scheme to interpret how Asian LCFs gradually assimilate the techniques of manufacturing. In his model, the early NIC entrant began with simple assembly skills and progressively and incrementally assimilates process capabilities. Progress depends primarily on the strategies and efforts of indigenous firms and the opportunities offered by foreign buyers. Hobday (1995: 42) has further suggested that "external factors (e.g. policy actions and the state of the macro economy) will impinge directly on the process". Moreover, this model is consistent with work on international product life cycles (Vernon, 1966, 1971). As the Asian LCF tends to enter at the mature, standardised end of the product life cycle and gradually assimilates its technological capability by learning. With each wave of new innovations they catch up little by little, closing the technology gap between themselves and the market leaders. In this sense, the East Asian LCFs travel backwards along the product life cycle, reversing the normal path (Hayter and Edgington, 2004). The idea of the latecomer firm and the reverse product life cycle model is also consistent with the flying geese model. The analogy of 'flying geese' is applied to interpret East Asian's industrialisation: "countries are said to follow one another in a developmental trajectory in which the latecomers replicate the developmental experience of the countries ahead of them in the formation" (Cumings, 1984; cited in Bernard and Ravenhill, 1995: 171). While the reverse product life cycle model illustrates an ideal path for latecomer firms, the flying geese model provides a broaden vision of industrialising development within Pacific Asia.

Although the flying geese model successfully captures the nature of spatial distribution and further predicts the shift of Japanese FDI within Pacific Asia, there are criticisms of this model. For example, Bernard and Ravenhill (1995) argue that the diffusion of manufacturing in East Asia has increasingly been characterized by shifting hierarchical networks of production linked both backward to Japanese innovation and forward to American markets for the export of finished goods instead of replicating Japan's development experience in country after country throughout the region as the flying geese analogy suggests. Gereffi also argues that the flying geese model fails to capture the significance of a network-centered view of the world economy and he suggests that "the successful export industries of Japan and the East Asian NICs are part of a broader process of globalization in which international production and trade networks create hierarchical divisions of labour within and between regions" (Gereffi, 1996: 76). Moreover, the model fails to give due recognition to the distinctive indigenous efforts of developing countries to accumulate technology and to export overseas (Edgington and Hayter, 2000). Another difficulty with the model is that it has underplayed the influence of other donor countries. Accepting the significance of Japan as a driving force for the region's development, Hobday stresses the importance of the USA both as a vital export market and as an important additional source of technology for the region (Hobday, 1995).

Alternatively expressed, the LCF learns how to plot a course through the latter stages of technological development to the early stage of the PLC, working back from the standardised market and technology stages to the more uncertain, early design-intensive and complex innovation stages. The result is that LCF paths to international production are likely to differ in their organisational approaches from firms that have had a much longer learning experience (Ernst, 1997: 216). The East Asian LCF, according to Kim (1997), has perfected a strategy to derive advanced technology as the principal resource for participation in high-technology industries rather than pursue a conventional R&D-led innovation strategy. Their learning strategy provides a capacity not just to 'receive' the imported technology and knowledge associated with it, but to "absorb, adapt, diffuse or disseminate and ultimately improve it through the efforts of indigenous technologists and engineers" (Kim, 1997). Their solution to overcoming barriers to entry is to couple technology development to export market needs under sub-contracting arrangement, the OEM system, licensing and other mechanisms. This approach enables them to learn from foreign companies and to rapidly expand exports.

This process of the rise of the LCF (and their home country) is closely linked to the emergence, maturation, and decline of certain industrial sectors. As for the role of the LCF in the changing international division of labour, it could be suggested that as the LCF gradually improves its technological capability or moves (back) along the PLC, there is a great possibility for the LCF to move towards the core from semi-periphery or even periphery as in the sense of core-periphery scheme within IDL. Although the core-periphery scheme remains in the NIDL, or the changing IDL, the border between core and periphery has become indistinct.

In order to succeed in international markets and move backwards along the PLC, the most significant task for the LCF is to overcome its technological disadvantages and to develop its own technological capability. In practice foreign MNCs are major sources for LCFs to acquire advanced technology. As Hobday (1995: 35) suggests, "latecomer learning of foreign technology has become embedded in a variety of institutional channels which usually involve foreign firms in contractual arrangements in return for a particular service". That is, through time the LCF obtains foreign technology from different channels involving MNCs. For instance, many Taiwanese firms upgraded their manufacturing industries by obtaining advanced industrial knowledge from foreign MNCs, particularly MNCs from Japan. Among those technology acquisition channels (Hobday, 1995), FDI and joint ventures are particularly important at the initial stage as most Asian LCFs have a great reliance on foreign firms to expand export markets.

In the case of Taiwanese LCFs, FDI played a significant role during the industrial take-off period and the links between foreign firms and indigenous firms subsequently evolved. By the late 1980s, several enterprises expanded internationally in their own right (Urata, 1998). Hobday has labelled these firms that have been able to absorb the technology expertise of established MNCs to become international firms themselves as latecomer firms. Moreover, Hayter and Edgington (2004) observe that some indigenous latecomer firms in Taiwan have already moved along the reverse product cycle model in developing their own technology.

### 2.3.2 Latecomer firms as locally based large firms

As Hobday (1995:95) notes: "industrial development (in Taiwan) relied on a multitude of small and medium sized enterprises (SMEs)", Taiwan's industrial success has mostly been credited to numerous local SMEs especially with respect to the continuous growth of the electronics industry. However, the importance of the SMEs seems to have declined as many local firms grew large and became predominant drivers for economic development after 1980s. Amsden and Chou (2003) observe that there is a trend toward 'large-scale' firms in the Taiwanese electronics industry; many local firms have grown from small to large-scale and acted as the most progressive and developmental force.

A number of latecomer firms in Taiwan have retained some specific characteristics after their continuous expansion over the past decade. Those firms seem to fall into the category of the 'large firms' based on Hayter et al.'s (1999) classification of business types. According to Hayter et al.'s (1999) triad model of business segmentation, the large firms (LFs) are generally dynamic innovators which target niche markets on an international scale. Hayter et al. (1999) suggested that LFs constitute an important segment of firms which exhibit distinctive characteristics which distinguish them from SMEs and giant multinationals. In fact, a considerable research literature has discussed the specific role of the LFs in different contexts (Kuhn 1982, 1985; Nakamura, 1990; and Simon, 1992). In Nakamura's (1990) research in Japan, the LFs have been vitally important in the Japanese economy, and are termed 'chuken' which is the Japanese word 'backbone'. In an American context, Kuhn (1982, 1985) highlighted the particular contributions of the LFs which are labelled as 'little giants' whereas in Germany the LFs are referred to as 'hidden champions' by Simon (1992). In their view, "LFs are an important feature of technically advanced, diversified industrial economies" (Hayter et al., 1999: 426).

According to Hayter et al. (1999), LFs typically evolve from small firms and their corporate priorities and culture are strongly influenced by the values of founding entrepreneurs. The highly entrepreneurial nature of the LFs further enables the firms to operate more efficiently compared with giant firms as the owner-entrepreneur can shorten the decision-making process by working close with workforce. Notably, the owner-entrepreneur might continue to exert a great influence on the firms as the firms expand.

As regards to product markets, LFs distinguish themselves from SMEs by fully exploiting economies of scale and scope, and from giants by relatively greater concentration on niche markets (Hayter et al., 1999). LFs typically target high value-added niche markets rather than scale-intensive production. Whereas they focus in highly specialised product markets, they may be global in scope. As Nakamura (1990: 3) noted, LFs have achieved dominant national and sometimes global positions in highly differentiated markets (see Hayter et al., 1999). Moreover, LFs focus their core technology in a limited product range in order to take advantage of the economies of scale. Hayter et al. (1999) further suggested that LFs are typically dominant suppliers to global niche markets which are not exposed to the direct competition of the giant firms. Meanwhile, LFs directly compete with giants in some markets, mostly in regional scale. LFs are highly innovative in order to compete within the global niche markets. As Hayter et al. (1999: 434) suggest, "R&D is a cornerstone of the innovation characterizing LFs", and the intra-firm R&D enhances LFs' technological capabilities. The intra-firm learning can be referred to 'enterprise specific skills' (ESS) in Koike and Inoki (1990)'s term. In addition to the intra-firm learning, LFs also gain substantial knowledge from inter-firm learning which is well illustrated by Asanuma's (1989) concept of the relation specific skill (RSS).

In terms of location choices and their spatial organization, LFs have strong attachment to home places, namely they are 'big firms locally' and they potentially play a pivotal role for the local industrial development (Hayter, 1997). Partly due to their entrepreneurial nature, as LFs expand their operation internationally, they often remain attached and embedded to their home regions. Thus even if they are virtually unknown outside of their market niches, LFs are generally locally well known. Moreover, in a local context, LFs are big enough to exert noticeable impacts on economic development (Hayter et al., 1999).

## 2.4 Conclusion

As some researches have shown, the significant role of LCFs has been recognised during in the evolution of the IDL in Asia (Scott, 1987; Hobday, 1995). As the notion of the latecomer firm has attracted interest in the literature, it remains a largely unexplored area in economic geography, including with respect to studies that have focused on the role of late-industrialising countries in Asia and the evolving NIDL (Scott, 1987). Thus this research addresses this research gap by exploring the development of latecomer in Taiwan. To date, Hobday (1995, 1997) provides the most comprehensive research of the development of LCF in East Asia in 1995. However, this research is s decade old, had an international focus, and in the context of Taiwan only one LCF, Acer, was studied as one of the few local firms which have gone beyond the OEM and begun to operate under its own brand name since 1990s. This study complements Hobday's research design by comparing several LCFs within one latecomer country, namely Taiwan.

This chapter has reviewed the most prominent interpretations of NIDL and discussed the role of MNCs and latecomer firms in the process of changing IDL with especial attention to technology transfer. The last section of this chapter explored the rise of local firms as latecomer firms and its implication on the regional development, and the central role of state in economic development for latecomer countries was briefly addressed. The impact of FDI as well as the role of local government on the local development will be discussed in next chapter with specific reference to Taiwanese electronics industry.

# CHAPTER 3:
# OVERVIEW OF THE ELECTRONICS INDUSTRY IN TAIWAN

The purpose of this chapter is to outline the evolution of Taiwanese electronics industry particularly with respect to government policy and direct foreign investment. As mentioned in chapter two the Asian NICs are notable exemplars of latecomer countries that have managed to catch-up with international market leaders such as Japan, Europe and the U.S., particularly within some fast growing industries, such as electronics industry.

The electronics industry, as one of the largest industries in the world economy today, has played a significant role in the development of the latecomer countries. For the past decades, the electronics industry has grown faster than most other industries, particularly within the developing countries of East Asia, making it an important 'engine of growth' for the production and trade of industrial products and services. In fact, the electronics industry is almost exclusively responsible for the phenomenon known as the 'East Asian miracle'. The Asian NICs have developed extensive, technologically sophisticated industries and in some products areas, for example, semiconductors, consumer electronics and microcomputers, have begun to compete directly with the dominant Japanese, USA and European producers. Additionally, many studies of the success of Asian NICs have stressed the importance of state policies in guiding industrialisation (Wade, 1990; Amsden 1989; Kim and Dahlman 1992; Appelbaum and Henderson 1992).

This chapter reveals the importance of the electronics industry for the latecomer firms by describing the evolution of Taiwanese electronics industry, along with the related government policy and highlights the contribution of the foreign MNCs. Information was gathered from secondary sources in the form of government agency reports and private consultancy published over the past few years, from industry associations, as well as from academic research. These reports provide valuable data on the development of Taiwanese electronics industry. The chapter comprises three main sections. The first section discusses the growth and development of Taiwanese electronics industry in terms of production, employment and foreign trade in the past few decades, and identifies four main periods. This discussion incorporates reference to government policy and to FDI as appropriate. However, given their importance the last two sections provide summary reflections on government policy and FDI respectively.

## 3.1 The Development Stages of the Electronics Industry

### 3.1.1 Pre-1970s: Origin and start-up phase

According to Wade (1990: 93), Taiwan's electronics industry originated in the late 1940s when some local firms began to assemble simple transistor radios using imported parts from Japan. There were also a number of firms which had transferred from Mainland China and produced simple electrical equipments such as wire, light bulbs and transformers. In the 1950s, to protect and encourage the local producers, the government restricted the import of finished electronic products and indicated that protection and other incentives would be given for certain products such as radios, fans, meters and fluorescent lights in the first Four Year Plan (1953-56). The local firms took advantage of the import restrictions. However, their growth was limited by the extent of the domestic market. These constraints were eased in the 1960s to encourage FDI, joint ventures and technical agreements with MNCs.

In the late 1950s, many large MNCs in western countries turned abroad to look for cheap labour locations due to rising wages in home countries. The cheap skilled labour force and government incentives encouraged many US firms, such as General Instruments (1964), TI and RCA (1967) to invest in Taiwan. National Cash Register (NCR) was the first US firm to begin operations in Taiwan with a subsidiary established in 1954 to sell computers and provide computing services for the local firms (Gee 1989: 1). In 1964 General Instruments began making consumer electronics in Taiwan and later transferred production of transistors, diodes and integrated circuits from the USA (Chaponniere and Fouquin 1989).

During this period, the government aggressively sought out foreign companies for investment, stimulated in part by .the reduction of US aid in the 1965 (van Hoesel, 1999). For this purpose, the Statute for the Establishment and Management of Export Processing Zone (EPZs) was promulgated in 1965 followed by the establishment of the first EPZs in Kaohsiung in 1966. The EPZ offered modern port facilities, tax incentives, and non-duties on equipment and parts as long as they are used for export production. Later, other EPZs were established in Taichung and Nantze. EPZs were important in helping Taiwan increase its exports in the 1960s. As a result of this new policy, approved inward FDI flows increased from a scant US$35.7 million in the 1950s to US$523.6 million during the period from 1960 to 1970. Most inward FDI in the 1960s occurred in the electronics industry. By the 1970s, the three EPZs provided 10% of all Taiwanese exports (Chaponniere and Fouquin 1989).

In 1966, the government published a plan to establish Taiwan as an electronics industry centre, again mainly to attract FDI (Wade 1990, p94). The introduction of Taiwan's fourth Five-Year Plan in 1965 which promoted electronics production thus led to the emergence of more US investors including, Philco (1965), Admiral (1966), RCA (1967), Motorola (1970) and Zenith (1971), that began to make simple electronics components and other products for export (Amsden and Chu, 2003:20). While the US MNCs took the lead in electronics, mostly through wholly owned subsidiaries, Japanese firms tended to supply the local market through joint ventures. Encouraged by the historical links and geographical adjacency, a number of Japanese firms had started to seek local partners for electrical assembly from the late 1950s. By the mid 1960s, several joint ventures were formed between local and Japanese electrical appliance manufacturers, mostly producing transistor radios, black and white TVs and simple components. The major Japanese joint ventures at this period included Sanyo (1963), Hitachi (1964), Matsushita (1966) and Sharp (1971) (Hayter and Edgington, 2004).

Given that most Japanese firms tended to produce items only for the domestic market with components from Japan, in 1962 the government imposed local content requirements for the production of electronics products such as TVs, refrigerators and air conditioners. These requirements proved to be an effective way to encourage MNCs, particularly the Japanese firms, to transfer technology to local firms. To ensure the quality of essential components, many Japanese firms helped their joint-venture partners with labour force training and technology upgrading. Because they had to buy locally, they wanted their suppliers to be as efficient as possible (Amsden and Chu, 2003).

During this period, the wave of FDI stimulated the development of electronics industry in Taiwan. Foreign investment in electronic and electric appliances contributed about 8.78 per cent of total approved FDI between 1952 and 1962. This share soared to 44.96 per cent between 1963 and 1972 but slightly fell off to 39.95 per cent between 1973 and 1982 (Table 3.1).

**Table 3.1: Approved foreign investments in Taiwan (US $thousand)**

| | Total | Electronic and Electric Appliances | The percentage of electronics |
|---|---|---|---|
| | Amount | Amount | Electronics/Total |
| 1952~1962 | 34,719 | 3,050 | 8.78% |
| 1963~1972 | 586,832 | 263,814 | 44.96% |
| 1973~1982 | 1,808,744 | 711,658 | 39.35% |
| 1983~1992 | 11,575,727 | 2,922,329 | 25.25% |
| 1992~2002 | 35,058,748 | 8,121,376 | 23.17% |

Data source: Statistics on overseas Chinese and foreign Investment, Technical Corporation, Outward Investment and technical cooperation 2002, Investment commission, MOEA, ROC

USA and Japanese firms provided opportunities for local firms to thrive as suppliers and subcontractors. Moreover, many Taiwanese technicians gained work experience and later left the MNCs, setting up their own businesses to supply market niches and services (Ernst, 2000). Numerous small local start-ups were later involved in direct contract manufacturing relations with foreign manufacturers in the electronics industry.

### 3.1.2 1970s: Industrial take-off

During the 1970s, when the electronics industry was still dominated by foreign firms, the consumer electronics industry took off, featuring such new product lines for export markets, as colour TVs, digital watches and calculators. For instance, Philips began making black and white TVs in Taiwan in 1970 and then colour TVs in 1976. The US firm RCA, which began making memory circuits in 1969, started producing black and white TV sets and tuners in 1971 (Hobday, 1995). Taiwanese electronic firms also grew around the industrial resources and experiences gained from manufacturing consumer electronics products While local firms still had heavy reliance on technical assistance from OEM or foreign buyers, in the early 1970s, IBM began purchasing large quantities of sub-assemblies and components from Taiwanese companies. Other US computer firms followed, helping local companies learn about an increasingly sophisticated array of components and systems (Hobday, 1995).

However, the electronics industry of Taiwan in the 1970s was still mainly a labour-intensive, assembly industry. In 1971, about 63% of the raw materials, parts and components used to manufacture electronics exports were imported from Japan and the USA; only 37% was from local sources. That is, Taiwan's electronic firms had great dependence on imported inputs (Amsden and Chu, 2003).

In order to deepen industrial development, the government imposed more export and local content targets on foreign companies to control labour-intensive investment by MNCs (Chung, 1997). Thus, the government encouraged jointly-owned ventures to manufacture components in Taiwan by protecting the local market through strictly controlled imports. Further, the government realized the need for more advanced capabilities to help the electronics industry become more technology-intensive. Specific recommendations to start a new semiconductor industry were framed by the Technical Advisory Committee in the early 1970s (Mathews and Cho, 2000). The single most important component for the electronics industry is the semiconductor. Taiwan's semiconductor industry was initiated in 1964 when General Instrument Microelectronics (GI) established a factory for its transistor packaging, while other MNCs such as TI and RCA also started semiconductor packaging operations in the next few years (Amsden and Chu, 2003). Until the mid 1970s, however, the main activities of this industry in Taiwan remained the labour-intensive part (packaging). In order to upgrade value-added operations in Taiwan, the government established a specialist laboratory under Industrial Technology Research Institute (ITRI) to start the new industry (Wu and Tseng, 2003). This led to the creation of the Electronics Research and Services Organization (ERSO) in

1974, which was given the job of promoting R&D in computers and coordinating the transfer of technology from companies such as IBM, Microsoft and AT&T (Executive Yuan 1988: 11; ERSO, 1994).

While the government played a leading role in promoting the development of the semiconductor industry, local firms were also accumulating technical know-how from producing consumer electronics. Amsden and Chu (2003) suggest that the manufacturing of TVs and calculators laid a foundation for the next era of computer manufacturing in Taiwan. Accordingly, "the accumulated technological knowledge and experience from TV manufacturing.... facilitated the technological capabilities of manufacturers to engage in the production of monitors and terminals" (Lin 1986: 86, cited in Amsden and Chu 2003: 24). This is because a TV largely consists of a monitor and a tuner, and TV terminals are a combination of a monitor, a keyboard and a logic board. Moreover, the notebook PCs industry stemmed from the calculator industry (Schive and Simon, 1986). By 1980 the foreign MNCs took the initiative to start the mass production of monitors and terminals in Taiwan. Local firms later established similar manufacturing capabilities and caught up with the foreign MNCs to account for 63% of total output of monitors and 51% of output of terminals in Taiwan by 1983 (Amsden and Chu, 2003).

### 3.1.3 1980s: Industry upgrading

During the 1980s, local firms thrived while many foreign firms withdrew from Taiwan as the total production costs increased mainly due to the rising local wages. Many local firms gradually accumulated technology by working as OEM firms for consumer electronics, which also laid the groundwork to transform the whole local industry structure into more technology-intensive industry. The industry enjoyed a rapid growth during the 1980s, as electronics output rose from US$ 4.1 billion in 1980 to US$ 13.6 billion in 1990. In 1986 the electronics sector surpassed textiles to become the largest industry in Taiwan's manufacturing sector (Table 3.2). The electronics industry contributed around 20% of total national exports during the late 1980s, while 70% of production was exported annually (ibid.).

**Table 3.2: Distribution of manufacturing value added in Taiwan, 1981-1996 (%)**

| Industry | 1981 | 1986 | 1991 | 1996 |
|---|---|---|---|---|
| Food | 7.1 | 7.1 | 6.4 | 6.0 |
| Textiles | 12.8 | 10.6 | 8.6 | 6.7 |
| Apparel | 3.5 | 4.5 | 2.0 | 1.0 |
| Chemicals | 8.0 | 6.9 | 7.3 | 9.8 |
| Chemical products | 1.9 | 2.1 | 2.5 | 2.9 |
| Petroleum | 7.0 | 4.6 | 4.5 | 5.8 |
| Plastics | 8.1 | 8.7 | 7.4 | 5.4 |
| Mineral Products | 4.0 | 3.6 | 3.8 | 3.5 |
| Basic metals | 6.4 | 6.7 | 7.7 | 8.7 |
| Metal products | 5.1 | 5.1 | 5.7 | 5.2 |
| Machinery | 3.7 | 3.9 | 4.9 | 4.8 |
| Electronics | 9.9 | 14.1 | 17.8 | 24.3 |
| Transport equipment | 5.9 | 6.0 | 7.4 | 6.6 |
| Precision instruments | 1.1 | 1.1 | 1.3 | 0.9 |
| Miscellaneous | 4.0 | 3.8 | 3.3 | 1.9 |
| Others | 11.6 | 12.2 | 9.5 | 6.5 |
| Total | 100 | 100 | 100 | 100 |

Data source: Industrial Production Statistics Monthly, Taiwan Area, ROC. Taipei: Ministry of Economic Affairs (various years)

To accelerate technology-intensive industries, the government followed the recommendation from the national consulting group to promote the electronics industry, particularly the semiconductor and computer industry. To encourage technology deepening, the state invested in its own research laboratories and organised collaborative R&D ventures among local firms. Thus in 1979, the Institute for Information Industry (III) was founded to assist in promoting computerisation, developing software, and collecting, analysing and disseminating technical and marketing information. In 1980 the first Science Park was established in Hsinchu, providing land and premises at low rent to attract companies to invest in manufacturing high-tech products. A high proportion of the value of production came from the manufacture of PC peripherals and semiconductors (Hwang, 1995:40). In 1982, the information (computer) industry was chosen as a strategic industry, and the government has offered additional financial incentives to encourage investment in this industry. Since then large numbers of small firms entered the professional electronics area, making computers, sub-assemblies, monitors, printed circuit boards, printers and keyboards (Hobday, 1995).

By the early 1980s, with their accumulating technical knowledge from manufacturing consumer electronics products, numerous Taiwanese electronics companies branched out from the production of consumer electronics into that of personal computers (PCs) hardware, such as monitors and terminals. With the additional inducements offered by the government, numerous local companies started to enter the information industry as subcontractors in OEM production as well as the foreign computer makers invested in production facilities in Taiwan. Due to the large amount of capital and manpower injected into the industry, computer manufacturers were able to expand their operations into several new areas, such as PCs, hard disk drives, and other computer peripherals (Lee and Pecht, 1997; Poon, 2002).

A considerable number of Taiwanese firms commenced computer manufacturing after the 1970s. From late 1970s, some Taiwanese companies started to assemble computers for US manufacturers, such as Apple Inc. Meanwhile, some local firms brought the talent of reverse engineering (and copying) into full play to make unauthorised clones of the Apple II computers and started to market the clones locally. However, in 1982 the government banned the illegal clones due to the pressure from Apple Inc. and the US government (Lee and Pecht, 1997). Those local computer makers, however, did not cease from manufacturing and instead they started to produce IBM compatible PCs with available equipments. In the early 1980s, as IBM began to license its PC products to be manufactured in Taiwan, which allowed more local companies to shift to computer manufacturing. In 1984, the local computer producer Acer, which has become one of the largest computers manufacturing company in Taiwan, developed its own 16-bit PCs. After Compaq first introduced an Intel-based 80386 32-bit microcomputer, Acer became the first to successfully develop this product in Taiwan in 1986 (Poon, 2002). The increasing computer manufacturing ability of local PC manufacturers then attracted more foreign computer makers. Thus the local PC market began to grow after 1983 with increasing investments, and large foreign PC manufacturers such as Digital started to place OEM orders for computers and peripherals during this period, still taking advantage of a relatively low-cost and increasingly skilled labour force (Dedrick and Kraemer, 1998:87). Electronics products simultaneously became the top-ranked import and export categories, and Taiwan later became the world's largest maker for some computer peripherals, such as motherboards, monitors, scanners and mouse (Lee and Pecht, 1997).

During the 1980s, Taiwanese manufacturers also moved beyond OEM arrangements to become involved in 'own-design manufacture' (ODM). Through cumulating experience, local firms gained the ability to perceive the market trends and introduce new improved designs in anticipation of market needs. As a result of their flexible and manufacturing ability, both US firms, such as IBM, Apple, Dell, Intel, and AT&T and Japanese firms such as Mitsui and Hitachi, were persuaded to place ODM orders with Taiwanese manufacturers by the late 1980s (Hobday, 1995). During this period, Taiwan's electronics industry shifted from consumer electronics to a new era centred around the information (computer) industry. Information products overtook consumer goods as the largest sub-sector, growing from around US$80 million in 1980 to US$2.1 billion in 1986, as Taiwan became one of the leading producers of personal computers. In 1989 its microcomputer production represented roughly 10% of total world production (on a volume basis). Its position has even stronger in other areas, e.g. 35% of global colour monitors production; 33% of computer terminal and graphics card production; 32% of keyboard production; 30% of monochrome monitor production (Ernst and O'Connor, 1992: 119).

While MNCs stimulated the information industry in Taiwan, semiconductor design and manufacture took root during this period by the lead of the government and its sponsored firms. Indeed, there was a diversification of activities in the semiconductor industry. Unlike the assembly or testing activities in which some local firms had been involved since 1970s, chip fabrication and manufacturing required a huge investment of capital. Accordingly, the government took the initiative to foster the latter activities with both technological and financial assistance, more precisely, the spin-off firms of Industrial Technology Research Institute (ITRI) and Electronics Research and Service Organisation (ERSO). Some of those spin-off firms such as UMC, established in 1980 as a mainstream IC producer, and TSMC, established in 1986, offered sophisticated silicon foundry services. Similarly, Winbond, launched in 1987 to manufacture various types of IC, became one of the leading IC companies both locally and globally (Poon, 2002).

The national research institute ITRI had started to look for foreign firms for advance technology of semiconductor manufacturing. Through ITRI/ERSO, in 1976 RCA started a venture to transfer chip technology to local firms. ERSO further appointed engineers to RCA in the USA for a thorough training programme which included chip processing, design engineering, cost accounting, sales and marketing, and even operations management (Hobday, 1995). RCA's training and technology transfer undoubtedly helped to accelerate the pace of semiconductor industry development in Taiwan. Another noteworthy event was when Philips began a joint venture with the Taiwanese government in 1987, forming the Taiwanese Semiconductor Manufacturing Corporation (TSMC) to make specialist circuits for local design firms. Under the venture, ITRI/ERSO arranged with Philips to transfer more advanced technology to the new venture. Similarly, ERSO designated engineers to Philips for training and then ERSO spun off around 200 personnel to join the new company after training from Philips (Mathew and Cho, 2000).

### 3.1.4 1990s: The transition period

By the early 1990s, the information (computer) industry had replaced consumer electronics as the largest sub-sector of the industry (Table 3.3). Simultaneously, as a result of currency appreciation after 1985 and rising local wages, much of Taiwan's consumer-good and other low-end electronics production was transferred to China and Southeast Asian countries, such as Thailand and Malaysia. The two main computer exports from Taiwan in 1990 were PCs (US$1.6 billion) and colour monitors (US$1.3 billion). Other computer peripherals, including keyboards, mouse and scanners amounted to US$2.2 billion in 1990 (Hobday, 1995). Within a few years, Taiwan became the world's biggest supplier of motherboards, mouse, scanners, monitors and keyboards. Since then, Taiwan has becoming a leading producer of certain electronic products, such as PC, monitors, computer boards, terminals and switching power supplies although mostly under OEM/ODM arrangement (Yu and Zhang, 2001)

**Table 3.3: Electronics product mix in Taiwan from 1991to 2001 (%)**

| | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Computer equipment & parts | 37.63 | 44.06 | 47.46 | 51.81 | 54.96 | 56.76 | 55.82 | 57.40 | 56.22 | 52.53 | 56.20 |
| Semiconductor | 8.13 | 7.44 | 9.77 | 7.48 | 9.75 | 11.27 | 14.76 | 12.76 | 14.69 | 19.64 | 15.65 |
| Communication & telecommunications | 13.16 | 11.10 | 9.98 | 10.05 | 8.36 | 7.78 | 6.82 | 7.58 | 6.44 | 6.03 | 7.37 |
| Total consumer | 10.86 | 8.64 | 6.25 | 5.17 | 4.20 | 3.18 | 2.46 | 2.07 | 1.91 | 2.13 | 2.32 |
| Other components | 26.81 | 25.78 | 23.89 | 23.13 | 21.02 | 19.65 | 18.94 | 19.12 | 19.83 | 18.84 | 17.46 |
| Others | 3.42 | 2.99 | 2.66 | 2.36 | 1.71 | 1.36 | 1.20 | 1.06 | 0.92 | 0.82 | 0.99 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

Data source: The yearbook of world electronics data, volume 2 (various years)

The success of the information industry allowed Taiwanese manufacturers to position themselves in world markets and gave further impetus to local firms to move beyond OEM. Several local computer makers, such as Acer and Mitac, started to sell their own-brand PCs from the late 1980s while demand continuously grew. As some Taiwanese firms made attempt to compete with their own-brands on the global market and expanded their business during the early 1990s, Europe and North America suffered from economic recession and caused the Taiwanese computer industry to undergo a collapse (Yu and Zhang, 2001).

As Lee and Pecht (1997: 34) state, a major setback in Taiwan's electronics exports growth occurred when global industry leaders, such as Compaq, AST, and DELL, began to reduce their product prices by 30 to 40 % to overcome the slow global sales in 1992, so that "the sales growth of Taiwan's own brand-name PCs almost came to a halt". Many local firms ceased business due to their earlier over-expansion, and larger Taiwanese manufacturers, such as Acer, put off plans to sell own brand-name products to overseas markets and concentrated more on their OEM business instead (Poon, 2002). Although the strategy of price-reduction led by Compaq slowed the pace of Taiwanese firms to move beyond OEM/ODM, it helped to consolidate the local information industry by phasing out the less-competitive companies. Moreover, the surviving manufacturers sought to "improve their capability in managing the global logistics of putting various parts and components produced in different geographical locations into finished computer systems" since many local firms had relocated low-end production to Southeast Asian countries, such as Malaysia and Thailand, and China for cheap labour (Poon, 2002: 54).

Meanwhile, some foreign MNCs, such as US's Zenith, also ceased their operations in Taiwan during this period as a result of the rising wages and increasing production costs. . The domestic firms then gradually grew to become the main force of the industry while the production of foreign companies decreased. Taiwan's computer industry resumed its rapid growth rate while Japanese firms such as Epson, NEC, Sharp, and Hitachi started to source PC components and put OEM/ODM orders for PC during the mid-1990 (Dedrick and Kraemer, 1998: 92). In 1994, the total output of the computer industry (computer equipments and parts) accounted for more than half (51.8%) of the electronics industry in Taiwan (Table 3.3) and was continuously the leading sub-sector. In 1995, Taiwan became the world's third largest producer of information products, behind only the USA and Japan (Wu and Tseng, 2003).

Although most indigenous firms still manufactured under OEM/ODM, a large volume of overseas contractors made Taiwan the world's major computer maker in the late 1990s. The indigenous computer makers thus were able to accumulate a large amount of capital and use it to develop new technologies, investing in key electronics components (e.g., semiconductor and display devices), and constructing new production facilities. During the mid-1990s, the local firms were confronted with their continued reliance on Japan and the USA for export of critical components. With the rapid growth of the computer industry, the domestic computer makers sought to secure the supply of these critical components (Lee and Pecht, 1997). The domestic firms took the initiatives to produce these components while the government made an effort to assist local manufacturers in producing more critical components and promoting the development of computer software and services. The range of IT products manufactured by local firms gradually expanded from computer systems and peripherals to more critical parts and components, such as the DRAMs and TFT-LCDs (Thin film transistor-liquid crystal display) (Poon, 2002; Amsden and Chu, 2003).

The 1997 Asian financial crisis granted the Taiwanese firms a great opportunity to enter the TFT-LCD industry while most Asian countries suffered from this crisis. Before 1997, there were no Taiwanese firms involved in the manufacturing of large TFT-LCDs due to its extremely high financial as well as processing requirements. The Japanese firms had dominated the industry in terms of technology and production before the Korean congregations; the 'Chaebol' (a Korean term for the conglomerate which consists of many companies) such as Samsung and LG (Lucky Goldstar) began the production of TFT-LCD in the mid-1990s (Amsden and Chu, 2003).

With the outbreak of the Asian financial crisis in 1997, Japanese business groups that were suffering from domestic recession became unable or unwilling to continue making the huge investments in TFT-LCDs necessary to keep up with the global competition. Therefore, some major groups, such as Mitsubishi and Toshiba, decided to cooperate with Taiwanese firms by granting them technology licenses and giving them OEM orders, which enabled them to obtain license fees and take advantage of Taiwan's production capability to supplement their own. For instance, Unipac, an affiliate of UMC, joined forces with Matsushita; Chung Hua Picture Tube (CPT), an affiliate of Tatung, obtained technology under the arrangement with Mitsubishi, and Hannstar, a manufacturer of electrical wire, hooked up with Toshiba, all in 1998 (Amsden and Chu, 2003). Thus the Taiwanese TFT-LCD industry experienced a strong growth with a great amount of investment and help from their Japanese partners while South Korean firms held off their expansion plans due to the financial crisis. By the end of 1999 the total amount of investment in the production of TFT-LCD was approximately NT$200 billion (Poon, 2002: 56).

In 1999, Taiwan surpassed Japan to become the world's largest manufacturer of notebook computers in terms of production volume, manufacturing 49% of the world's share for the first time. Even Toshiba, the company producing the largest number of notebook computers in the world, placed OEM orders to Taiwanese manufacturers in 1999 (Poon, 2002). Taiwan's share of global capacity increased from 0 % in 1998 to 2% in 1999, to 15% in 2000, to 26% in 2001, and to 34% in 2002 (Amsden and Chu, 2003). Table 3.4 indicates that the production and exports amount of Taiwan's electronics industry had grown twofold and threefold, respectively from 1991 to 2001. Despite the temporary decline in 1998 as a result of the Asian financial crisis, other Asian NICs, excluding Hong Kong, also experienced a notably growth of their electronics industry in the same period. The decline of Hong Kong's production in electronics after 1998 could be partly referred to its repatriation within Chinese control in 1997. Compared with the rapid expansion of electronics industry in the Asian latecomer countries, including East Asian NICs and the second tier latecomer countries, such as Malaysia and Thailand, Japan's production of electronics industry has declined since 1998, at least as of 2001. Overall, among these countries the core countries of the US and Japan still dominated production while Taiwan experienced the faster rate of growth during the 1990s. Although the data is not fully available for China for 2001, the evidences suggested that China's electronics industry had grown faster than Taiwan during the 1990s and even surpassed Taiwan and South Korea to become only second to USA and Japan as for 2000 (Yearbook of World Electronics Data, 2002/03).

**Table 3.4: Production and exports of the electronics industry (selected years)**

**Amount: Millions of US dollars**

| Country | 1991 | 1995 | 1998 | 2000 | 2001 |
|---|---|---|---|---|---|
| **USA** | | | | | |
| -production | 206,413 | 285,097 | 318,294 | 385,145 | 319,187 |
| -exports | 60,661 | 98,800 | 108,332 | 137,180 | 120,405 |
| **Japan** | | | | | |
| -production | 207,400 | 267,109 | 196,180 | 263,451 | 194,461 |
| -exports | 83,933 | 120,680 | 97,364 | 126,187 | 96,444 |
| **South Korea** | | | | | |
| -production | 25,446 | 49,368 | 39,275 | 76,059 | 53,648 |
| -exports | 17,306 | 34,698 | 32,253 | 60,223 | 45,259 |
| **Taiwan** | | | | | |
| -production | 15,779 | 29,416 | 33,574 | 50,193 | 39,260 |
| -exports | 13,580 | 32,332 | 37,949 | 57,015 | 44,715 |
| **Hong Kong** | | | | | |
| -production | 8,340 | 9,597 | 8,218 | 8,083 | 7,033 |
| -exports | 20,364 | 48,447 | 50,531 | 67,159 | 63,365 |
| **Singapore** | | | | | |
| -production | 16,710 | 39,825 | 37,850 | 47,318 | 34,870 |
| -exports | 22,382 | 62,495 | 58,717 | 75,169 | 63,545 |
| **Malaysia** | | | | | |
| -production | 9,091 | 27,763 | 27,420 | 44,539 | 36,555 |
| -exports | 10,578 | 33,124 | 32,985 | 45,612 | 39,437 |
| **Thailand** | | | | | |
| -production | 5,403 | 12,511 | 14,577 | 18,880 | 14,350 |
| -exports | 4,903 | 12,210 | 14,719 | 19,578 | 16,965 |
| **China** | | | | | |
| -production | 13,663 | n/a | 52,456 | 81,035 | n/a |
| -exports | n/a | n/a | 34,509 | 47,903 | n/a |

Data source: Yearbook of World Electronics Data, Volume 2 (various years)

Note: Exports include re-exports. It should be noted that re-exports are very high for Hong Kong and Singapore (Yearbook of World Electronics Data (2) 2003

## 3.2 Reflections on the Role of the Government

The Taiwanese government played a vital role in the development of high-tech industries, more specifically, the electronics industry. These interventions have gone beyond the role of government normally associated with the market model (Amsden and Chu, 2003). The noteworthy part of the government's intervention is to assist local firms to develop their technological capabilities by means of the national research institutes. The national research institutes have carried out research and development for many cutting-edge technologies in conjunction with indigenous firms, which prepared the way for local production of the 'next hot, mature product' (Amsden and Chu, 2003).

During the early stages of the development of the electronics industry, instead of much direct industrial intervention toward, the government encouraged private enterprise by securing a stable macroeconomic environment by keeping inflation low and promoting exports. While this approach helped the development of labour-intensive products in the 1950s and 1960s, the government began to take different measures in the 1970s, especially in relation to fiscal policy, national research institutes and investment on public infrastructure, in order to upgrade the local industry (Lee and Pecht, 1997). Among various measures, the most significant initiatives are the establishment of the national R&D institute, led by ITRI, in 1973, the creation of the Electronic Research and Service Organisation (ERSO) in 1974 and the Institute for Information Industry (III) in 1979 (Table 3.5). These three organisations have played pivotal roles in promoting technological levels among Taiwanese companies and helped transfer advanced technology from foreign firms. In the 1980s, the role of the government became more supportive as local firms have grown to become the leading force behind the development of the electronics industry. Table 3.5 briefly delineates the Taiwanese government policies toward the development of the electronics industry from 1959 to 2002, relating specific initiative to specific economic situations.

**Table 3.5: Government policies to promote the electronics industry in Taiwan**

| Year | Economic situation | Programme & Law | Institute & infrastructure | Note |
|---|---|---|---|---|
| 1959 | - Export promotion<br>- Improvement environment for investment | Nineteen-point programme of economic and financial reform | Establishment of National Science Council (NSC) | The NSC was established to initiate and coordinate science and technology development. |
| 1960 | - Develop labour-intensive & export-oriented industries | Statute for encouragement of investment | | The Statute offered incentives to investors mainly to attract foreign firms at this stage. |
| 1961 | | Third four-year economic development plan | | |
| 1965 | | Statute for establishment and management of export processing zones (EPZs) | | EPZ offered modern port facilities, tax incentives; no duties on equipment and parts as long as they are used for export production. |
| 1973 | - Industrial consolidation<br>- Encourage industrial R&D | | Industrial Technology Research Institute (ITRI) | ITRI was established to provide technical support to upgrade the local industry and help to disseminate research results to the private sectors. |
| 1974 | | | Electronics Research and Service Organisation (ERSO) | ERSO was set up to research and develop advanced technology and product for local electronics industry. |
| 1976 | - Develop technology-intensive industries | | Committee for Scientific Development of the Executive Yuan established | |
| 1979 | | Science and Technology Development Programme | Institute for Information Industry (III) | III was established to promote the domestic use and development of computer systems.<br>Science and Technology Development Programme identified information technology systems as a key area and semiconductors and computers were targeted as strategic sectors in this document. |
| 1980 | | | Establishment of Hsinchu Science-Based Industrial Park | The government launched the first science-based park in Taiwan. |

| Year | Economic situation | Programme & Law | Institute & infrastructure | Note |
|---|---|---|---|---|
| 1981 | - High-technology industrialisation<br>- R&D subsidies | Information technology industry development plan | | |
| 1982 | | Eighth Four-year Development Plan | | Computer hardware system and system integration were designated as the strategic technologies for future development. |
| 1982 | | Assistance Programme for Strategic Industries (APSI) | | The government initially selected 151 products as strategic products for development in APSI, most of them were electronic or information products |
| 1983 | | Strengthen training and acquisition of high-tech personnel Act | | The Act facilitated the return of the first wave of overseas Chinese scientists and engineers |
| 1984 | | Development of New Industrial Products programme | | In 1984 new tax incentives were introduced for companies carrying out R&D activities. |
| 1986 | | Ten-year S&T (Science& Technology) Development programme (1986-1995) | | The programme aimed to promote the development of high-tech key industries |
| 1991 | | Six-year national development plan (1991~1996) | | Telecommunications, information technology, consumer electronics, semiconductors were designated as part of the 10 "star industries" whose development was considered essential for future industrial success in the plan. |
| 1991 | | National Science Council Plan (1991-1995) | | Integrated circuits (IC), liquid crystal display (LCD) and DRAM were designated as key products. |
| 1991 | | Development Targeted Leading Products programme | | The government provides subsidies (50%) to encourage companies to develop new products. |

| Year | Economic situation | Programme & Law | Institute & infrastructure | Note |
|---|---|---|---|---|
| 1992 | | Development of Critical Components and Products programme | | Initially, 66 items were selected for import substitution in order to reduce the reliance on foreign firms (mainly Japanese firms) for critical components. |
| 1995 | | | The Southern Taiwan Science Park (STSP) | It aimed to upgrade industry in southern Taiwan, with a view to balance the high-tech development area throughout the island. |
| 1996 | | | Incubator Centre/ ITRI's Open Laboratory programme | ITRI started its own incubator to help entrepreneurs start up their new technology-based businesses |
| 1997 | | Statute for Governing the Relations Between the People of the Taiwan Area and the Mainland Area (amendatory) | Technology Development Programme (TDP) | TDP gradually allowed participation by private enterprises to encourage innovations and applied research |
| 1999 | - Economic restructuring | Statute for Upgrading Industrial (amendatory) | | The amendment encourage local firms to conduct R&D and locate their headquarters in Taiwan, it also encourage foreign companies to establish international logistic and distribution centres in Taiwan |
| 2001 | | National Science and Technology Development Plan (2001~2004) | | |
| 2002 | | Challenge 2008: The six-year National Development Plan (2002~2007) | ITRI's branch in the Southern Taiwan Science Park began operation | |
| 2002 | | Promoting Industrial Innovation R&D Center programme | | |

Data source: ERSO, 1994; Lee and Pecht, 1997; Poon, 2002; Amsden and Chu, 2003, Taiwan NSC (various years)

### 3.2.1 The national research institutes and science parks

The establishment of the national research institutes by the government resulted partly from the predominance of SMEs in the local economy. Since most local enterprises lacked sufficient resources to engage in R&D activities, the Taiwanese government started to fund state-owned industrial research institutes to administer R&D expenditures to provide technical support to local companies (Naughton, 1997). These research institutes were founded to undertake research programmes and to develop new products and technologies. Additionally, they also became the technology diffusion centres, helping to transfer advanced technology from foreign firms and further disseminate the results to the local firms by means of spin-off firms. Aside from working on the advanced technology front, the research institutes offer private enterprises assistance on specific R&D project on a contract basis (Chaponniire and Lautier, 1998).

In 1973, the Industrial Technology Research Institute (ITRI) was first established, and since then it has played a pivotal role in local technological development. In its early stage, ITRI undertook key technology projects to help to promote strategic industries, such as semiconductors and PCs, which were designated as primary sector by the government. ITRI also became an important source of the local work force for high-tech industry. By 2000 there were more than 15,000 professionals who had worked at one time or another for ITRI, and of these 15,000 professionals, more than 12,000 had gone to work in one or another high-tech sector (Amsden and Chu, 2003).

In 1974, Electronics Research and Service Organisation (ERSO) was founded under ITRI with the aim of focusing on the development of the local electronics industry. ERSO was authorised to set up joint ventures with foreign business and private firms to commercialise its technology, which helped ERSO to obtain technology efficiently and diffuse it to the local firms. ERSO was successful in pursuing this spin-off model, particularly in the semiconductor industry. The spin-off firms from ERSO, UMC and TSMC, later became the leading firms of Taiwanese semiconductor industry. ERSO remained as the main source of technology for local integrated circuit (IC) manufacturers until the 1980s. ERSO also played a crucial role in developing the local computer industry. Since 1979, ERSO had sent engineers to the Wang Computer Company (USA) for training courses and these engineers helped diffuse computer know-how to the local firms. Another noteworthy achievement of ERSO was its effort to help Acer make Taiwan's first 16-bit IBM-compatible personal computer in 1984. Other computer technology developed by ERSO and transferred through training courses to private computer firms included the Ethernet and the Token Ring network, the workstation, the terminal and monitor, and file management software (ERSO, 1994; ITRI, 2003).

In accordance with the diversification of the local high-tech industry in Taiwan and the increasing demand for more advanced technology, more research institutes were established aimed toward each specific aspect of the electronic industry. In 1979 the Ministry of Economic Affairs (MOEA) contracted out the implementation plan for computer technology to ITRI and invited relevant state agencies and firms to jointly establish the Institute for Information Industry (III) to promote the domestic use and development of computer systems (Chung, 1997). As a result of the global PC boom in the late 1980s, numerous local firms joined the computer industry and started to manufacture PCs under OEM arrangements with foreign MNCs. In 1990, Computer and Communication Research Labs (CCL) was split from ERSO to mainly focus on the computer industry (ERSO, 1994).

The establishment of science-based industry parks is another important form of government support for the development of the high-tech industry. In order to offer local firms impetus to invest in high-tech products, the government announced its intention to build a Science Park in the late 1970s. In 1980, the first and still the most successful science park- Hsinchu Science Park, was established in Hsinchu which located south of Taipei. Due to the great accomplishment of the first park, the second one was founded in southern Taiwan in Tainan in 1995 (Wang, 2002).

The science parks provided resident firms with high-quality factory buildings or sites at relatively low rents compared with the market prices. Subsidies, including tax and import duty exemptions, grants and subsidised credit, were given to park residents (Wang, 2002). The location of the parks also allowed a strong connection between private firms and local universities, as park residents can get access to university research facilities. The science park system further encouraged the geographical agglomeration of the electronic industry. Indeed, the establishment of the Hsinchu Science Park in particular became a "breeding ground" for Taiwan's electronics industry. Since its opening in 1980, the Hsinchu Science Park has attracted over 150 firms and 40,000 employees, mostly in electronics (Chaponniire and Lautier, 1997). The large input to the R&D by park residents has been proved by the increasing share of national total input, for as much as 18 % in 1998, out of Taiwan's total R&D spending (Amsden and Chu, 2003).

### 3.2.2 Industry targeting

The Taiwanese government also played a significant role by providing a strategic direction for development of the local electronics industry, under the rubric of industry targeting. As Chaponniire and Lautier (1997: 230) note, "its (the Taiwanese government) picking the winners policy speeded up the development of several sectors, starting from textiles in the 1960s to semiconductor and aerospace in the 1980s and 1990s". Starting from the late 1970s, the Taiwanese government began to favour the electronics industry. The Science and Technology Development Programme that was enacted in 1979 first identified information technology systems as a key industry and further targeted semiconductors and computers, energy, materials and automation as the sectors of most strategic value for Taiwan (Wang, 2002). In 1982, computer hardware systems and system integration were selected as the strategic technologies for future development. Preferential fiscal measures and financial state incentives were offered to the 'strategic industry' (see Table 3.5). Later the Six Year Development Plan (1991-1996) selected ten 'star industries' whose development was considered essential for future industrial success: telecommunications, information technology, consumer electronics, semiconductors, precision machinery and automation, aerospace, advanced materials, specialty chemicals and pharmaceuticals, medical and health care, pollution control. According to Say (1994), the definition of strategic sectors was based on the same 'two high-two large-two low' principle, in other words, industries targeted were high in technology and value-added intensity, large in market potential and industrial lineages, and low in energy consumption and pollution (cited in Chaponniire and Lautier, 1997: 230)

Even as more local companies entered the electronic industry and engaged in high-tech electronic products manufacturing, there remained a heavy reliance on foreign firms for critical components. In order to encourage product range upgrading, the government further selected certain critical components and products and offer generous subsidies to encourage local firms to conduct R&D towards those targeted items. The criteria used by the government to pick certain components or products included those that were highly value-added with great market potential, and for which Taiwan's industry is heavily import dependent (Amsden and Chu, 2003). Private firms engaged in new product components development could apply for several advantages in terms of state subsidies (as much as 50 % of the development costs), low interest loans, research support, and other administrative privileges. As shown in Table 3.4, three main programmes were launched since 1980s, the Development of New Industrial Products programme in 1984, the Development Targeted Leading Products programme in 1991, and the Development of Critical Components and Products programme in 1992. The National Science Council Plan (1991-1995) also gave priority to the development of integrated circuits (ICs), liquid crystal displays (LCDs), and dynamic random access memories (DRAMs). Some targeted products or components such as CD-ROM, LCDs and ICs soon replaced low-end electronic products such as keyboards and mouse to become the main electronics export products by the mid 1990s.

## 3.3 Reflections on the Influence and Contribution of FDI

FDI played a significant role of the development of Taiwanese electronics industry, particularly at the initial stage. Foreign MNCs came to Taiwan during the 1960s and 1970s to set up wholly owned subsidiaries or joint ventures for the production of transistor radios, black-and-white television sets, and electronic components and parts, taking advantage of the cheap and skilled labour. Meanwhile, foreign MNCs also provided opportunities for local firms to accumulate technology and sparked off the growth in electronics. Foreign firms hired and trained local engineers in their subsidiaries, and many Taiwanese technicians eventually left foreign MNCs then found their own business to supply market niches and services, sometimes to their former employers (Ernst, 2000). Through the 1980s, local engineers trained in foreign firms became a direct source of technology. Foreign firms also acted as demonstrators for local firms to imitate, and some local firms gained direct access to training and engineering support under joint ventures, such as Tatung (Hobday, 1995). FDI, therefore, laid the groundwork for the electronics industry in Taiwan and further led to subcontracting and OEM operations into the 1980s.

The role of FDI, however, started to decline after the 1980s, mainly due to the currency appreciation as well as continuously rising local wages. Many foreign firms suspended their production in Taiwan and shifted to other Asian countries, such as Malaysia, Philippines and particularly the Mainland China for its cheaper labour. As Amsden and Chu (2003: 64) suggest, "the opportunity costs for foreign enterprises of investing directly in Taiwan became too high as the skills of national firms rose". Consequently, the foreign firms lacked the motivation to undertake further improvements or upgrading of their operations in Taiwan, and this led to the exit of many foreign MNCs. The declining role of FDI was extremely striking in the electronics industry. In the early 1980s, foreign MNCs took the lead in the production of computer hardware and foreign subsidiaries accounted for around 44% of the value of Taiwan's computer production in 1986. However, in 1990 foreign subsidiaries accounted for less than 30% of the value of Taiwan's computer production, while local Taiwanese companies accounted for 70% of computer hardware production (Dedrick and Kraemer, 1998).

As the local firms grew in stature and capability, the share of FDI in exports of electronics fell sharply after 1975 (Table 3.6). In 1975, foreign firms accounted for over 80 % of the electronic industry's export and its share dropped to only 8 % in 1995. The disinvestments of foreign firms from Taiwan's electronics sector, however, did not indicate less influence of the foreign MNCs. As Amsden and Chu (2003) observe, foreign firms shifted the mode of their operations in Taiwan from FDI to subcontracting and OEM arrangements. Thus Foreign MNCs still transferred technology to local firms through those arrangements and linked them into large foreign markets.

**Table 3.6: Share of foreign-owned firms in exports, by industry, 1975~1998 (%)**

| | 1975 | 1985 | 1991 | 1995 | 1998 |
|---|---|---|---|---|---|
| Food | 1.5 | 2.6 | 9.3 | 2.4 | 7.1 |
| Textiles | 25.9 | 7.3 | 3.0 | 6.9 | 3.7 |
| Minerals | 13.3 | 3.7 | 8.9 | 26.3 | 9.0 |
| Metals | 10.7 | 5.1 | 5.6 | 4.6 | 1.5 |
| Machinery | 22.7 | 13.6 | 7.8 | 12.1 | 10 |
| Electronics | 81.9 | 35.7 | 18.4 | 8.1 | 7.9 |
| Other | 9.1 | 3.5 | 5.4 | 10 | 5.1 |
| Total Industry | 19.7 | 10.4 | 8.5 | 7.8 | 7.7 |

Data source: Taiwan, MOEA (various years), Amsden and Chu , 2003

By the late 1980s, local wages had risen markedly and many foreign MNCs ceased their operations in Taiwan. Firms, such as RCA (Taiwan) Ltd and Zenith Taiwan Corporation, who were ranked among the top ten foreign companies in Taiwan for many years, ceased their operations in the early 1990s. Among Japanese firms, Dashen Electronic, which was a subsidiary of Mitsubishi Electric, and Orion Electric (Taiwan) discontinued their production in Taiwan, while Funai Electric of Taiwan announced a shift of its major production base to China in the late 1980s (Sato, 1997; Amsden and Chu, 2003).

While many MNCs exited, some local firms seized the opportunities to expand by taking over the skilled labour and factory space left by the foreign firms. For example, the Yageo Corp acquired two of Phillips' plants that made passive components; Inventec, which later become one of the major notebook computer manufacturers in Taiwan, bought the Taiwan subsidiary of DEC when Compaq acquired US-based DEC. Acer acquired Hitachi's TV plant and TSMC acquired ASMI which was a joint venture between Texas Instrument and Acer to manufacture semiconductors (Amsden and Chu, 2003).

From the description above, it can be observed that foreign multinational firms used to exert great influence on the development of Taiwan's electronics industry at the early stage, specifically through FDI and joint ventures, and helped indigenous firms to improve their technological capabilities. Over time, the role of foreign multinational firms declined as the local firms have accumulated their own technological capabilities with technical assistance from the national research institutes and grown to compete with MNCs in the global market. As a result, Taiwan's electronics industry is now largely driven by local firms who have earned the label 'latecomer firms' which are the most important and innovative firms in the electronics industry and three example of Taiwanese latecomer firms will be discussed in the next two chapters.

# CHAPTER 4:
# LATECOMER FIRMS: THE CASE STUDY OF TAIWAN SEMICONDUCTOR MANUFACTURING COMPANY

This chapter focuses on the technological transfer and learning processes in Taiwan's electronics industry from the perspective of the leading latecomer firm, namely Taiwan Semiconductor Manufacturing Company (TSMC). The next chapter focuses on two other important latecomer firms, Chunghwa Pictures Tubes (CPT) and Kinpo Electronics. Each of these three main case studies are all latecomer firms and in the same broadly based business segment classified as locally based 'large firms'(chapter two). They provide key insights into the evolving division of labour within Taiwan's electronics industries (chapter three). Each firm also reveals interesting differences in corporate origins and processes of technological learning, as well as in product mix. TSMC is the biggest and best known electronics firm within Taiwan and beyond. The analysis draws from interviews conducted with Mr. Feng Wei-Zhong who is the General Secretary in Human Resource department of TSMC in 2003, and interview with a key supplier company, Topco, and secondary data sources, such as annual reports.

The chapter is divided into three main sections that examine the evolution of TSMC's technological capability in a progressively focused way. The first section documents the overall evolution of TSMC, beginning with its unusual creation as a large firm from the start through the abilities of a dominant entrepreneur, Dr. Morris Chang. Dr. Chang had considerable technological expertise in the electronics industry and was able to negotiate effectively strong connections with the Taiwanese government and MNCs as a basis for TSMC's emergence as a global as well as a local leader. The second section outlines how TSMC developed its technological capabilities since its establishment, especially through its connection with its powerful customers, mainly foreign MNCs, and in relation to key local suppliers such as Topco. Finally, the internal development of its enterprise specific skills (ESS) is outlined, providing a direct expression of Taiwan's division of labour.

## 4.1 Overview and Origins of TSMC: The Pioneering IC Foundry Firm in the World

Taiwan Semiconductor Manufacturing Company Ltd. (TSMC) was launched in 1987 as a joint venture between Philips Electronics N.V. and the Taiwanese Government. In particular, the Electronics Research & Service organisation (ERSO) of Industrial Technology Research Institute (ITRI), which is the major governmental research institute in Taiwan, arranged with Philips to transfer static random access memory (SRAM) technology used by TSMC at its start-up. TSMC is now one of the biggest integrated circuit (IC) foundry firms in the world with more than 15,000 employees in 2003. TSMC is managed in an "owner hands-on" way by Dr. Morris Chang, the founding entrepreneur spirited the company.

### 4.1.1 Origins of TSMC

TSMC was established as the world's first dedicated IC foundry firm (i.e. a firm with wafer fabrication but no design capabilities) that aimed to produce specialised circuits for local design firms. Dr. Morris Chang, the current chairman and CEO of TSMC came up with the idea of the 'pure play' IC foundry while he was the president of ITRI in 1985.

Born in mainland China and educated in the U.S., Chang is credited with creating Taiwan's semiconductor industry. Chang earned his B.S. and M.S. degrees in Mechanical Engineering from the Massachusetts Institute of Technology in 1952 and 1953, and a Ph.D. in Electrical Engineering from Stanford University in 1964. Prior to his career in Taiwan, Chang was employed in the United States. He had wide experience in the global semiconductor industry, heading up Texas Instruments' global semiconductor operations while being the Group Vice President at Texas Instruments from 1958 to 1983. He was subsequently the President of General Instruments (GI) from 1984 to1985 (TSMC, 2003). From there Chang was recruited as the new president of ITRI by the former Taiwanese Premier Yu and former ITRI president Dr. Xu in 1985. Chang was first contacted by the former premier Yu to join the national advisory boards of technology development as well as the president of ITRI in 1981, but Chang chose to remain in Texas Instruments at that time. Over the next few years, Chang was constantly in contact with the former

Premier Yu and former ITRI president Dr. Xu. In 1985, Chang finally decided to return to Taiwan and take over the position as president of ITRI (Hong, 2003). Chang's experience in the semiconductor industry and connections with big foreign MNCs proved to be a peculiar asset for TSMC. Chang has been a decisive influence in developing TSMC as one of the largest silicon foundry firms in the world. Selected by Time Magazine and CNN in 2001 as one of the Top 26 Most Influential CEOs, Chang was also the 2000 recipient of the IEEE Robert N. Noyce Award for exceptional contributions to the microelectronics industry. He is currently a member of the MIT Corporation and the USA National Academy of Engineering, and is on the advisory boards of the New York Stock Exchange, Stanford University, and the University of California at Berkeley (TSMC, 2003).

After becoming ITRI's third president in 1985, Chang introduced the concept of a 'pure-play silicon foundry' (i.e. a dedicated IC foundry firm which only engages in wafer fabrication) that operated VLSI (very large scale integration) process technology to manufacture chips for small Taiwanese firms and international clients (Hong, 2003). At the same time, Chang was invited by the government to propose a new spin-off venture from ERSO that would take Taiwan into the VLSI era in the semiconductor industry. Chang suggested that there was a potential market for a full-time silicon foundry due to the costs of establishing wafer fabrication facilities (fabs) which he predicted would continue to rise (According to TSMC's annual report in 2002, the firm planned to invest NT$77.6 billion on its new Fab 14 factory). Thus, in addition to pioneering the idea of a 'dedicated silicon foundry' for TSMC's start-up, he proposed to transform the VLSI lab factory in ITRI into TSMC's private sector domain as well. This firm, he suggested, could achieve economies of scale by manufacturing for both foreign and local semiconductor firms (under the OEM arrangement). Moreover, this venture could provide fabrication facilities for Taiwan's small chip design firms in Taiwan that could not afford to build the chips themselves. Chang conceived that it was necessary to set up a "large firm" which was capable of advanced technology development on its own, and thus Chang convinced the Taiwanese government to make a large-scale investment, around US$200 million dollars, in the development of TSMC in 1987 (Hong, 2003; ITRI, 2000).

Although this innovative proposal was accepted by the government on ITRI's recommendation, the source of capital for such a large project – the cost of which was US $200 million – remained a great challenge. The great amount of investment was partly due to Chang's insistence on setting up a large firm because he suggested that SMEs lack the resources and capability to develop the core competence technology. The former Premier Yu stipulated that the sponsors for this spin-off firm should include a foreign MNC whose involvement would give the project greater credibility and increase the possibility to transfer more advanced technology. Chang then started to canvass support among his international business contacts and previous colleagues, but the radical proposal did not receive a strongly positive response in spite of Chang's great reputation in the US semiconductor industry (Hong, 2003).

Initial interest was expressed by four foreign firms: Texas Instruments (Chang's previous firm), Intel, Matsushita and Philips. In the end, only Philips was a serious candidate for the new venture. Aside from its US$40 million investment, Philips consented to transfer its more advanced VLSI technology to the new venture providing Philips with substantial equity in the venture (Mathews and Cho, 2000; Hong, 2003). Later, a group of Taiwanese firms were persuaded to make up the balance of the investment. Thus TSMC was finally established in 1987 mainly with governmental funding support (Development Fund of the Executive Yuan) and with Philips as its leading equity holder. Under the equity agreement, Philips agreed to transfer technology to the new company, as well as its own portfolio of cross-licensing agreements. These proved to be a valuable asset for the new venture since they made it exempt from many intellectual property disputes that pestered most fledgling semiconductor firms in Taiwan (Mathews and Cho, 2000; ITRI, 2000).

### 4.1.2 Production bases and plants

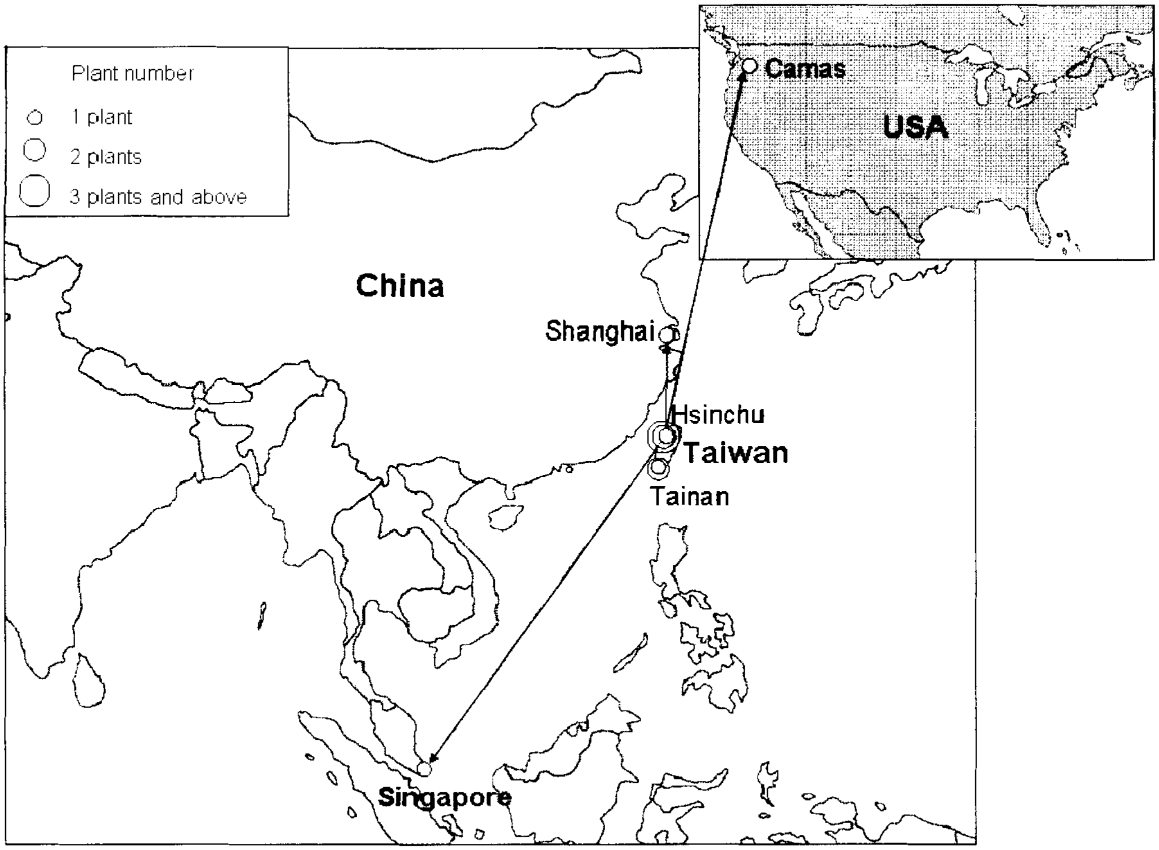
Since its establishment, TSMC has grown rapidly both regarding its manufacturing capacity and annual sales (Table 4.1). By 2003, TSMC had eight plants in Taiwan, including one 6-inch wafer fab factory (at Fab 2, the first generation wafer foundry), five 8-inch fab foundry plants (at Fab 3,5,6,7 and 8), and two foundry plants for the latest 12-inch wafer (300mm) fab foundry (Fab 12 and 14). Additionally, the company has capacity commitments in its subsidiary Wafer Tech in Washington, United States, its affiliate VIS (Vanguard International Semiconductor Corporation) in Taiwan, and a joint venture with Philips Semiconductor under the name of SSMC (Systems on Silicon Manufacturing Company) in Singapore. After receiving permission from the Taiwanese government, TSMC also established an 8-inch fab in Shanghai, China under its subsidiary, TSMC Shanghai in 2003 (see Table 4.1 and Figure 4.1).

**Table 4.1: The location and establishment of TSMC's plants**

| Plant | Establishment date | Location | Capacity | Note |
|---|---|---|---|---|
| Fab 2 | 1990 | Hsinchu Science Park | 6-inch wafer fab | |
| VIS (Vanguard International Semiconductor Corporation) | 1994 | Hsinchu Science Park | 8-inch wafer fab | - A spin-off firm from ITRI.<br>- Chan is VIS's chairman and TSMC has been the biggest stockholder of the firm |
| Fab 3 | 1995 | Hsinchu Science Park | 8-inch wafer fab | |
| Fab 5 | 1997 | Hsinchu Science Park | 8-inch wafer fab | |
| Wafer Tech | 1998 | Camas, Washington, USA | 8-inch wafer fab | |
| Fab 6 | 2000 | Tainan, Taiwan | 8-inch wafer fab | |
| Fab 7 | 2000 | Hsinchu Science Park | 8-inch wafer fab | |
| Fab 8 | 2001 | Hsinchu Science Park | 8-inch wafer fab | WSMC merged |
| Fab 12 | 2001 | Hsinchu Science Park | 12-inch wafer fab | |
| SSMC | 2001 | Singapore | 8-inch wafer | TSMC & Philips jointly set up SSMC |
| Fab 10 | 2003 | Shanghai, China | 8-inch wafer fab | TSMC's subsidiary in Shanghai |
| Fab 14 | 2003 | Tainan, Taiwan | 12-inch wafer fab | |

Data source: TSMC annual reports (various years)

**Figure 4.1: Geographical distribution of TSMC's plants**



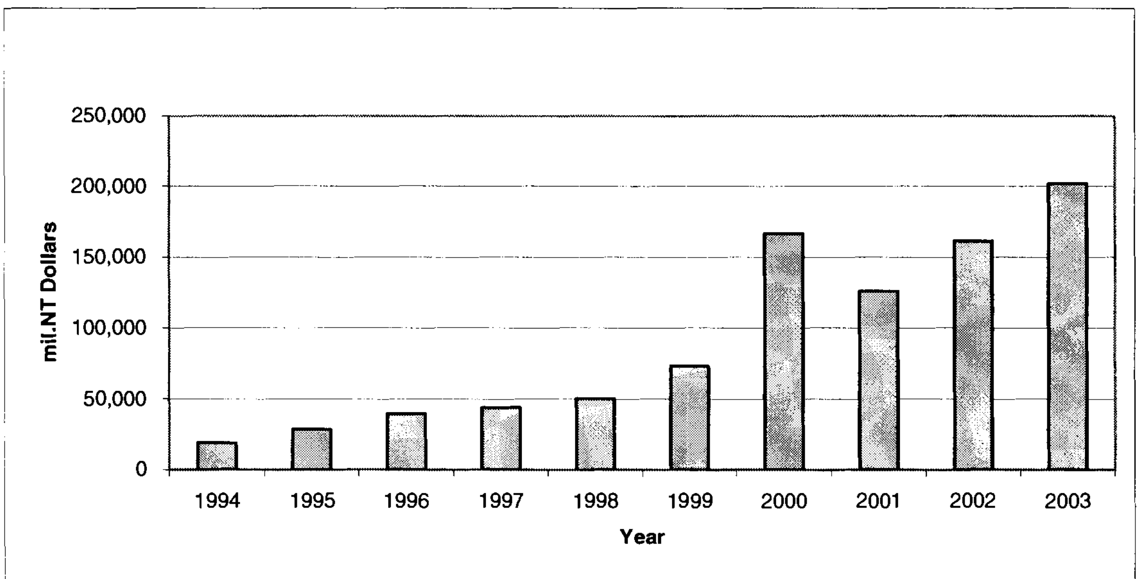

Data source: TSMC annual report, 2003

As of 2003, TSMC's major production base remained in Taiwan, more specifically, the Hsinchu Science Park. TSMC located its headquarters and six foundry plants in the Hsinchu Park, while having only two plants in Tainan Science Park. Since 1997, TSMC has pursued significant expansion by establishing nine factories within six years (1997-2003) as well as a substantial progress on its foundry technology from 6-inch wafer to 12-inch wafer. TSMC was one of the few semiconductor firms in the world to commence starting mass production of the new 12-inch fab in 2002. While capable of manufacturing the latest wafer fab, TSMC also possesses a great capacity of 8-inch fab which remained the mainstream in the market in 2003.

### 4.1.3 Annual sales

TSMC's continuous expansion has been sustained by rapidly growing sales. After the Asian financial crisis in 1997, TSMC's annual sales increased in and even soared to NT$ 166 billion by 2000. The 1997 Asian financial crisis also gave TSMC an opportunity to expand its business globally and raised its market share while some major semiconductor firms from Japan and South Korea suffered from domestic recession and unable or unwilling to continue increasing investment on production facilities during that period. In 2000 its annual sales dropped to NT$125 billion as a result of the global economic recession and the oversupply of semiconductor wafers. However, TSMC soon recovered from the depression and its annual sales reached another peak, at NT$ 201 billion at 2003 (TSMC, 2003; also see Figure 4.2).

**Figure 4.2: Annual net revenue of TSMC, 1994~2003**




Data Source: TSMC annual report (various years)

During its initial stage, TSMC's specific operation mode, namely a 'pure-play' foundry firm, was considered a venturous move by many semiconductor firms, both local and foreign, as well as by the Taiwanese government. Yet this risky investment proves to be a successful model with its booming business and increasing annual sales (see Figure 4.2).

**Table 4.2: TSMC: geographic distribution of sales, 2000-2001**

| | Area | 2000 | 2001 |
|---|---|---|---|
| Export | North America | 48.27 % | 49.7 % |
| | Europe | 25.36 % | 18.57 % |
| | Asia | 6.71 % | 5.85 % |
| | Total | 80.34 % | 74.12 % |
| Import | Taiwan | 19.66 % | 25.88 % |

Data source: TSMC annual reports (various years)

Under the joint venture with Philips, TSMC not only gained access to its advanced technology but was exempt from many intellectual property disputes. Under this protectorate, TSMC was able to carve out its export market in Europe and North America without paying considerable licensing fees at its inception. Although the domestic market has grown in the past few years, more than 70 % of TSMC's semiconductor waffles are for export, specifically the North America market which accounted for almost half of the annual sales in 2001 ( Table 4.2).

## 4.2 The Acquisition of TSMC's Technological Capabilities

Since its establishment, TSMC has regularly upgraded its technological capabilities through different means. In particular, TSMC has developed its technological capabilities through cooperative R&D with the ITRI, Philips and other foreign firms, and by investment in-house R&D.

### 4.2.1 Cooperative research with ITRI

At the beginning, TSMC had both local and foreign sources of advanced technology, the ITRI and Philips. TSMC originated from a VLSI (very large-scale integrated circuit) research project (1983-1988) funded by ITRI, and most resources involved in the VLSI project including engineers, equipment and process technology were transferred to the company after its establishment. As the spin-off firm of ITRI, TSMC has maintained a close relationship with ITRI for advanced technology projects. At its initial stage, ITRI was the incubator for TSMC, providing the equipment, a skilled workforce and access to advanced technology. Before its first wafer foundry factory came into actual operation, TSMC was approved to rent the VLSI fab from ITRI/ERSO. There was around 200 staff of ERSO, mostly engineers who joined the new company after training from Philips in Holland (Hobday, 1995). Those experienced engineers then became the backbone of the firm and created an unofficial bond between the employees in ITRI and TSMC. Moreover, TSMC was funded by ITRI to continue the VLSI project until 1991 under the cooperative arrangement. At least until 2003, TSMC has maintained a long-term technology cooperation agreement with ITRI which began in 1987.

TSMC is not the first spin-off firm of ITRI but is definitely the most well-known and successful one. Following TSMC, ITRI also established several firms in accordance with the same track as the TSMC. Nevertheless, none of the other spin-off firms could surpass TSMC both in business scale and in achievement. TSMC is a landmark for ITRI as well as the semiconductor industry in Taiwan.

### 4.2.2 The role of Philips and other foreign firms (customers)

Philips was a major source of advanced technology for TSMC in its early stage. Being TSMC's biggest stockholder, Philips agreed to transfer its 2-micron and 1.5-micron VLSI wafer-fabrication process technology at no charge under the equity agreement and in exchange for access to TSMC's foundry service. Philips accounted for a great portion of TSMC's initial competence since Philips possessed more advanced fabrication technology than ITRI/ERSO in 1987 (Mathew and Cho, 2000). Under the equity agreement, TSMC was authorised to use Philips' patents by paying a percentage of its net sales. Additionally, TSMC was empowered to use patents from some foreign MNCs such as IBM, Intel, and Toshiba through Philips's cross-licensing arrangements (Wu, 2001:137). Aside from offering a training programme and advanced technology in the beginning, Philips adopted a technology cooperation agreement with TSMC which later became a mutually beneficial relationship.

In addition to its role being TSMC's major stockholder, Philips has been one of TSMC's main customers. Thus it has also helped TSMC for the sake of its own products. While Philips demanded a certain (1.2-micron) processing technology for its chips, it transferred its chip specifications to help TSMC upgrade (Mathew and Cho, 2000). With its peculiar strategy to focus on chip manufacturing, TSMC soon caught up with Philips in the wafer fabrication technology. According to Mathew and Cho (2000), by the time TSMC was able to shift to 0.8-micron process technology; it was no longer dependent on technology transfers from Philips. TSMC even achieved a better yield performance than Philips in the early 1990s and assisted Philips in improving its yield management for IC foundry (Hong, 2003).

Since then, TSMC has turned to other foreign firms and relied on specification transfers from its customers as a main source to upgrade its technology and expand its foundry capabilities into a broad range of products. In particular, TSMC formed stable relationships with leading USA and Japanese IC firms within 'partnership' arrangements, through which they received favoured customer access to the foundry, in exchange for the transfer of more advanced process technology. These partnerships soon proved an effective and powerful technique for TSMC to enhance its technological capabilities. The partnerships involved leading US firms, such as Advanced Micro Devices (AMD) and Japanese firms, such as NEC and Fujitsu. TSMC and AMD reached an agreement in 1994, under which AMD was able to double its production capacity for its Am486 microprocessors through TSMC's foundry, in return for transferring 0.5-micron processor technology to TSMC (Mathew and Cho, 2000). TSMC later made similar agreements with NEC and Fijitsu of Japan. Both Japanese firms agreed to transfer the necessary process technology to TSMC, while TSMC offered them with guaranteed foundry capacity for their products. In this way, TSMC gradually accumulated its own technological capability and attracted more customers with its ability to offer an astonishingly broad range of process technologies. TSMC soon became a leading IC foundry company and possessed more advanced IC process technology which in turn became the main source of its revenue. In 2003 there were approximately 62 % of TSMC's revenues generated from its state-of-the-art 0.18 um-and-below manufacturing processes while the market mainstream technology remained at 0.25-0.18 um.

Being a "pure-play" foundry firm, TSMC did not have its own product. Instead, it offered foundry service to its customers. In other words, it was a supplier instead of a competitor to its customers.

As the manager of TSMC noted:

> We don't really have our own products; products were made based on our customer's demand. TSMC basically provide the foundry service and practical suggestions for products requested by our customers based on our experiences. That is to say, we don't just help our customers to manufacture but also improve their products with our progressing technology. (Interview conducted with Mr. Feng Wei-Zhong, the General Secretary in Human Resource department of TSMC, Oct 03, 2003)

Thus TSMC developed a mutually beneficial relationship with its customers, especially regarding the technology transfer by offering foundry service in exchange for chip technology. Consequently, TSMC was able to rapidly move towards more advanced technology, becoming less dependent on these customers.

TSMC's peculiar strategy as a chip supplier for its customers enabled TSMC to increase both economies of scale and scope in chip manufacturing, production and innovation. As the firm expanded, TSMC became the major chip subcontractor of many semiconductor firms, including those firms which have their own chip foundry factory. Thus TSMC is able to drive down the costs of chip manufacturing while increasing its products range. Because each customer has different product specification, TSMC also realized economies of scope in its production (of end-products) and related innovation, which enabled TSMC to be master of various chips process technologies. In this way, TSMC became more indispensable to its customers.

In a conference held in Taipei in 2004, chairman Chang stated that "TSMC was pursuing a 'customer-partnership' business model to deal with the challenges of rising costs (of semiconductor manufacturing)" (Taipei Times, 2004). Chang believes that there is a strong tendency toward the disintegration of the global semiconductor industry mainly as a result of the rising costs of chip manufacturing, and he suggests that it is important for semiconductor firms to form strong partnerships. According to Chang, in 2004 'a state-of-the-art chip factory alone can cost up to NT$ 100 billion (US$ 3 billion)', and it will cost an estimated US$ 1 billion for TSMC to develop the latest chip production technology, which is twice as much as the previous generation of technology (Taipei Times, 2004). Consequently, Chang believed that it was inevitable for chip firms to form strong partnerships with other semiconductor firms to survive the highly competitive market.

Aside from continually advancing its technological capability, TSMC started to expand its service capabilities gradually in order to maintain its leading role as an IC foundry firm while facing new competition from new entrants in the contract chip business, such as Semiconductor Manufacturing International Corp from China. As the chip design houses (design firms), which made up about two-thirds of TSMC's customers, work with more than one contract chipmaker, it was a challenge for TSMC to make itself indispensable for its customers in order to secure future contracts with its customers. To strengthen its relationship with customers, TSMC has begun to offer its customers in-house design services since the late 1990s. More accurately, TSMC helped customers with the IC design work by improving customer design or offering practical suggestions.

Although TSMC no longer depended on its customers for more advanced process technology, it continued to work closely with them. To ensure that customer's demands were adequately addressed, TSMC conducted regular reviews meeting through the whole production process. TSMC engineers have drawn up improvement plans based on feedback from their customers. Moreover, TSMC assisted its clients to streamline their advanced process designs by providing tested solution to various design issues, which helped customers to cut costs and increase productivity before products went into production, and this in turn reduced the time to achieve "yield maturity" for new products (TSMC annual report 2003).

As the manager of TSMC noted:

> Since we are manufacturing IC for our customers based on their demand (proprietary designs), both our engineers and R&D group will be involved to the regular meeting with our clients to control the product quality. We now also offer the design service to help some clients with their product improvement.

Working closely with its customers also helped TSMC to detect potential problems regarding IC manufacturing. As noted, most of TSMC's customers are IC design houses which have a great reliance on TSMC for its IC foundry service and lack the ability to do IC manufacturing themselves. Indeed, their design plans are often impractical. Therefore, TSMC has assisted its clients to solve the design problems and improve the product based on the original design through regular meetings. While customers have obtained a troubleshooting plan based on their design flaws, they also provided the engineers in TSMC more ideas on process technology improvement.

> We aim to improve the IC manufacturing process, and that is the priority of our R&D. Sometimes we also play the role as consultants for our customers regarding their new products. For example, sometimes customers would show us their new product design and our engineers would study the feasibility of the new product and offer our customers suggestions to modify or even better the product design.

In order to react timely to variations in demand from customers, TSMC established strong and mutually beneficial relationships with key process machine and materials vendors, which have enabled TSMC to perceive new solutions and master the new process technology ahead of most IC foundry firms. TSMC engineers have maintained a routine meeting with equipment suppliers to review the machine and update the troubleshooting scheme; the frequency of the review meeting would depend on the condition of each machine. Consequently, the firm is able to attract more customers with its advanced technological capability.

### 4.2.3 The role of a local supplier firm – Topco

Aside from the foreign firms, local suppliers have also been another source of technology learning for TSMC. An important case is Topco, which launched in 1990 and is one of the main importers for machinery and materials in Taiwan. Topco is one of TSMC's major supplier firms for wafers and other materials. Topco started by importing semiconductor materials (wafers) from the Japanese Shin-Etsu Co. and as its solo agency in Taiwan. Shin-Etsu Handotai Co. Ltd (S.E.H) is a subsidiary of Shin-Etsu Chemical Company in Japan and is mainly involved in the production and sale of semiconductor silicon (*Handotai* is Japanese for semiconductor). S.E.H is the world's largest silicon wafer manufacturer with a global market share of over 30% in 2003 (Topco, 2003).

Topco is the sole agency of Shin-Etsu, and this enabled the company to grow rapidly at its initial stage during the early 1990s. Topco soon began to expand its business by importing different machineries and materials from foreign firms. Following 1995, Topco built up an extensive (import) product range and became a major supplier for many Taiwanese electronics firms, including TSMC (Topco, 2003)

TSMC itself has tried to reduce its reliability on any single supplier and procured materials from multiple suppliers to reinforce risk management and to ensure adequate material supplies for volume manufacturing. TSMC has also maintained competitive price and service agreements with its suppliers, including collaborative agreements with its key suppliers. Due to S.E.H's stable product quality, S.E.H has been one of the major wafer suppliers, and thus Topco has been able to maintain a close relationship with TSMC. In 1999, Topco accounted for 17.42% of TSMC's annual replenishment for wafers and other materials and was the lead local supplier for TSMC (TSMC, 2000).

Technically, Topco itself has not been considered as a 'supplier' but rather a liaison company between Shin-Etsu in Japan and TSMC in Taiwan. Whereas Topco has provided its customers with customised service regarding both products and technical support, the firm has tried to add value by offering comprehensive service and increasing its product range to serve its customers. On the other hand, Topco has also taken advantage of its peculiar position to gradually accumulate its own technological capabilities by transfer technology from foreign firms that have supply relations with Topco. For Topco, the technology transfer from the foreign firms involves the transfer of physical goods, such as capital goods in the form of machinery and equipment as well as the transfer of tacit knowledge, such as vital know-how and technical skills. After the purchase of machinery and equipment, foreign firms have sent their engineers to Taiwan to offer technological assistance and have assisted Topco with the training of local staff. Thus Topco has benefited through this agent relations.

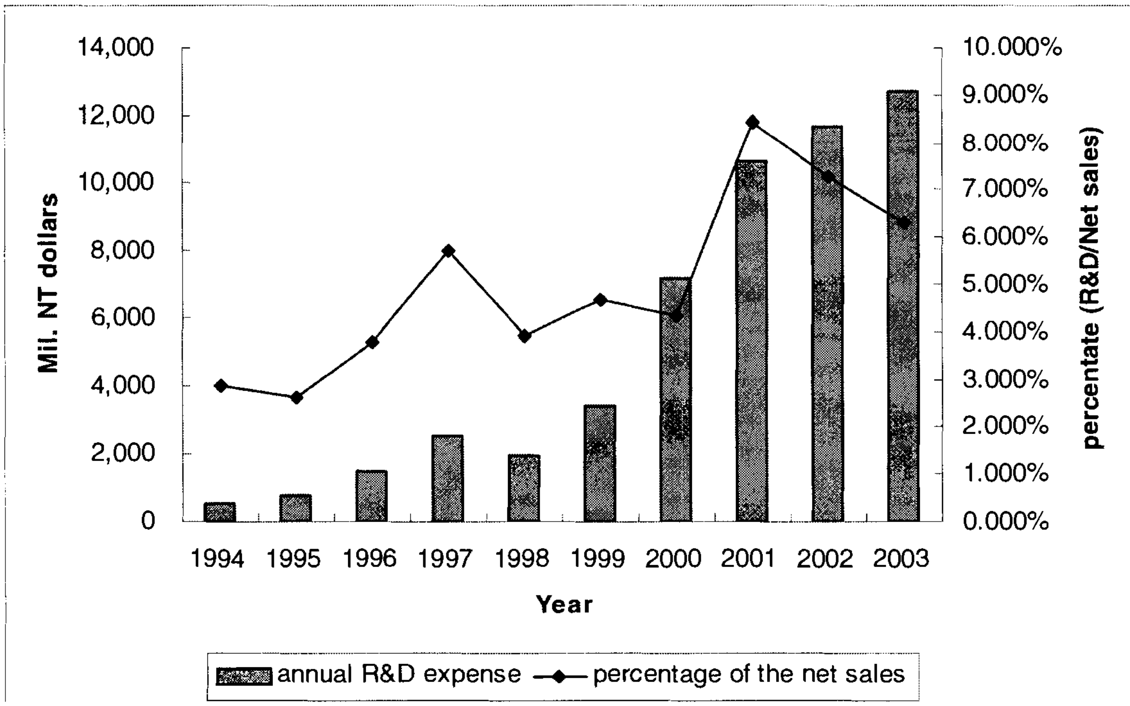
As TSMC mainly relies on foreign suppliers, such as Sumitomo, S.E.H and Wacker Co., for raw material and equipments, the case of Topco manifest the specific role of local firms in the context of the RSS (chapter two). Since Topco provided TSMC with materials and equipments which it imports from foreign firms, it seems that Topco rudely falls into the category of the 'catalogue goods suppliers' which according to Patchell and Hayter (1994: 348) "represents 'off the shelf purchase' of goods about which the core firm have virtually no know-how". Although Topco rarely has its own products, the firm has played a vital role regarding the market procurement of necessary materials as well as new equipment at the early stage. Thus the firm has acquired know-how with respect to important products, mainly equipment, which it purchased from foreign firms, and transfer related information to local firms that it served. Over time, acting as a medium of information exchange between its foreign suppliers and local buyers, Topco has accumulated a certain level of technological know-how during this process. Thus Topco transformed itself from a merely importer to a veritable 'catalogue goods suppliers', and has been cable of doing maintenance of the equipments that it sold to its local customers, and in some cases offering its customers information about new equipment which might improve their production efficiency (Topco, 2003).

In all, TSMC and Topco have developed RSS with each other based on the benefits which they receive from their relationship. As Topco has helped TSMC to obtain high quality products that fit its requirement as well as to assure the product quality, Topco has then acquired technological capabilities to a considerable degree during this process. Moreover, the close relationship allows Topco to secure continued order from TSMC (Topco, 2003).

### 4.2.4 In-house R&D

Abiding by its primary strategy of being a dedicated IC foundry firm, TSMC has retained its particular position within the industry as a foundry-only firm and gradually accumulated its own technological capabilities from its customers. Simultaneously, TSMC's own internal learning has progressed by means of increasing investment in its own R&D (Figure 4.3). TSMC allotted a certain amount from its increasing net revenues to invest in in-house R&D. Figure 4.3 shows that TSMC has continuously increased its R&D investment. In fact, its R&D expenses has accounted for more than 6% of its annual net sales since 2001. In 2003 its R&D expenditure increased by 11% to NT$ 12.7 billion.

**Figure 4.3: The R&D expense of TSMC and its percentage of net sales (1994~2003)**




Data Source: TSMC annual reports (various years)

Unlike most local electronic manufacturers in Taiwan, TSMC has made great efforts to develop its own technology since it became independent from ITRI/ERSO. This development was stimulated by Chang's idea of the need for large firm to 'develop core competence' (Hong, 2003).

TSMC has moved substantially toward its goal of developing its own technological capabilities, as indicated by the increasing number of its own patents. With respect to all patents granted by the United States, Table 4.3 shows the remarkable growth rate of the US patents granted to TSMC in the last decade, specifically compared to ITRI. Before 1995, TSMC only accounted for approximately 1% of all US patents granted to Taiwan but this share has grown, reaching 9.8% in 2001. TSMC now possesses many patents on IC foundry process technology. In 2003 the firm was awarded 431 US patents and 552 ROC (Taiwan) patents. Most patents are aimed at IC manufacturing process improvement.

**Table 4.3: US patents granted to Taiwan, ITRI and TSMC (1990~2003)**

| Source country and organisation | Pre 1990 | 1990 ~1992 | 1993 ~1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Taiwan | 2,341 | 2,639 | 4,252 | 1,897 | 2,057 | 3,100 | 3,693 | 4,667 | 5,371 | 5,431 | 5,298 |
| ITRI | 55 | 133 | 366 | 110 | 153 | 218 | 208 | 198 | 221 | 217 | 207 |
| TSMC | 1 | 9 | 45 | 74 | 130 | 218 | 290 | 385 | 529 | 448 | 431 |
| TSMC /Taiwan | 0% | 0.3% | 1.0% | 3.9% | 6.3% | 7.0% | 7.9% | 8.2% | 9.8% | 8.2% | 8.1% |

Data source: US patents and trademark office 2003

In 2003 TSMC set up its R&D centre, TSMC Academy, within its headquarters located at the Hsinchu Science Park. This centre aims to "extend Moore's law[1] by innovative work internally as well as by working together with industry leaders and academic in finding cost-effective solutions" (TSMC annual report, 2003). TSMC also has set up an auxiliary R&D centre in the Tainan Science Park along with its Fab 6 plant located at south Taiwan. There is no precise data with respect to the number of TSMC's R&D staff. However, TSMC has increased its processing and R&D staff by 12 % in 2002 and over 7.5 % in 2003, and the personnel engaged in exploratory technologies increased three-fold in order to strengthen long-term R&D focus (TSMC annual reports, various years).

## 4.3 Internal Learning-the Formation of ESS (Enterprise Specific Skill)

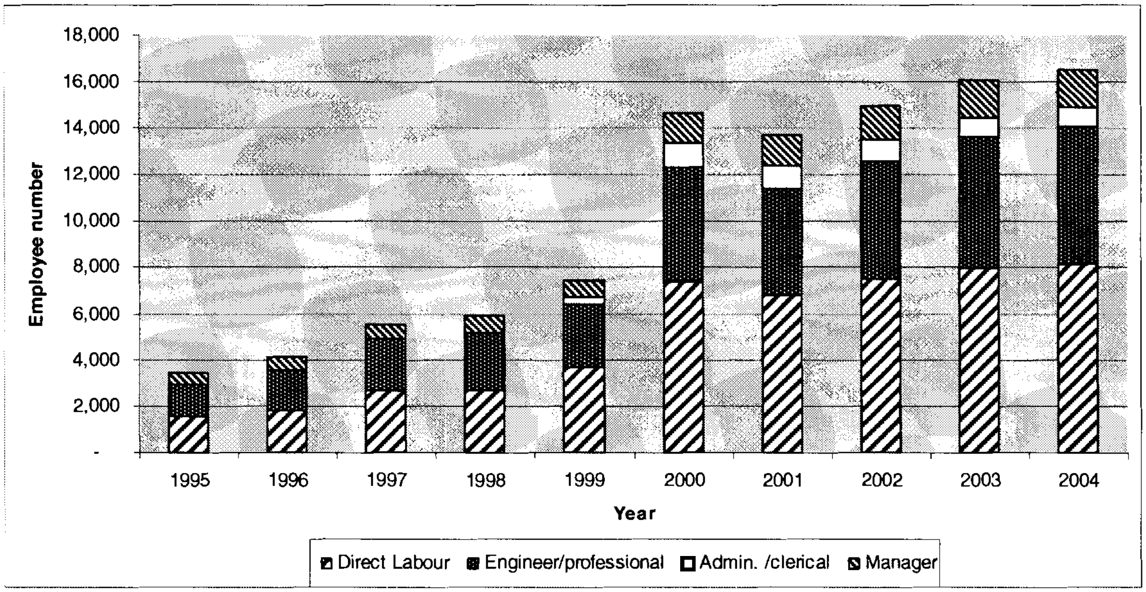
### 4.3.1 Labour force structure

TSMC started with around 800 employees in 1987 and grew to become one of the largest MNCs in Taiwan, with more than 16,000 employees globally at 2003. TSMC now has eight IC foundry factories in Taiwan, and the segment of direct labour (production

[1] The famous observation made in 1965 by Gordon Moore, co-founder of Intel that the number of transistors per square inch on integrated circuits had doubled every year. In his original paper, Moore observed this exponential growth in the number of transistors per integrated circuit and predicted that this trend would continue for the near future. The press called it "Moore's Law" and the name has stuck. In subsequent years, the pace slowed down a bit, but data density has doubled approximately every 18 months, and this is the current definition of Moore's Law. Many IC firms have been trying to break down barriers to Moore's Law, meanwhile, most experts, including Moore himself, expect Moore's Law to hold for at least another decade (Intel, 2004; Jupitermedia Co., 2004).

workers) accounted for around half of the total staff since 1995 while the employee number kept increasing for the past decades.

**Figure 4.4: The labour force of TSMC**




Data Source: TSMC annual reports (various years)

Figure 4.4 demonstrates a sustained stability in its main labour segments. The number of direct labour (production workers) has accounted for about 46% to 50% of total employees since the outset while the percentage of engineers has been about 33% to 35% of total staff.

Generally, TSMC's staff is well educated: 2.5% of employees hold PhD's, 26.3% Masters, 40.8% university and college degrees, and 30.4% are high school graduates in 2003 (Table 4.4). For new production workers, high-school education level is a basic condition and working experience is not required. However, the average number of years of school education reached by production workers has been rising for the past few years. The main reason underlying this trend is not because of any changing requirement from the firm itself or any new technology that would demand more educational blue-collar workers; it was due to the rising education level in Taiwan for the past few years. In 2002, university and (junior) college graduates in Taiwan reached 296,884 in number, representing an increase of 33.9% from 1997. In 2003, the portion of employees in

TSMC who are only high school graduated is down to 30.4% from 40.6% in 1997. However, "the higher educational background doesn't guarantee better skilled capability" (TSMC interview). Even the average educational level of TSMC's production workers has been rising; the workers themselves are not expected to perform more skilled jobs.

**Table 4.4: TSMC personnel structure by job title and education level**

| | | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 |
|---|---|---|---|---|---|---|---|---|
| Total employees | | 5,593 | 5,908 | 7,460 | 14,622 | 13,669 | 14,938 | 16,066 |
| Manager | | 681 | 730 | 704 | 1,249 | 1,286 | 1,465 | 1,627 |
| Engineer/Professional | | 2,200 | 2,467 | 2,765 | 4,950 | 4,600 | 5,077 | 5,697 |
| Assistant Engineer/Clerical | | - | - | 316 | 1,063 | 982 | 914 | 816 |
| Direct labour/Technician | | 2712 | 2711 | 3675 | 7,360 | 6,801 | 7,482 | 7,926 |
| % of direct labour | | **48.49%** | **45.89%** | **49.26%** | **50.34%** | **49.75%** | **50.09%** | **49.33%** |
| Average age | | 28 | 29 | 29 | 28.9 | 29 | 30.0 | 30 |
| Average service year | | 3.3 | 3.9 | 3.8 | 3.2 | 4.1 | 4.2 | - |
| Education (Years of school education) | Ph.D. (more than 20 years) | 1.8% | 2.2% | 2.3% | 2.2% | 2.3% | 3.0% | 2.5% |
| | Masters (18 years and more) | 20.0% | 22.2% | 23.1% | 23.7% | 24.2% | 25% | 26.3% |
| | University and Colleges (16years) | 37.6% | 37.7% | 38.5% | 40.9% | 40.9% | 40.9% | 40.8% |
| | High school & vocational school (12 years) | **40.6%** | **37.9%** | **36.2%** | **33.2%** | **32.6%** | **31.2%** | **30.4%** |

Data source: TSMC annual reports (various years)

Since most of the production workers are high school graduates without experience, all the newly hired operators are given a basic training programme for at least a week as well as on-line operation practice prior to officially starting their jobs. Moreover, new workers will be assessed for their working efficiency for three months after they start working on line. Most production workers are adequate to perform their jobs after being fully trained for around five months. However, workers are encouraged to keep advancing their own knowledge with respect to their jobs and related work. As the TSMC manager noted:

> Since the working experience was not the requirement, we offer all the newly hired employees, including production workers and technicians, a one-week basic training programme before they start their job. The basic

training programme includes a practical training to let the new workers have better understanding of the actually on-line work.........Generally, it takes approximately three months for a new production worker to become fully competent, sometimes even longer. Most operators are able to be familiar with around 80% of their work in two months, and the rest of 20% required more experiences which would be accumulated on the job.

**Table 4.5: TSMC personnel structure by gender, age and service year**

| | | 2000 | 2001 | 2002 | 2003 |
|---|---|---|---|---|---|
| Gender | Male | 41.7% | 42.1% | 42.4% | 42.2% |
| | Female | 58.3% | 57.9% | 57.6% | 57.8% |
| Average age | | 28.9 | 29.8 | 30.0 | 30.2 |
| Average service year | | 3.2 | 4.1 | 4.2 | 4.5 |

Data source: TSMC annual report, 2003

According to TSMC's annual report, female employees account for 57.8% of total employees of TSMC at 2003 (see Table 4.5), and most of the female employees are production workers. There are more than 90% of TSMC's production workers are female and according to the interview with the TSMC human resource manager, it is relatively easier to recruit female workers in Taiwan. Female workers are also considered stable and circumspect regarding work which requires high dexterity. Semiconductor foundry is a very delicate job which demands highly accurate operation through the whole process. Accordingly, operator dexterity is a critical characteristic for workers in this field and TSMC has a preference for female employees for its production workers. While most of the production workers are female, the tradesmen are mostly male workers. However, the recruiter made some adjustments in the unwritten rule for female operator preference for the past two years, as the TSMC manager noted:

> In fact, it was just the last two years that we started to recruit male production workers due to the lack of competent workers. It has become a common problem for the whole industry while more and more factories being established in accordance with the increasing market demand.

### 4.3.2 Internal training programmes

On-the-job training (OJT) has remained the major way for production workers in TSMC to master their jobs, while various periodic Off-the-job training (Off-JT) courses within the firm are offered to all employees to fortify OJT programme. TSMC provided its employees with a broad range of technical, professional and management training programmes for different purposes. TSMC's Off-JT programmes are categorised in Table 4.6.

**Table 4.6: The off-job-training programmes of TSMC**

| Off-JT programme | Nature of the programme | Note |
|---|---|---|
| Basic training | Basic training programme which is given to newly hired workers prior to starting their jobs | All employees |
| General knowledge training | According to government or corporate policy, this type of training programme is designed to improve some particular skills, such as quality control, environmental protection and industrial safety. | All employees |
| Professional training | This programme is aimed to promote some professional skill; courses include equipment engineering, manufacturing process, marketing, human resource, communication skills, computer application programmes and general management. | Engineers and employees other than production workers |
| Production worker training | The programme is aimed to offer operators at shop floor essential knowledge and techniques. | Production workers |
| Management foundation programmes | The programme is to help management to better and improve managerial skills. | Managers |

Data source: TSMC website and interview

As veteran production workers were assigned to each production line as 'leaders', each leader had a vice-leader to assist them perform the supervisory duties under the project managers. Leaders have helped operators master their own jobs and prepared for more difficult tasks. However, for some particular tasks, Off-JT courses were critical to all production workers. For instance, in order to operate each particular machine, production workers have had to obtain training certificates from the Off-JT courses. Production workers who took adequate training programmes, which provide essential knowledge and techniques regarding any particular machine, and passed the examinations can be conferred a certificate to operate the machine. Moreover, production workers can take other Off-JT courses to be a trainer or a team leader.

Leaders have taught their fellow workers the skills to deal with unusual operations and unforeseen problems. According to Koike and Inoke (1990: 8), unusual operations involve dealing with changes and solving problems. For changes in respect of product itself, such as "product mix" or new products, workers at TSMC obtained knowledge and experiences from both OJT and Off-JT courses to deal with those changes. New products sometimes meant new production methods, and new courses in accordance with the new product or method were offered to workers who were assigned to the new production lines. Production workers also gained experiences to deal with changes of product mix by job rotation.

Actually, every production worker was expected to perform more than one kind job. Within a project team, workers unofficially rotated among several jobs but still work for the same project. The managers also assigned workers to different team according to the workload and available labour force.

> To advance each operator's capacity, everyone production workers will rotate to perform different jobs. For instance, there are 12 machines in a production line, and each workers of this team is capable of operating at least two different machines. Thus workers can support and learning from each other at work. Every operator has at least one competent substitute for his or her work. The point is to assure each worker's duty can be performed well even there is any worker absent.

Every employee can apply to rotate to other departments after entering the firm for more than one year. There was an annual personal merits review programme, which assessed every employee's contribution and performance on job for the last whole year. Workers were graded from the best performance-O (outstanding) to S (successful), I (improvement)...etc. Only those workers who were graded as "S" for two years in a row are qualified to apply for job rotation.

Operators were encouraged to learn from their fellow workers, mostly from more experienced workers or leaders, and accumulated experiences to deal with different "changes" and problems. However, solutions differ for problems regarding the machines themselves. Literally production workers were not expected to solve the problems with machine but to report to a higher body. The report were then confirmed by the team leader and then by the supervisor (manager).

> Since all the machines are extremely delicate, workers are not supposed to make any efforts to 'solve the problem' themselves but report to their leaders if there is any unusual operation happening. Leaders will try to identify the problem and report to both the project manager and the engineers who are assigned to operate and maintain the machines. 'Ask for help', that's the only thing we ask the production workers to do while they found anything wrong with the machine.

Tradesmen (Subordinate-engineers) at TSMC were the persons who work most closely with production workers other than the supervisors and project managers. Most of the tradesmen were vocational high school graduates without any experience. Before TSMC designed a thoroughly completed training programme for tradesmen, both OJT and Off-JT, apprenticeship programme was the major way for newly hired tradesmen to master their jobs at the initial stage. Currently, every new tradesman works as an apprentice after the basic training programme before they are certificated by the senior engineers or pass the examinations at Off-JT courses. After the new tradesmen were solely in charge of their jobs, each of them were assigned to different machines and visit the workshops regularly to examine and maintain the running machinery.

If any unusual operations happened at the workshops, tradesmen were immediately notified and made a further inspection to determine whether a notice should be sent to the repairmen from the equipment supplier firms. Tradesmen were only in charge of maintaining the running machinery to keep the steady flow of production. If the problems were beyond a certain level, they would turn to repairmen for help, for instance, it the problem requires an overhaul of the machine.

## 4.4 Conclusion: TSMC as a 'Large' Latecomer Firm

TSMC can be seen as a 'large firm' (LF) according to Hayter et al.'s (1999) description (chapter two). They delineate LFs as highly innovative firms which generally act as dominant suppliers to global niche markets. Moreover, LFs are strong locally based firms whereas they usually operate internationally. Those characteristics are evident in TSMC as shown in Table 4.7.

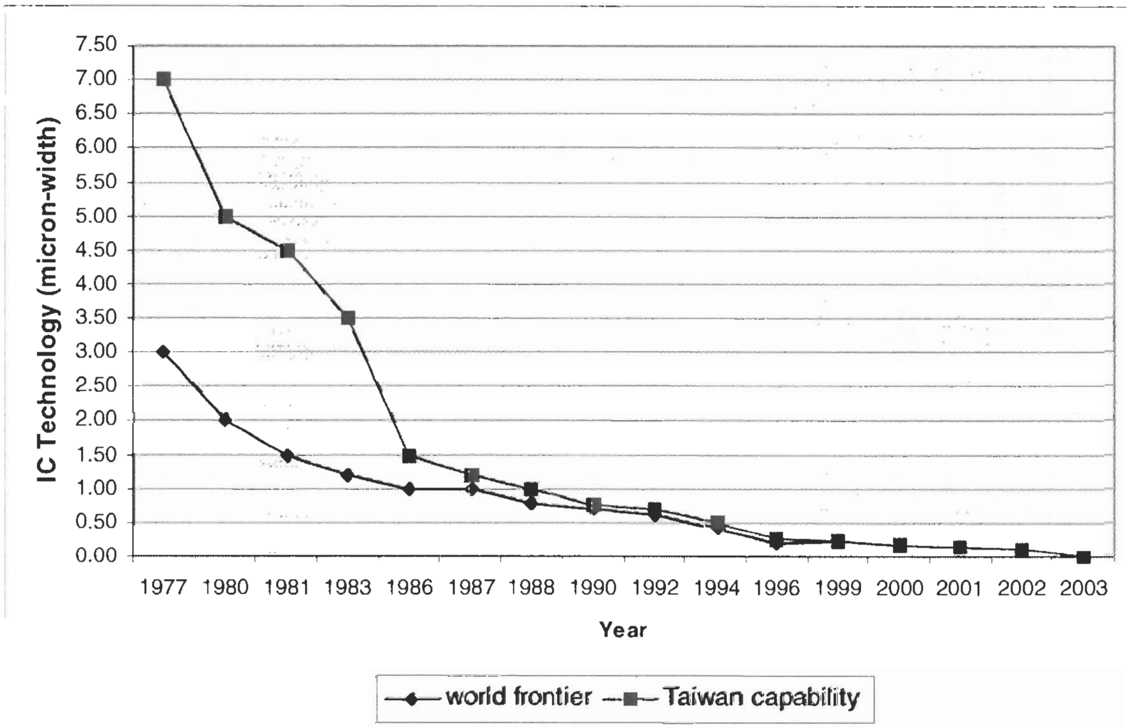
**Table 4.7: Selected characteristics of TSMC, 1987~ 2003**

| Characteristic | Comment |
|---|---|
| Origins | Founded in 1987, TSMC was the first dedicated semiconductor foundry firm in the world. It was a government-sponsored start-up in Hsinchu Science-Based Industrial Park and a spin-off of ERSO/ITRI in Taiwan. |
| Headquarters | Hsinchu Science-Based Park, northern Taiwan |
| Size | 2003 employment: 16,066<br>2003 sales: NT$201 billion (US$5.76 billion) |
| Manufacturing | Eight Plants in Taiwan (6 plants in Hsinchu Science-Base Park, 2 in Tainan, Taiwan); one plant in the US (Camas); one in Singapore (a joint venture with Philips semiconductor); one plants in Shanghai, China (TSMC Shanghai) |
| Product-Mix | Integrated circuit (IC) manufacturing, later also provides other foundry services, such as mask making, IC packaging, testing and design support service. |
| Entrepreneurship | Hands-on running of company by chairman &CEO Dr. Morris Chang; 21.72% owned by Philips, Holland. |
| R&D | 2003 (2000) R&D expense: NT$12.7 billion (NT$7.2 billion) |
| Innovation | TSMC focused on the process technology for IC manufacturing (wafer fabrication). It was granted 462 patents in the USA and 552 patents in Taiwan on 2002. |
| Market position | One of the leading global suppliers of ICs (logic IC and Memory ICs). TSMC's market share of the foundry segment reached 56% in 2002, after 53% in 2001. TSMC had active business dealing with more than 200 customers in 2003. |
| Exports | Global sales with North America as the main export market.<br>74% of total production for exports in 2001. |
| Investment in China | A subsidiary in Shanghai which operated an 8-inch fab factory built in 2003. |

Source: author's research files

Since its outset, TSMC has been managed mainly by its founder Dr. Chang who is also TSMC's current chairman. As a result of its pioneering and peculiar way of operation, as a dedicated IC foundry firm, TSMC's has grown at a remarkable pace, setting up 10 plants in the past decades with adequate annual revenue to support its constantly expanding business. Being a dedicated foundry firm, TSMC is able to focus its core competence in a certain scale of semiconductor technology, which enables it to increase the economies of scale in chip manufacturing as well as to develop the economies of scope in its production and marketing. TSMC has offered more services over time to its customers, such as mask making, IC packaging, testing and even the design support service. Even so, IC manufacturing remains TSMC's main business and major source of profits. TSMC also helps customers to upgrade their IC designs by establishing long-term relationships and makes itself indispensable. Today TSMC has become a dominant chips supplier to the global market, accounted for 56% of global market share in 2002.

**Figure 4.5: Taiwanese semiconductor industry closes the technology gap**

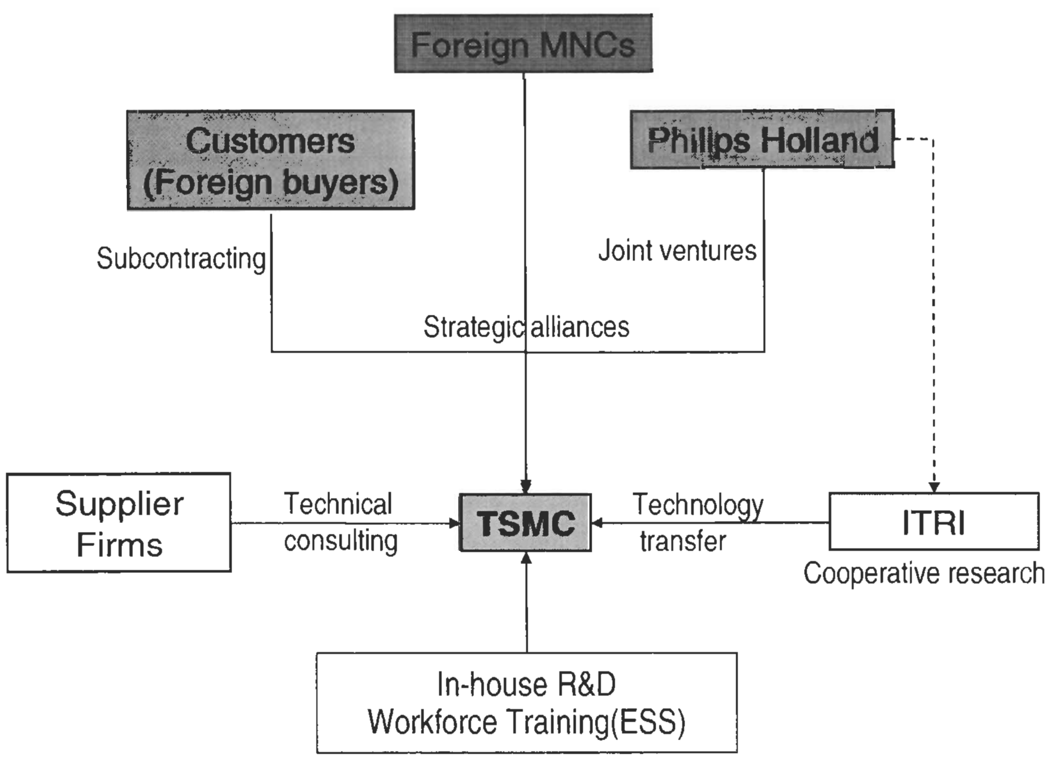



Date Source: Mathew and Cho, 2000; ERSO, 1994; ITRI, 2000

TSMC is now the leading semiconductor foundry firm in Taiwan and exerts a great impact on local semiconductor firms for technology advancing, which gradually helps Taiwanese semiconductor industry to narrow down the technology gap (Figure 4.5). With its substantial foundry capability, TSMC helps to spark the small local IC design firms (also known as design houses) by offering them foundry service. While the IC process technology keeps advancing, the required capital for the establishment of an IC foundry factory keeps rising and most IC firms could not afford to set up their own foundry factories. TSMC acted as a foundry for many Taiwanese IC design houses and in turn enabled them to accept product orders from around the world.

TSMC also joined some significant international research consortia, such as the Competitive Semiconductor Manufacturing project and the VSI Alliance, which gave it insight into the developments in the global semiconductor industry. In 2000, TSMC surpassed the ITRS (International Technology Roadmap for Semiconductors) roadmap at the first time by its 0.13-micron process technology. The ITRS is an assessment of the semiconductor technology requirements, alternatively expressed; ITRS identifies the potential technological challengers and demands for the semiconductor industry in the next 15 years. This roadmap is a cooperative result of the global semiconductor manufacturers and suppliers, government organisations, consortia, and universities (Semiconductor Industry Association, 2003). From this point, TSMC has started to possess the leading-edge process technology among the global semiconductor manufacturers.

**Figure 4.6: Technology learning of TSMC**



The various ways for TSMC's technology learning are graphically summarized as in Figure 4.6. As a result of its special background, namely being a joint venture of the government and leading MNCs (Philips), TSMC had the advantage to easily gain access to advanced technology even at its initial stage. Although the role of government research institute ITRI was important for its establishment, the foreign MNCs remained to be the major source for TSMC's technology learning throughout. As the description above, TSMC continuously sought technology support from the foreign leading semiconductor firms through various channels, including the joint venture at the beginning to the subcontracting relationship afterward. Meanwhile, TSMC itself has made great efforts to improve and further upgrade its innovation capability by increasing investment in its in-house R&D. Whereas TSMC has followed an exceptional learning trajectory which differs from most of the latecomer firms in Taiwan to some extent, the next chapter's case studies offer various learning strategies of Taiwan's latecomer firms.

# CHAPTER 5:
# LATECOMER FIRMS: CHUNGHWA PICTURE TUBES AND KINPO ELECTRONICS

This chapter extends the analysis of latecomer firms in Taiwan's electronics industry by a focus on two other Taiwanese electronics firms, Chunghwa Pictures Tubes (CPT) and Kinpo Electronics (Kinpo). These firms are both locally based 'large' latecomer firms, like TSMC. There are, however, two important differences between CPT, Kinpo and TSMC. First, CPT and Kinpo were among the first firms in Taiwan to become established in the 'new' electronics industry in the 1970s. They subsequently grew to become 'Large Firms'. Second, both CPT and Kinpo have manufactured final consumer goods in addition to acting as suppliers to other firms. The analysis draws from interviews with a manager of CPT and the vice president of Kinpo, and also secondary data sources such as, papers and annual reports of both firms.

The chapter is divided between the case studies and, similar to chapter 4, the analysis of each case study comprises three main sections that examine the evolution of the technological capabilities of the two firms in a progressively focused way. In general, the first sections address the overall evolution of the firms, the second outlines how technological capabilities were developed and the third explores the internal development of enterprise skills (ESS).

## 5.1 Chunghwa Picture Tubes, Ltd. (CPT)

### 5.1.1 Overview of CPT

Chunghwa Picture Tubes (CPT) was established in 1971 by the Chairman of Tatung Corporation Lin Ting-Sun. CPT was a subsidiary of Tatung and manufactured picture tubes, which has been a vital component of video telecommunication products, such as TVs. As at 2004, CPT was ranked as one of the biggest global manufacturers of display devices and picture tubes for PCs, notebooks, television and other electronics products. Its main products consist of display devices that employ thin-film transistor liquid crystal display (TFT-LCD), cathode ray tube (CRT), and plasma display panel (PDP). In 2003, CPT's sales reached around US$ 2.54 billion.

### 5.1.1.1 Production bases and plants

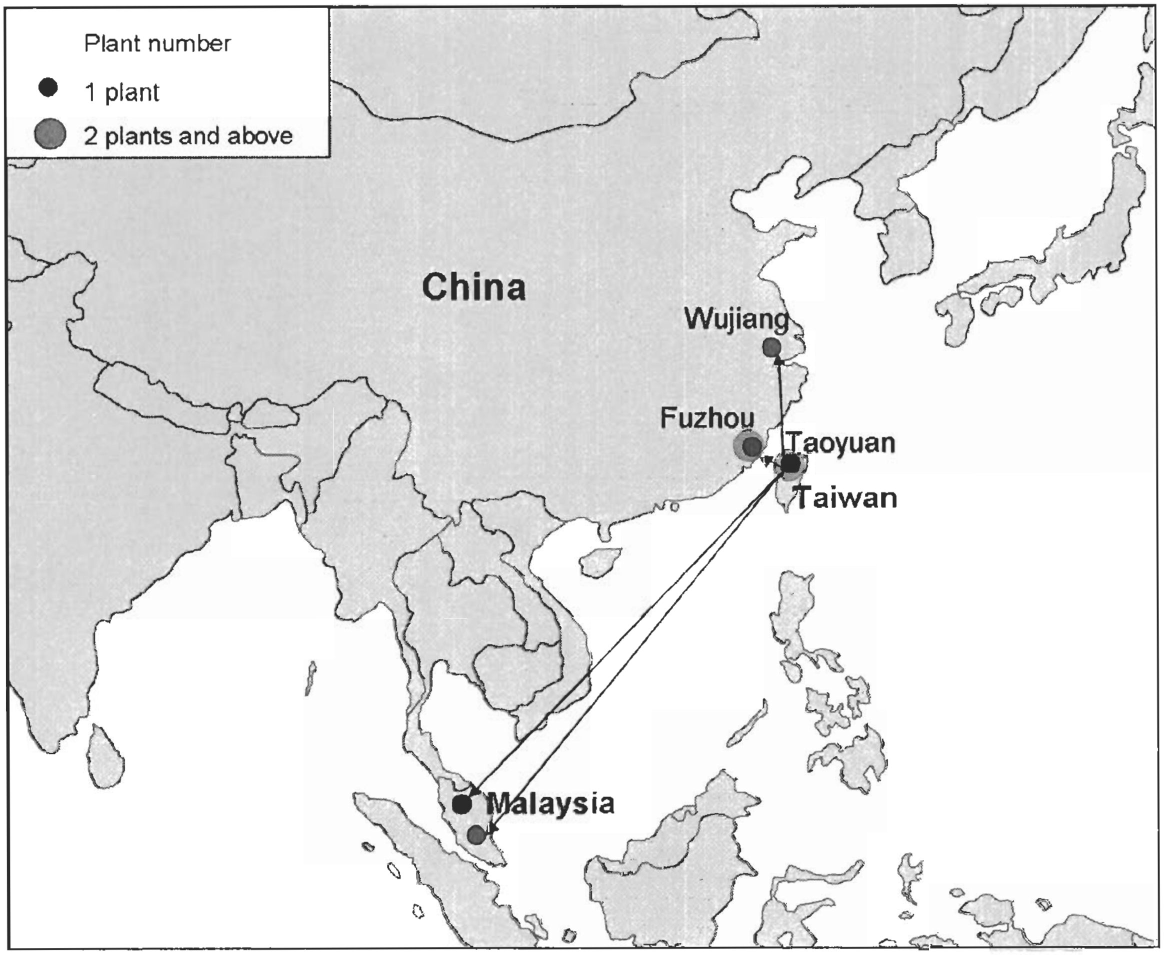
By 2003, CPT operated eight plants globally; all of them were located in Eastern Asia (Table 5.1; Figure 5.1). CPT's major manufacturing facilities were located in Taiwan, two plants in Taoyuan and one in Lungtan. The three plants in Taiwan were for CPT's most advanced products manufacturing, namely TFT-LCD and PDP. CPT also had overseas operations in Malaysia and Mainland China under its wholly and majority-owned subsidiaries.

**Table 5.1: The location and establishment of CPT's factories**

| Factory | Established date | Location | Products | Employees (2003) | Note |
|---|---|---|---|---|---|
| Taoyuan plant | 1973<br>1995 (remodelled)<br>1999 | Taoyuan, Taiwan | CRT (before 1995)<br>TFT-LCD,STN-LCD(after 1995)<br>PDP (after 2001) | 3830 | The first plant of CPT and used to be for CRT manufacturing. It was updated for STN-LCD and TFT-LCD products after 1995. |
| CF Yangmei plant | 1987 | Taoyuan, Taiwan | CF | 600 | |
| Malaysia plant | 1989 | Selangor, Malaysia | CRT (CDT/CTV) | 3730 | The first and major plant of CPT in Malaysia |
| Kamper plant | 1991 | Kamper, Malaysia | Electron Gun | 1560 | |
| Fuzhou plant (CPTF) | 1994 | Fuzhou, China | CRT, electron gun | 6660 | The primary plant for CRT product manufacturing |
| TFT Lungtan plant | 1999 | Taoyuan, Taiwan | TFT-LCD | 1175 | For the new generations TFT-LCD |
| Wujiang plant | 2002 | Jiangsu, China | TFT-LCD module (LCM) | 1235 | Conduct the follow-up work to support the TFT-LCD plant in Taiwan |
| FuJian plant | 2003 | Fuzhou, China | PDP and TFT-LCD module | 120 | |

Data source: CPT annual repost (various years)

**Figure 5.1: Geographical distribution of CPT's plants**




Data source: CPT website

Considering that it has been introduced to the market since 1950s and become the most common used display device, the CRT has become a mature product in the market. Product maturity generally has meant the availability of core technology, including basic product designs and process technology, but it has also meant declining and small profit margins (Amsden and Chu, 2003). Moreover, as a result of the introduction of new display device products, such as TFT-LCD and plasma TV, to the market, the price and demand for CRT products gradually went down. To retain its advantage of low-price, CPT tried to reduce its production cost by shifting some of its CRT production to Malaysia and established two major plants there from 1989.

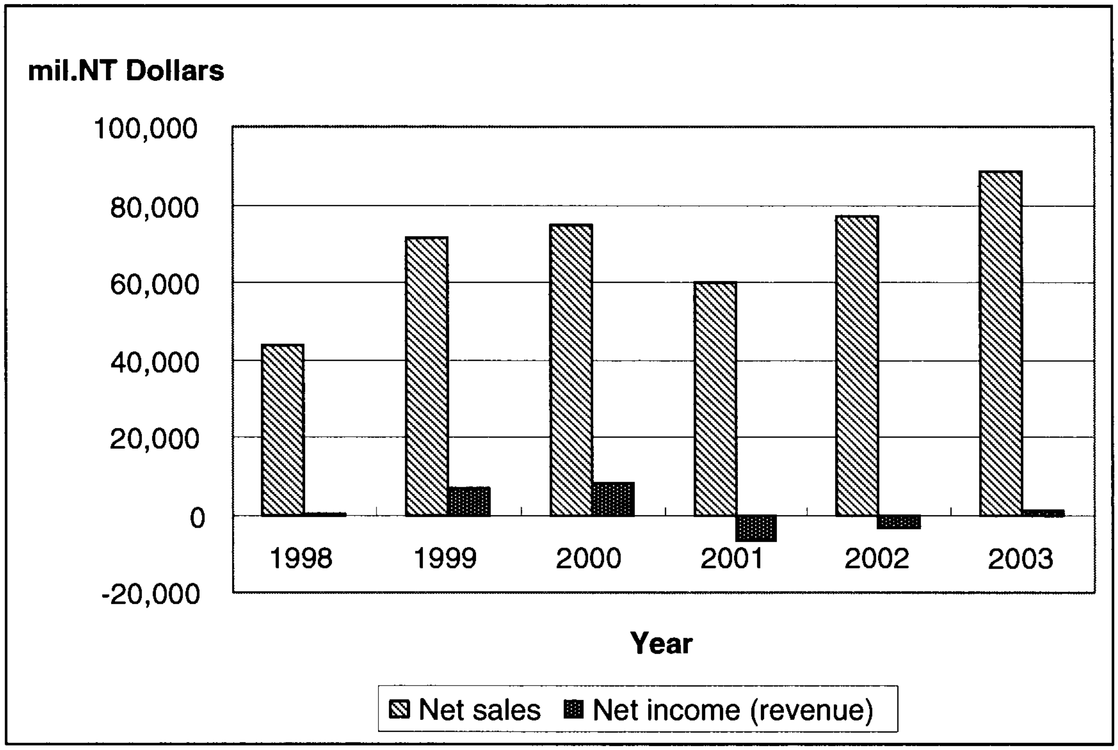
In the mid 1990s, after Taiwanese government loosened its China investment policy in 1992, many Taiwanese firms, including CPT, swarmed into China to set up plants and take advantage of the local cheap labour force. Since then, CPT started to relocate its CRT production to China and set up a plant in Fuzhou, China in 1994, which has retained the primary production base for CPT's production of cathode ray tube (CRT). Meanwhile, the introduction of more mature TFT-LCD products to the market brought about the decreasing demand for CRT at the late 1990s. In order to hold its leading edge in the global display device market, CPT began to source new technology from foreign firms. After CPT made a license and technical assistance agreement with Mitsubishi ADI (Advanced Display Inc.) in 1997, CPT replaced the CRT production lines in Taiwan with new production lines for TFT-LCD while continuously shifting its production of low-end products (mainly CRT) to Malaysia and China in order to improve its cost competitiveness. Within a few years, CPT's China plants have accounted for all CRT production and part of the TFT-LCD module work. By 2001, CPT was among one of the biggest CRT supplier worldwide, after LG. Philips and Samsung, and more than 80% of CPT's total capacity for CRT has been moved to China.

Although CPT has planned to further expand its facilities in China to take advantage of cost savings associated with local labour, logistics and components supply, most of its TFT-LCD production remained in Taiwan as a result of Taiwanese government's policy. To prevent the "hollowing out" (Edgington, 1997) of some cutting-edge industries, Taiwanese government has restricted local firms from shifting the production of certain advanced electronics products beyond the borders, such as wafer fabrication (semiconductor) and big scale TFT-LCD by enacting new law specifically with respect to the FDI in China.

#### 5.1.1.2 Annual sales and revenue

CPT was determined to enter the TFT-LCD market, and it has invested heavily in licensing for the new technology as well as establishing new plants. However, the TFT-LCDs (industry) "represented a great challenge to a manufacture owing to their extremely high financial as well as processing requirements" (Amsden and Chu, 2003:105). Due to its great amount of investment on the facilities for TFT-LCD, CPT was not able to balance its revenue and expenditure until 2003 (Figure 5.2). Meanwhile, the CRT segment provided a relatively "stable cash flow and does not require significant capital expenditure going forward" (CPT annual report 2002). As in 2004, CPT remained one of the largest CRT manufacturers (CPT was ranked as the third largest CRT manufacturer worldwide in 2001 with 21% market share).

**Figure 5.2: Annual sales and net revenue of CPT (1998~2003)**




Data Source: CPT annual reports (various years)

By 2003, TFT-LCD's share of CPT's net sales exceeded that of CRT for the first time. TFT-LCD's share of the company's net sales increased from 17.8% in 2000 to 48.9% by 2003, while CRT's share declined from 80% to 46% during the same period. In 2003, CPT was the third largest large-area TFT-LCD panel manufacturer in Taiwan, and the sixth largest in the world with a global market share of approximately 6% based on units sold (CPT annual report 2003).

CPT's main customers include many of the world's leading manufacturers of notebook computers, computer monitors and television sets, such as Dell, Hewlett-Packard, Sharp, Sony, Philips and NEC-Mitsubishi Visual Display Systems. Geographically, the majority of its business is generated from OEM/ODM customers in Asia, specifically in China, where it generated 68% of its net sales in 2003 (Table 5.2).

**Table 5.2: CPT: geographical distribution of sales (2000~2002)**

| | Area | 2000 | 2001 | 2002 | 2003 |
|---|---|---|---|---|---|
| Exports | *China* | *18.89 %* | *25.65 %* | *46.08 %* | *68.24 %* |
| | Southeast Asia | 44.21% | 31.69% | 23.32% | 7.45% |
| | Europe | 2.24% | 3.88% | 2.46% | 1.02% |
| | USA | 1.04% | 1.49% | 1.93% | 0.27% |
| | Others | 1.71% | 14.19% | 8.68% | 9.30% |
| | ***Total*** | ***68.19 %*** | ***76.90 %*** | ***82.46 %*** | ***86.28 %*** |
| Domestic | Taiwan | 31.81% | 23.10% | 17.54% | 13.72% |

Data source: CPT annual reports (various years)

In the past decade, many foreign electronics firms, especially brand-name personal computer manufacturers, such as Dell, HP and IBM, have increasingly outsourced the manufacturing of their products to OEM service providers in Taiwan. Yet most of the Taiwanese firms have shifted their production to China. CPT has benefited from this outsourcing trend in large part due to its location in China, which has allowed it to better coordinate its production and services with its customers' requirement, especially in the areas of delivery time and product design support.

### 5.1.2 The acquisition of CPT's technological capabilities

Technology transfer from foreign firms and licensing agreements have been the primary source of CPT's advanced technology from the outset. CPT has had a great reliance on foreign firms for new technology, products information, even assistance on plant establishment, particularly for the TFT-LCD product. Technology transfer and assistance from foreign firms help CPT to shorten the time to pick up the new skills and further to master the production of new products. Except the technology cooperation with foreign firms and licensing, CPT also has made a large investment in its own R&D segment to develop its own technological capabilities. The role of the major government research institution, namely the ITRI (Taiwan Industrial Technology Research Institute), only had a slight impact on the development of CPT's technological capabilities formerly, but ITRI has begun to exert its influence by advancing its own technology regarding the display device industry in the past few years.

#### 5.1.2.1 Technology transfer from foreign firms

CPT's parent firm, Tatung, has been one of the largest electronics makers in Taiwan since 1960s and Tatung entered into a strategic joint venture in 1964 with the Tokyo based Toshiba Co. to manufacture television sets. Given its experience with TVs manufacturing, Tatung later diversified into monitors and cathode ray tubes (CRT) manufacturing with the technical assistance from Toshiba, and CPT was then established for the purpose of CRT manufacturing. Being an affiliate of Tatung, CPT also acquired technological assistance from Toshiba for CRT production

Following the same route as its parent firm (Tatung), CPT assimilated manufacturing know-how initially under a technical cooperation arrangement, licensing agreement and OEM arrangements with foreign MNCs. As shown in Table 5.3, CPT has sourced technology from different Japanese firms regarding certain products in each period. At its initial stage, CPT inherited the strong link with Toshiba from its parent firm, Tatung, at its commencement in 1971. CPT has still retained a close link with Toshiba for certain display device technologies under a licensing agreement in 2003. With the assistance and technology transfer from Toshiba, CPT later advanced its products from mono-colour CRT to high-resolution colour CRT in 1985. In 1995, CPT entered a cooperative research with Toshiba on Large CRT technology. By the late 1990s, CPT had possessed relatively mature technology about CRT products, although an annual licensing fee was to be paid to Toshiba.

While the CRT became a relatively mature product in the market, CPT started to look for more advanced product before CRT became completely obsolete. Thus it entered another research cooperation agreement with Toshiba with respect to the liquid crystal display (LCD) product in 1995. In line with the increasing demand of flat display panels, CPT started to source technology on TFT-LCD and PDP from Mitsubishi ADI in 1997. As a result of its foresight on the evolution of the display device market, CPT became the first company in Taiwan to introduce the large scale TFT-LCD in mass production by the late 1990s. The firm then focused on developing its new TFT-LCD segment after 1999 and successfully transformed itself from a primarily CRT manufacture into one of the major global TFT-LCD suppliers.

**Table 5.3: The technology source for CPT's different products**

| Product | Introduction date | Technology Source | Note |
|---|---|---|---|
| Mono-colour picture tubes | 1971 | Toshiba | Tatung had acquired the technology from Toshiba before CPT established in 1971 |
| Colour monitor CRT | 1985 | Toshiba | Toshiba was the main source for colour monitor technology, but later CPT has also adopted some patents which belong to Mitsubishi and Hitachi |
| Large CRT | 1995 | Toshiba | CPT entered a Cooperation Contract with Toshiba on Large CRT Technology in 1995 |
| LCD (Liquid crystal display) | 1995 | Toshiba | CPT entered a Cooperation Contract with Toshiba on LCD Technology in 1994 |
| TFT-LCD | 1997 | Mitsubishi/ADI (Advanced Display Inc) | TFT LCD Technical transfer from Mitsubishi ADI:<br>- Marketing and product development monthly meeting<br>- 15% TFT-LCD output to NEC Mitsubishi visual display division |
| PDP | 1999 | Mitsubishi | Contract with Mitsubishi Electric on PDP technical cooperation |

Data source: CPT website and annual reports (various years)

Nonetheless, the 30 years experience on display devices manufacturing (mainly CRTs) did not equip CPT with adequate technological capability to start its own TFT-LCD business. According to the CPT manager, "even though CRT and TFT-LCD are both display devices, they are technically very different products". Therefore, CPT chose to source advanced technology from abroad to shorten its learning period.

From traditional CRT to TFT-LCD, Japanese firms have been market leaders of the display devices. According to information from ITRI (1999), "liquid crystal displays were pioneered in the late 1970s and 1980s by Japanese firms". Thus CPT again relied on Japanese firms for TFT-LCD technology to speed up the transformation to high value added products through technical assistance agreements and licensing arrangements. Generally, licensing agreements granted CPT permission to manufacture and sell certain products both in Taiwan and overseas during a fixed term, in return for certain amount of royalties based on the sales of relevant products. Yet the technical assistance agreements provided CPT with the provision of technical support for production or development activities in return for the payment of a fixed fee. The payment of royalty fees with respect to these agreements amounted to NT$ 585 million in 2000 and NT$ 409 million in 2002. The major licensing and technical assistance agreements between CPT and foreign MNCs in 2003 are shown on Table 5.4

While CPT has gradually advanced its own technological capabilities, it also engaged in confronting with intellectual property disputes with leading foreign MNCs. In 2002, Sharp and LG Philips both filed a patent infringement lawsuit against CPT in the USA. CPT ended up compensating Sharp with a licensing fee from 2002, while the litigation between it and LG Philips was still pending in 2003 (Liberty times News, 2003.9.29). Moreover, some foreign firms who hold patents in the TFT-LCD area have begun to request license agreements with CPT for royalty payments. Considering the increasing licensing fees each year, CPT has determined to raise its investment in its own R&D, and has set up its first R&D centre, Central Research Institute, in Taoyuan in 2002 (CPT annual reports, 2003).

**Table 5.4: CPT's technical cooperation agreements in 2003**

| Products | Company name | The term of contract | Note |
|---|---|---|---|
| CRT | Toshiba (Tokyo) | 1994~2004 | A license agreement relates to CPT and CDT |
| | Mitsubishi | 1997~2007 | A license agreement relates to scandium-oxide technology (for CRT) |
| | Hitachi | 2001-2006 | A license agreement relates to CRT for colour display monitors |
| TFT-LCD | Advanced Display Inc. | 1997~2006 | A license and a technical assistance agreement, relating to TFT-LCD manufacturing and production engineering. |
| | Sharp | 2002~2006 | A patent licensing agreement for non-silicon patents relating to TFT-LCD |
| | Hitachi | 2001~2010 | A patent license agreement relates to TFT-LCD technology. |
| PDP | Mitsubishi | 1999~2006 | A technical transfer and assistance agreement, a supplementary agreement and a work development agreement, relating to PDP manufacturing and production technology |

Data source: CPT annual report, 2003

#### 5.1.2.2 In-house R&D

Since CPT decided to invest in the TFT-LCD industry, one of the most fast-growing and intensely competitive electronics industries for the past few years, CPT has undertaken certain major upgrades of its facilities to construct new plants for more advanced products. CPT also has started to work on developing its own TFT-LCD process technology based on what it has learned from Mitsubishi electronics Cooperation (CPT, interview, 2003).

In 1997, CPT set up its first TFT-LCD plant, which was called as "third generation" (or G3 fab) with full assistance from Mitsubishi ADI. In 1999, CPT was capable of building a "fourth generation" plant (the TFT Lungtan plant I) which CPT invested in NT$ 60 billion, and Mitsubishi only provided some suggestions regarding the module design patterns this time. Changes in the 'generation' of the TFT-LCD plant implied the dimensions of the TFT-LCD panels; for example, the fourth generation plant was capable of larger panels manufacturing than the third generation plant. Thus each new generation facilities (plant) has enabled the manufacturer to raise the product yield and ramp up production efficiency with relatively less raw material costs.

Technical assistance from foreign firms appeared to be extremely important at the initial stage for CPT, but CPT managed to pick up the vital technology within a short time. As the manager of CPT noted:

> Technically, the first TFT-LCD plant was a wholly 'transplant' from Japan (Mitsubishi ADI), but the second (TFT-LCD) plant was mainly our own technology with mediocre technical assistance from Mitsubishi. ...The (TFT-LCD) technology was totally transferred (from Mitsubishi) at the beginning and Mitsubishi also offered technical support, but the TFT-LCD technology we apply to our actual production at the moment is not exactly the same as Mitsubishi's. (Interview conducted with Mr. Lin Yen-Chung, General Manager of Corporate Management Division of CPT, Oct 15th, 2003)

At the beginning, CPT transplanted an entire TFT-LCD plant from Mitsubishi Electronics in Japan to its factory site in Taiwan. Mitsubishi Electronics provided assistance to establish CPT's first TFT-LCD plant as well as to purchase equipments and to offer essential technology, by sending a group of Japanese engineers to Taiwan. The engineers from Mitsubishi Electronics not only just helped to train CPT engineers but also supervised the initial production to ensure adequate product quality (CPT was under an obligation to provide 15% of its TFT-LCD output to NEC/Mitsubishi Visual Display by the technology transfer contract). After CPT successfully produced its TFT-LCDs, it has retained a close relationship with Mitsubishi Electronics and monthly meetings between two firms have continued. However, the focus of these meetings has shifted from technological assistance to marketing and product development (CPT interview, 2003).

**Table 5.5: Net sales and R&D expense (1998~2003)**

**Amount: NT$ Million**

| | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 |
|---|---|---|---|---|---|---|
| R&D expense | 975 | 2,313 | 1,811 | 1,890 | 2,144 | 3,021 |
| Net sales | 43,839 | 71,700 | 74,858 | 60,133 | 77,014 | 88,970 |
| percentage of Net sales | 2.23% | 3.23% | 2.41% | 3.14% | 2.78% | 3.4% |

Data source: CPT annual reports (various years)

For the past few years, CPT has increased its R&D investments partly due to the higher licensing fees related to the TFT-LCD technology (see Table 5.5). In 2003, CPT had an R&D staff consisting of 530 employees organised into teams based on its product categories, namely CRT, TFT-LCD and PDP. As CRT is a relatively mature product, CPT has focused its R&D on achieving greater manufacturing efficiency through increased automated production and on improving the performance of products. The R&D team has cooperated with the company's sales and marketing department to collect information from customers and suppliers and develop new products based on the customers' requirements, required specifications and features. The R&D personnel have participated in weekly phone meeting with customers and conduct regular customer visits. The R&D efforts have enabled CPT to increase yield rates and reduce production downtime. In 2003, the total R&D expense accounted for 3.4% of CPT's annual sales (Table 5.5). To further enhance its technological capability, CPT set up its own R&D centre, the Central Research Institute in Taoyuan, in 2002 and aims to develop more patents on TFT-LCD manufacturing processes. CPT has conducted cooperative research projects on various process technologies with other Taiwanese firms, such as Hunet for colour sequential technology and Rainbow Displays for TFT-LCD tile technology.

#### 5.1.2.3 The role of the Taiwanese government research institution-ITRI

Originally, CPT had planned to develop its own TFT-LCD technology with assistance from ITRI. In 1988, CPT participated in a cooperative research project on TFT-LCDs with ITRI and several local firms, which was initiated by ITRI. However, this project proved to be in vain because ITRI itself was still short of key technologies for TFT-LCD manufacturing. While ITRI itself depended on Japanese firms for TFT-LCD technology, many local firms in Taiwan decided to form their own direct cooperative research partnerships with Japanese firms. Thus, none of the project participants, including CPT and Acer, relied on ITRI's technology while they started to set up their TFT-LCD plants in the early 1990s.

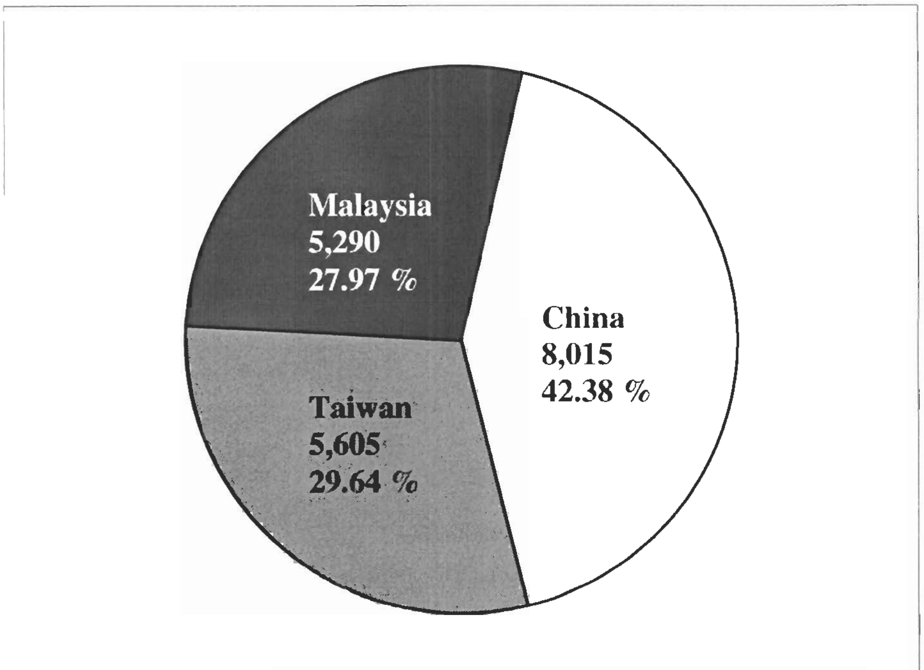
Although the first attempt for ITRI to assist local firms to develop TFT-LCD technology failed, ITRI kept working on its own TFT-LCD technology development and it developed some key components for more advanced types of panel display (Amsden and Chu, 2003: 107). In 2000, ITRI established Taiwan's first LTPS TFT-LCD laboratory and was able to start making contribution towards the local firms with its advanced technological capability. In 2003 TTLA (Taiwan TFT LCD Association which consists of major Taiwanese TFT-LCD manufacturers, including AU Optronics, Chi Mei Optoelectronics and CPT) purchased 232 TFT-LCD patents from ITRI (Liberty News, 2003). CPT also has plans to form cooperative research projects with ITRI in the near future.

### 5.1.3 Structure of the work force

By 2003, CPT had about 18,910 employees globally and China had become CPT's biggest production base, with 42% of CPT's total employees as shown in Figure 5.3. While direct production workers accounted for 83.7% of total staff in 2003, the number of R&D staff had also increased from 423 in 2000 to 657 in 2003 (CPT annual report, 2003). Furthermore, CPT had shifted its CRT production lines as well as its R&D

work on CRT products to China. The R&D centre in Taiwan is aimed at its advanced TFT-LCD and PDP products, mainly dealing with process technology improvement.

**Figure 5.3: The geographically distribution of CPT's employees in 2003**




Source: CPT annual report, 2003

### 5.1.4 Conclusion: CPT as a locally based large latecomer firm

The case of CPT illustrates an example of a large latecomer firm in Asia. Starting as a wholly owned subsidiary of Tatung in 1971, CPT has grown to become a 'large' firm. Table 5.6 briefly summarises the specific characteristics of CPT as a large latecomer firm.

CPT is export- and growth-oriented while it possesses a significant market shares. Today CPT is among the biggest display devices manufacturers in the world as well as a major supplier for many foreign MNCs. CPT has retained its primary focus on being a display device manufacturer with a major shift from a mature product (CRT) to a more advanced display device, namely the TFT-LCD. Being a major supplier for many foreign firms, CPT is capable of increasing economies of scale in production by cutting down production costs. CPT is highly innovative and has continuously advanced its technological capabilities by outsourcing technology from foreign MNCs as well as by investing on its in-house R&D.

**Table 5.6: Selected characteristics of CPT**

| Characteristic | Comment |
|---|---|
| Origins | Established in 1971 as a wholly owned subsidiary by Tatung for display devices manufacturing |
| Headquarters | Taipei, Taiwan |
| Size | 2003: 18, 910 employees globally (5,600 in Taiwan)<br>2003 (2001) sales approx. NT$89 billion (NT$60.1 billion) |
| Manufacturing | There are five production bases, two in Taiwan (three plants), and one in Malaysia (two plants) and two in China (three plants). The plants in Taiwan are for TFT-LCD products. CRT production lines were relocated to Malaysia and China since 1994. |
| Product-Mix | TFT-LCD (Liquid crystal Display), CPT (colour picture tube), electron gun, CDT (colour display tube), PDP (Plasma Display panel) |
| Entrepreneurship | The founder Lin Ting-sun was the chairman of Tatung Corp. thus CPT is an affiliate of this family-owned enterprise group and is personally managed by its chairman Lin Cheng-hung who is one of Lin's sons. |
| R&D | 'Central Research Institute' was established as the main R&D centre in Taoyuan, Taiwan in 2002. |
| Innovation | Original emphasis on CRT products has been shifted to the newer TFT-LCD products since 1995. |
| Market position | Leading global supplier of CRT (Cathode Ray Tube) and TFT-LCD, 21% global market share of CRT in 2001. |
| Exports | Southeast Asia, especially China, has been the major export market and accounted for more than 70% of CPT's annual sales in 2003.<br>In 2003, 86% of production for exports |
| Investment in China | The first China plant was built in 1994, and China has become the major production base particularly for the CRT products. |

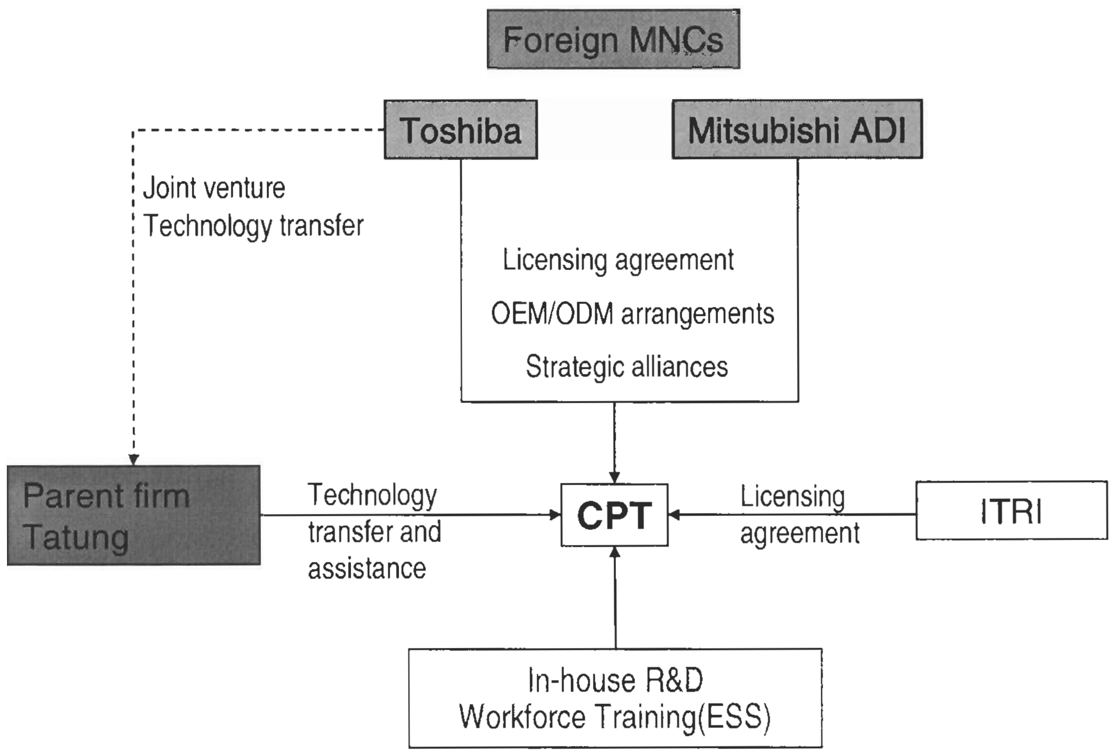
Source: author's research files

Note: 1.The CPT's TFT-LCD business started in 1997 with the technology from Mitsubishi, and CPT was ranked as the 6th largest TFT-LCD manufacturer worldwide in 2002. (1st - LG. Philips LCD (LGP); 2nd-Samsung; 3rd-AU Optronics (Taiwan); 4th- Sharp; 5th -Chi Mei Optoelectronics (Taiwan)

2. CPT set up its own PDP production line with Mitsubishi assistance in 1999

In terms of the spatial division of labour, as its technological capabilities progressed, CPT allocates different sectors to different regions. The geographical distribution of CPT's plants as well as its labour force illustrates an evolution of the sectoral division of labour within the firm itself. CPT relocates the manufacturing of its mature products to other regions such as China and Malaysia while the Taiwan factories proceed to manufacturing and development of advanced products.

**Figure 5.4: Technology learning of CPT**




The various ways for CPT's technology learning are graphically summarized as in Figure 5.4 and briefly discussed below. While it continuously improved and upgraded its technological capabilities, CPT has followed the route of the 'reverse product cycle model' with regards to its technology learning. CPT commenced manufacturing TV set in the early 1970s as being the subsidiary of Tatung which was one of the largest electronics makers in Taiwan. Over time, CPT received technology support from its own parent company as well as to acquire technology from foreign MNCs through Tatung. CPT has also developed its technological capabilities by increasing its R&D expense over time. Since its establishment, CPT relied upon foreign MNCs for advanced technology through various means, including licensing, subcontracting, OEM arrangements and later the strategic partnerships. This change shows that CPT has accumulated its own technological capabilities to a certain degree, which enables the firm to form strategic alliances with leading firms, such as Mitsubishi Electronics, to jointly develop new technology. Although CPT remained in several licensing agreements with foreign firms as of 2003, CPT entered the licensing agreements mostly for patents application instead of new technology.

## 5.2 Kinpo Electronics (Kinpo)

### 5.2.1 Overview of Kinpo

#### 5.2.1.1 The company structure

Kinpo Electronics was established in 1973 by its chairman Rock Hsu and started as a major local calculator manufacturer in Taiwan. For the past few decades, Kinpo has diversified its product range and has grown to become an enterprise group consisting of three main companies, Kinpo Electronics, Compal Computers and Cal-Comp Electronics. These companies have developed and manufactured a full range electronic products, including consumer electronics, communication and information electronics products. In 2002, Kinpo had more than 10,000 employees worldwide with its headquarters and major R&D design facilities in Taipei, software develop centres in Shanghai and Beijing, mass production facilities in Dongguan (China), and manufacturing supports in Thailand (Cal-comp electronics).

Since the beginning, Kinpo has performed contract manufacturing under OEM arrangements for many foreign MNCs, the major clients including Hewlett Packard, Casio, Canon and Ricoh. Kinpo started its business by manufacturing calculators and fax machines and the firm started to diversify its product line following the 1980s. In 1984, Kinpo founded Compal to assemble computers and manufacture computer peripherals. By 2002, Compal had become a large firm with about 9,000 employees globally and was ranked among Taiwan's top ten computer and peripheral companies. Table 5.1 shows the geographical distribution of three major subsidiaries and their plants in the Kinpo Group (also see Figure 5.5).

While Compal took in charge of all the computer product lines, Kinpo itself continued producing electronic calculators and fax machine, and diversified into other electronic products, such as printers, monitors and digital cameras. Its early experience in manufacturing electronic calculators provided a strong base for developing a series of advanced calculators, fax machines, printers, and electronic dictionaries into the 1990s. Since the 1990s, Kinpo has become a global major OEM maker of calculators, and by

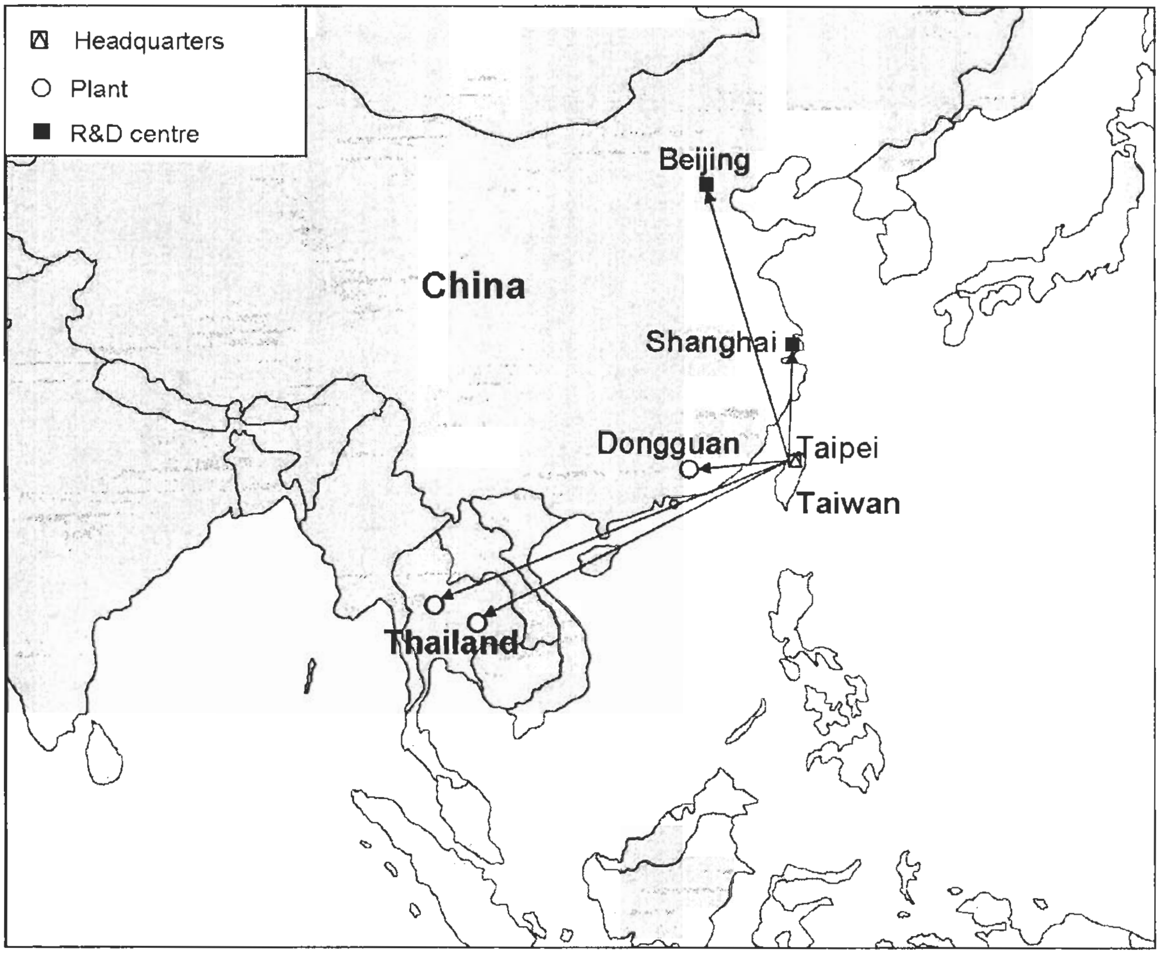
2002 it accounted for about 20% share in the global calculator market (Kinpo, 2003). However, Kinpo was well known overseas under the name of 'Cal-comp'.

**Table 5.7: The major firms and plants in the Kinpo Group (2004)**

| | Location | Employee number | Establishment date | Features | Note |
|---|---|---|---|---|---|
| Kinpo Electronics | Taipei, Taiwan | 830 | 1973 | Headquarters and major R&D centre | |
| | Dongguan, China | 4,000 | 1996 | Major factory | It became the major production base for Kinpo since 2002 |
| | Shanghai, China | 200 | 1996 | R&D and Software design centre | Shanghai and Beijing are both under the "Kinpo International" which is an100% wholly owned subsidiaries by Kinpo |
| | Beijing, China | 200 | 1998 | R&D and Software design centre | |
| Cal-comp | Thailand | 6,100 | 1989 | Six plants (1989~2001) R&D centre (1997) | Kinpo is still the major stockholder and main source of production orders for Cal-comp |
| | Suzhou, China | n/a | 2002 | Cal-comp set up this plant to support the production in Thailand | Cal-comp started to establish its second plant in China at 2003 |
| Compal | Taipei, Taiwan | 1,600 | 1984 | Headquarters | |
| | Pin-Cheng, Taiwan | 3,100 | 1985 | Factory (high-level products manufacturing) | Factory for high-level products (such as notebook computer, mobile phone) |
| | Kunshan, China | 8,500 | 1996 | Two plants(1996, 2002) which are in charge of the mass production | |

Data source: Kinpo, Cal-comp and Compal company websites

**Figure 5.5: Geographical distribution of Kinpo's plants**




Data source: Kinpo website

By 2004, Cal-comp had six factories in Bangkok, Thailand, with more than 6,000 employees working on about one hundred assembly lines, which produce computer printers, fax machines, cordless phones, LCD monitors, and so on. Cal-comp exerted its efforts on manufacturing capacity expansion and R&D capability. In addition to the factories in Thailand, Cal-comp also set up new factories in China; one site in Southern China and the other in Northern China. Cal-Comp has also established R&D centres in Taiwan, Singapore and South Korea to take advantage of the local skilled workforce. Despite its autonomous operation, Cal-comp in 2004 was still under the Kinpo group and a major support of mass production for Kinpo (Kinpo, 2004; Cal-comp, 2004).

Another reason for Kinpo to forgo its predominant role over Cal-comp in 1998 was the cheaper labour available in China. While Kinpo first chose Thailand for its first overseas production site in 1989, the Taiwanese government still imposed a restriction against indigenous firms investing in China. But in 1992, the Taiwanese government enacted a statute (Governing the Relations between the People of the Taiwan Area and the Mainland Area Statute), which lifted the restriction on business transaction between Taiwan and China. Since then, many Taiwanese firms started to 'legally' shift their production to China while many investments had been made via the firms in Hong Kong (Poon 2002).

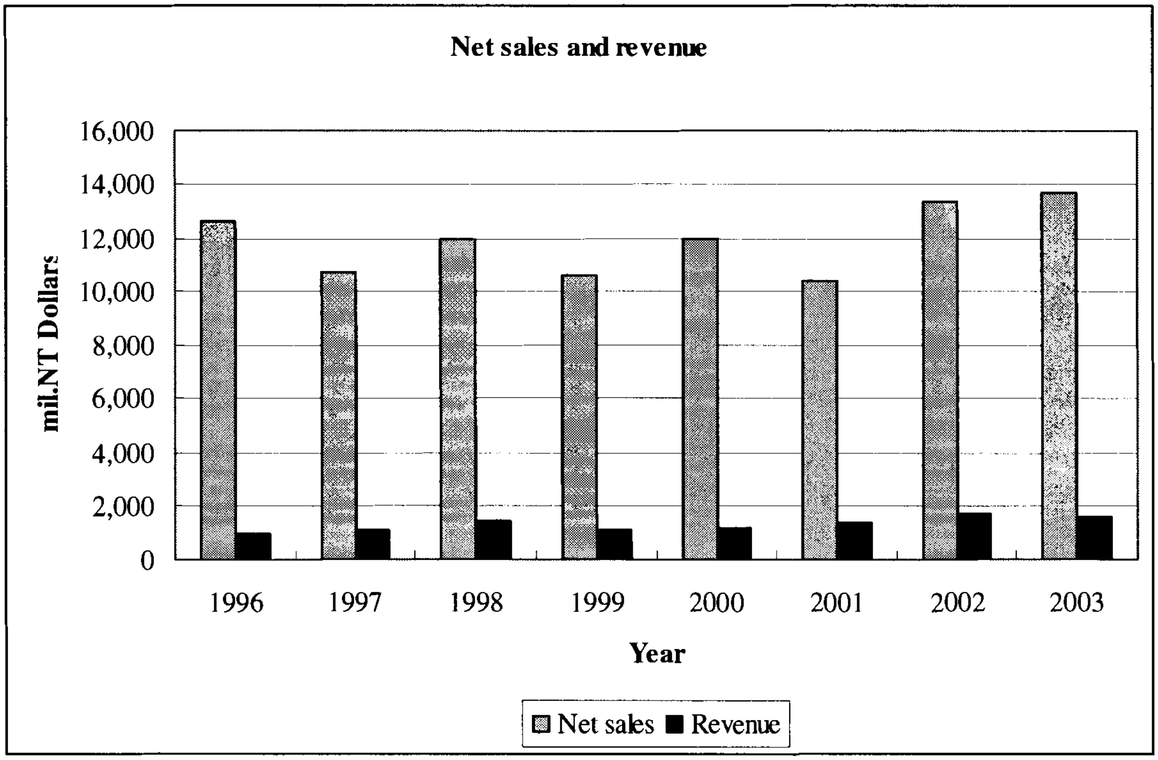
In 1996, Kinpo began to set up production facilities in Dongguan, China and, since then, has expanded its operations to Shanghai and Beijing. The Chang-An factory in Dongguan is Kinpo's major manufacturing with about 4,000 employees. Kinpo has commenced the outsourcing of (most part of) the production process to China since the Chang-An factory started to operate. Kinpo then established its software design centres in Shanghai (1996) and Beijing (1998) to support the Taipei R&D centre and conduct the R&D assignments passed from Taipei. Both centres have employed and trained nearly 200 engineers (Kinpo annual report, 2003).

In the early 2000s, Kinpo restructured its organisation in order to raise working efficiency, and redeployed its resources according to each region's comparative advantages. While labour-intensive operations and mass production were relocated to China and Thailand, new products were introduced to the main plant in Taipei. In 2002, the Taipei office was defined as the firm's "global operations hub" and a major R&D centre, which is in charge of R&D results integration and planning. There were around 800 employees in Taiwan by the end of 2003, and more than half of them were R&D workers. The Taipei headquarters was also in charge of accepting orders for productions out of its China based subsidiaries (plants) (Kinpo interview, 2003).

#### 5.2.1.2 Annual sales and revenue

By 2003, Kinpo had become a primary global supplier for certain electronics products, namely calculators and fax machines. Unlike CPT, Kinpo retained and concentrated on improving its original products mix instead of shifting to more advanced products. Since the manufacturing of mature products under the OEM arrangements only allow a small margin of profits, Kinpo's growth pace has been rather steady, without severe up-and-down fluctuations regarding its annual revenue for the past few years (see Figure 5.6). Yet Kinpo has been capable of securing stable annual revenue with its great market share of those mature products.

**Figure 5.6: Net sales and revenue of Kinpo (1996~2003)**




Data Source: Kinpo annual reports (various years)

**Table 5.8: Kinpo: geographical distribution of sales (1999~2003)**

| | Area | 1999 | 2000 | 2001 | 2002 | 2003 |
|---|---|---|---|---|---|---|
| Exports | North America | 33 % | 32 % | 26 % | 29 % | 31% |
| | Europe | 26 % | 22 % | 27 % | 17 % | 12 % |
| | Asia | 40 % | 45 % | 46 % | 53 % | 56 % |
| Total exports | | 99 % | 99 % | 99 % | 99 % | 99 % |
| Domestic | Taiwan | 1 % | 1 % | 1 % | 1 % | 1 % |

Data source: Kinpo annual reports (various years)

Kinpo has been an export-oriented firm from the beginning as almost all of its products (99 %) were for export (see Table 5.8). As a result of the rise of many Asian electronics firms, specifically in China, the Asian market has been growing in the past few years and accounted for 56 % of Kinpo's export in 2003 (Table 5.8).

#### 5.2.1.3 From OEM to ODM

Considering the operation of the firm, Kinpo has progressed from OEM to ODM but has not broken through to OBM thus far. Compared with most local Taiwanese electronics firms, the Kinpo Group had a relatively complete product line in 2004, including consumer electronics, computers and peripherals, information and semiconductor products. However, Kinpo did not have any products under its own brand name and still manufactured products under various OEM/ODM arrangements.

The major reason was that Kinpo still had a great reliance on OEM/ODM arrangements for the majority of its exports and did not want to take the risk to offend or lose its current clients. As Hobday (1995: 133) suggests "...the OEM/ODM system provided the technology and market lifeline" for latecomer firms. Kinpo chose to remain working under OEM/ODM arrangements to secure stable revenue.

> It is extremely difficult to do our own brand name marketing especially while we rely a lot on our OEM/ODM customers (buyers) particularly for the export market. The point is we operate our own brand name, we would then compete against our own customers, and they (the OEM/ODM buyers) would stop placing orders with us anymore. (Interview conducted with Mr. Pearce Chiu, the Vice president & special assistant to chairman of Kinpo Group on Oct 21st, 2003).

As a result of the heavy competition between the local Taiwanese firms to obtain OEM contracts, the net profits from working under OEM/ODM is decreasing. To secure further OEM contracts, it is thus more cost effective to invest in efficiency improvement of its shop-floor operations and the quality of its output than to build up its own marketing capabilities.

### 5.2.2 The acquisition of Kinpo's technological capabilities

Since its establishment, Kinpo has developed its technological capability by making great investment in R&D as well as by reverse engineering (learning by doing) under OEM arrangements. In 2003, Kinpo possessed about 250 patents (including US and Taiwan patents) for various process technologies (Kinpo interview, 2003).

#### 5.2.2.1 Foreign firms

The OEM buyers have served as an important source for Kinpo to upgrade its technological capabilities. Under the OEM arrangements, the foreign buyers supply Kinpo technological assistance to ensure the production quality particularly at the beginning of new production. Accordingly, Kinpo gained direct access to engineering support from its OEM buyers for certain products. At the outset of new production, the OEM buyers would send a group of engineers to assist the training of local engineers and to supervise the start-up of new production. The OEM buyers also provide detailed specifications for goods, and feedback on product quality. As Kinpo gradually advanced its technological capability, it has also improved its products quality control ability as well as its production capacity. As a result, its OEM buyers have increased their dependence on Kinpo's production capacity. Accordingly, the OEM relationship between foreign buyers and Kinpo has evolved into a more lengthy cooperation. Kinpo then progressed from simple OEM through ODM and finally to form joint developments of technology with various foreign leading firms.

As the vice-president of Kinpo noted:

> We only focused on few certain products (such as calculators, fax machine and printers) at the beginning and invested a lot to improve production techniques, thus we became a master manufacturer for those products at satisfactory product quality. For example, Canon has commissioned us (Kinpo) to manufacture few products for a long time.... Kinpo is the biggest calculator's manufacturer in the world to date and has possessed some advanced (process) technology regarding certain products. Thus our OEM buyers have started to increase their dependence on our mass production capability for specific products because they found it more efficient to commission Kinpo to manufacture those products instead of doing it on their own.

Working under OEM for more than two decades laid the groundwork for Kinpo to realize sufficient economies of scale to cut production costs further and became one of the electronics conglomerates in Taiwan. As Kinpo grew to become a corporate group and learned to master few particular products, it had started to reduce its reliance on its OEM buyers for new technology (regarding its old products). Whereas Kinpo recognised the need to invest in its in-house R&D to upgrade its own technological capability, it also began to seek for other means in order to speed up its technology development. Aside from conducting cooperative R&D with other firms (both foreign and local firms), overseas investment provides an alternative source to technology acquisition. Kinpo purchased or invested several foreign high-tech firms to get access to foreign technology and acquire skilled engineers and equipments. For instance, to compensate for its shortage of communication and information production techniques, Cal-comp invested in Telian Corporation and Wide Telecom in South Korea (Cal-comp, 2004).

#### 5.2.2.2 In-house R&D

The trajectory for Kinpo to obtain and accumulate technology for the past few decades has slightly different from the general route at which most Taiwanese electronics firms have been following. Kinpo has took the strategic decision to venture a large amount of money on its in-house R&D since the early 1980s while most Taiwanese firms still had a great reliance on foreign firms for advanced technology. The endeavours for Kinpo to improve its own technological capabilities later enabled the firm to acquire more OEM orders from leading foreign firms. The vice-president of Kinpo noted:

> In order to develop our own technology, we decided to invest in our own R&D instead of paying a great amount of money for licensing from those leading Japanese firms. However, it was like "burning the money" at the initial stage of the R&D development. For instance, the firm invested an annual $10 million (NT) for fax machine development for several years. $ 10 million (NT) was a great amount (in the 1970s), and we didn't get a satisfying outcome after 8 years.

While most local OEM firms still required more assistance on new products manufacturing from their foreign buyers, Kinpo possessed adequate skills from its in-house R&D and reverse engineering (learning by doing); thus it was able to achieve the production quality requirement in a shorter period. Yet the "burning the money" on R&D

strategy equipped Kinpo with sufficient in-house technology and made Kinpo stand out from the other indigenous OEM supplier firms in Taiwan.

> After we successfully developed our own fax machine, Kinpo learned to master some optic techniques which later became the developing ground for new techniques and advanced optic products, such as printers. Many foreign OEM buyers would like to place orders with those local firms that already have experience to manufacture similar products. For instance, while HP (Hewlett-Packard) was looking for its joint firm, it started with those local firms who had optic production experience. Thus Kinpo's experience to manufacture fax machine became our 'core competence' which attracted HP to further considered Kinpo for its OEM supplier.

The main reason for Kinpo to stick at its "burning the money" for in-house R&D strategy at its start-up phase was the idea of its top management to build its own technological capability thus it was then reckoned as the firm's priority to enhance in-house technology at the time. Seeing that many Taiwanese local firms had a great reliance upon foreign firms for new technology while foreign firms always held the critical techniques, Kinpo was aware of the truth that only by developing its own technology would equip it with an advantageous position for further development.

**Table 5.9: Annual R&D expense and net sales of Kinpo (1997 to 2003)**

**Amount: NT$ Million**

| | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 |
|---|---|---|---|---|---|---|---|
| R&D Expense | 297 | 397 | 456 | 442 | 408 | 507 | 598 |
| Net Sales | 10,702 | 11,983 | 10,547 | 11,988 | 10,364 | 13,359 | 13,710 |
| percentage of net sales | 2.77% | 3.31% | 4.33% | 3.69% | 3.94% | 3.80% | 4.36% |

Data source: Kinpo annual reports (various years)

For the past few years, Kinpo has continuing complied with its primary strategy to build up its own technological capabilities by increasing its annual R&D expenditure (Table 5.9). In 2003, its annual R&D expenses were NT$598 million dollars (around US$14 million), which accounted for 4.36% of Kinpo's net sales. Kinpo employs 465 R&D engineers working in its Taipei headquarters to carry out core technology research and integration of R&D results from each affiliate. Kinpo also established two software design centres in Shanghai and Beijing to support the Taipei R&D centre. Both centres have employed and trained nearly 200 engineers to provide follow-up design and software support according to new product design and assignment developed in Taiwan.

In addition to Kinpo itself, other firms under the Kinpo Group, such as Cal-comp and Compal, have also established their own R&D centres. Each firm under the Kinpo Group was assigned to concentrate on a specific field and certain products, such as calculators and printers for Kinpo, basic calculators (lower-level products) and monitors for Cal-comp, computer and peripherals for Compal; thus there were few inter-firm co-operative R&D efforts within the Kinpo Group.

Excluding the outsourcing of major production process to China (the Chang-An factory in Dongguan), Kinpo has also shifted part of its in-house R&D to China. Since 1996, Kinpo founded two R&D centres in China (Shanghai and Beijing) to take advantages of local engineers as a result of the shortage of the skilled engineers in Taiwan.

> We have to assign part of the research work to our subsidiaries in China for lack of adequate engineers in Taiwan; however, the subsidiaries are only designated to do the 'low-hand' jobs. ......The R&D centre in Taipei is in charge of new projects design and assign part of the jobs to the R&D support centres in China as well as the final results integration.

As there is concern over the possible "hollowing out" (Edgington 1997, 1999) of both labour-intensive (mass production) and technology-intensive (R&D) operations in Kinpo (Taiwan), Kinpo is aware of the possibility that its Chinese subsidiaries might become incubators of potential competitors. The spokesperson of Kinpo stated:

> Reducing production costs has been of concern to Kinpo plus the shortage of competent engineers in Taiwan, it is evitable for us to shift our production and part of the research projects to China. ...... We try to control the subsidiaries by assigning less important jobs (with respect to the R&D projects) to them; meanwhile, we will continuously upgrade the technological capability of our Taipei R&D centres.

Alternatively expressed, the Taipei R&D centre takes charge of the major schemes of new projects while the China R&D offices are defined as "software design centres" and conduct the follow-up detailed work for each project pass on by the headquarters.

#### 5.2.2.3 The role of governmental research institution-ITRI

Aside from cooperative research with foreign firms (mostly under the OEM arrangements), Kinpo had also cooperated with ITRI in the early 1980s for research for new projects. However, this was a rather vain attempt since ITRI was more like a 'research lab' which lacked for enough sense for actual market demands at that time. As the vice president of Kinpo notes:

> As ITRI was more like a pure research laboratory at that time, and it did not give careful consideration to the actual market demand, the result of our cooperative project was not effective regarding its market value.........That is part of the reason why Kinpo decided to invest in our own R&D at the early stage. But I think ITRI has changed a lot and their research projects have being more practical (regarding the market need).

Whereas ITRI recognised the importance of practical applications of its research projects, it began to conduct research in close association with private firms since the 1990s. Since then ITRI has proved itself to be a valuable research institute for local firms in Taiwan by assisting them to develop patents and taking the initiative in promoting research consortia. Although Kinpo in 2003 had no plan to cooperate with ITRI, Kinpo was positive about the possibility to cooperate with ITRI in the near future (Kinpo interview, 2003)

### 5.2.3 Internal learning—the formation of ESS

#### 5.2.3.1 Labour force structure

In 2004 there were 830 employees working at the Taipei headquarters of Kinpo, and more than half of them were R&D engineers (Table 5.10). Kinpo used to have a plant in Taipei but ceased the factory operation in 2002 as a result of the rising local wages. As the R&D centre of Kinpo, the staff of Kinpo's headquarters was well educated. Table 5.10 indicates that in 2004, there was 83% of Kinpo's employees that possessed a bachelor's degree or above.

**Table 5.10: Kinpo personnel structure by job title and education level (headquarters in Taipei)**

| | | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|---|---|
| Total staff | Total | 1238 | 1271 | 1025 | 797 | 863 | 827 | 830 |
| | Managerial personnel & staff | - | - | 319 | 290 | 286 | 250 | 244 |
| | R&D group | - | - | 505 | 507 | 573 | 577 | 586 |
| | direct worker | - | - | 201 | 0 | 0 | 0 | 0 |
| Education | Ph.D. & Masters | 2.18% | 2.2% | 2.05% | 3.39% | 4.63% | 6.05% | 5.78% |
| | University and colleges | 54.12% | 56.02% | 54.64% | 72.52% | 74.28% | 77.14% | 77.59% |
| | High school | 22.54% | 21.64% | 21.46% | 20.7% | 18.19% | 15.48% | 15.42% |
| | below high school | 21.16% | 20.14% | 21.85% | 3.39% | 2.9% | 1.32% | 1.2% |

Data source: Kinpo annual reports (various years)

#### 5.2.3.2 Internal training programs

With more than 5,000 employees working in different regions, Kinpo had developed a comprehensive training program for its staff (Table 5.11). Employees could receive training either through the internal courses or at external institutions. The training group of the firm drew up an "annual training plan" every year and arranges for various courses. For the external training, supervisors of each department recommend their staff for training at an external institution, in response to company policy, advanced technology, specialised requirements within department or employee's need for self-development.

Except for those Off-job-training programs, employees also learned to do their work by On-the-job training (OJT). Contrary to the Off-JT, each department supervisor was responsible for the OJT program arrangement as well as providing instruction and guidance for individual job position. According to the respective function and requirement of each department, the department supervisor planed the OJT program.

**Table 5.11:The off-job-training programmes of Kinpo**

| Off-JT programs | Nature of the program | Note |
| --- | --- | --- |
| Newcomer training | The general pre-job training provides newcomers with practical understanding of the company's organisation, evolution, business concept, business culture, welfare system, management regulations, products, overall environment, etc. | All the newly hired employees |
| General training | Training organised for all employees, including language training (English and Japanese) and computer operation, intellectual property rights and psychological health seminars, fire drill, etc. | All employees |
| Professional training | Professional skill training such as electronics, digital technology and communication technology, and professional management training such as financial statement analysis, marketing and project management, are organised to improve specialised personnel's technical standard and cultivate a second skill for employees. | All employees exclude production workers |
| Self-improvement training | The company provides books, training materials, specialised publications, magazines and cassette (video) tapes for employees to study and improve themselves after work or during recess time. | All employees |
| Management development training | Various management skill training programs are implemented according to requirements of different ranks and job functions so as to boost management and problem-solving abilities, improve leadership, interpersonal communication and coordination skills. | Managers |
| Quality management training | Skill training related to quality management, recognition, skill and method, including policy management, TQM (total quality management) | All employees |

Data source: Kinpo website and annual reports (various years)

### 5.2.4 Conclusion: Kinpo as the locally based large latecomer firm

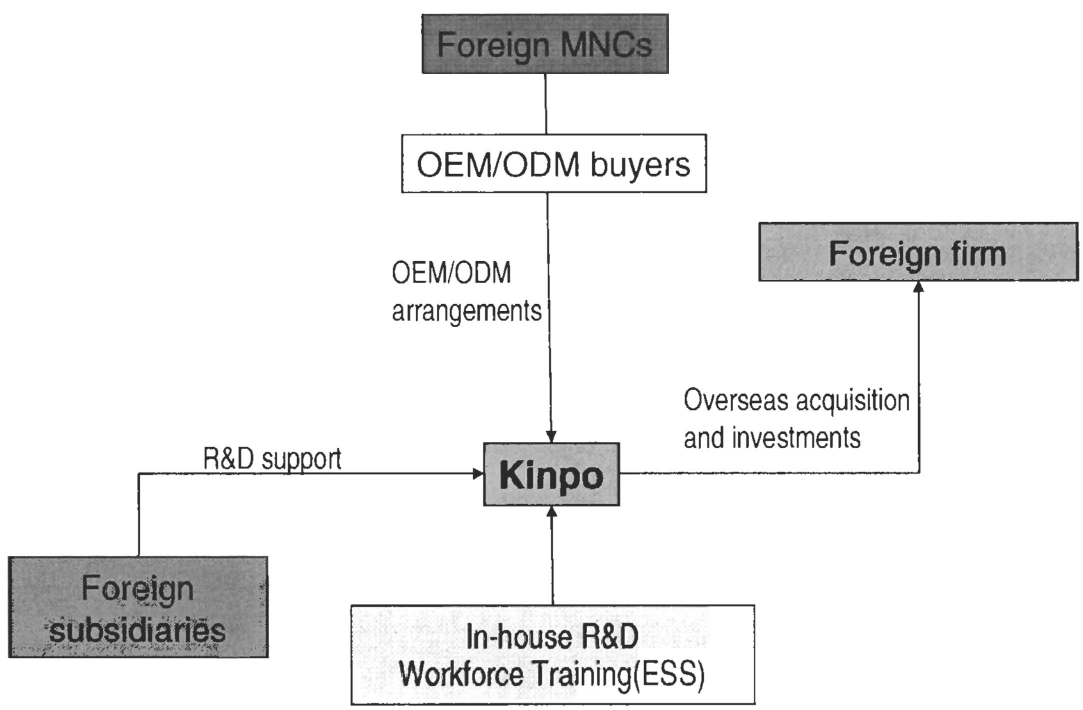
Since established in 1973 as a local supplier of consumer electronics, Kinpo Group has grown to become a conglomerate that consists of several large firms and Kinpo is the core firm of this business group. Kinpo has diversified its products range by setting up new firms instead of adding up new products lines within Kinpo itself. Compared with CPT, Kinpo illustrated a different type of 'large' latecomer firm in Taiwan with respect to both the firm's structure and technology learning strategies. Table 5.12 outlines the selected characteristics of Kinpo as a locally based 'large' latecomer firm.

**Table 5.12:Selected characteristics of Kinpo**

| Characteristic | Comment |
|---|---|
| Origins | Began as a basic electronic calculator's manufacturer in 1973. After its expansion for the past two decades, Kinpo group has subsidiaries in Thailand (Cal-comp), China (two subsidiaries in BJ and Shanghai, one factory in Dongguan). |
| Headquarters | Taipei, Taiwan |
| Size | 2004: 830 employees including 586 R&D staff in the headquarters in Taipei (the total employees is more than 10,000 globally in 2003, including the Cal-camp in Thailand)<br>Annual net sales: NT$ 13.7 billion in 2003 |
| Manufacturing | A major plant in Dongguan, China and six plants in Thailand |
| Product-Mix | Consumer electronics products including calculators, fax machines, scanners, printers, digital cameras and monitors...etc. |
| Entrepreneurship | Chairman Rock Hsu set up Kinpo and focused on few particular consumer electronics products, such as calculators and fax machines, at the outset and started to diversify into other electronics fields on this sound foundation. Now the Kinpo Group consists of three major electronic firms, including a major Taiwanese notebook PC manufacturers Compal. |
| R&D | Headquarters in Taipei is responsible for the main R&D; two subsidiaries in Beijing and Shanghai designated as sub-R&D centres which conduct R&D programs under the supervision of Taipei headquarters. In 2003, the R&D expense was NT$ 598 million (4.36 % of annual sales) |
| Innovation | Kinpo initially emphasised on reverse engineering of foreign technology, mainly from Japanese firms, while working under OEM arrangement. After becoming a major supplier of some particular electronic products, the firm has concentrated on technology improvement rather than developing new products. |
| Market position | Leading global supplier of calculator and fax machine since 1992 |
| Exports | Exports important (99% sales for exports) with Asia (56%) and North America (31%) the major markets in 2003. |
| Investment in China | Investment in China started at 1996; a major factory was founded in Dongguan and two R&D centres in Beijing and Shanghai. |

Kinpo has been highly export-oriented with 99 % of its annual sales for exports in 2004 and was a dominant supplier for certain electronics products, such as calculators and fax machines. As Kinpo has focused its core technology in a limited product range, the firm has increased the economies of scale in its production. Additionally, its efforts to advance its own technological capabilities through investment in in-house R&D have enabled Kinpo to develop economies of scope in R&D, and subsequently open up opportunities in related areas. Although both firms are innovative, Kinpo's learning route has been different from CPT's. For instance, CPT has great reliance on foreign MNCs to update its technology whereas Kinpo has accumulated its technological capabilities mainly through its own R&D. Kinpo has also gained substantial knowledge from its OEM buyers as a subcontractor. The various ways for Kinpo's technology learning are graphically summarized as in Figure 5.7.

**Figure 5.7: Technology learning of Kinpo**



The evolution of Kinpo illustrates how a latecomer firm has gone through a process of location differentiation while it branched out. Kinpo developed its affiliates in different regions distinctively over time, and each affiliate has become specialised in different sectors. In addition to the geographical shift of its basic manufacturing from Taiwan to other countries, Kinpo also established R&D support centres elsewhere other than its Taiwanese headquarters.

# CHAPTER 6:CONCLUSION

In order to respond to the research questions set out in Chapter one, the results obtained from the research in the previous chapters are integrated below. In this concluding chapter, I first summarise my research's main findings on the technological learning processes of the case study (latecomer) firms with reference to the role of foreign MNCs. These results are then discussed in the context of the spatial division of labour. Finally, the chapter discusses the implications of the research findings for the changing international division of labour and highlights issues that have been raised.

## 6.1 The Development of Latecomer Firms

As shown in Table 6.1, the case studies can be crudely divided into two groups in terms of origins. On the one hand, TSMC is a latecomer firm that began operation in the late 1980s while CPT and Kinpo were beginners at the initial state of the electronics industry in Taiwan in the early 1970s. Interestingly, CPT and Kinpo were both established as indigenous firms in the time when the wave of FDI surged and stimulated the development of electronics industry in Taiwan. Conversely, TSMC was founded as a joint venture in the late 1980s when the FDI inflows started to experience a gradual decline.

The product range for CPT and Kinpo have focused on different segments of consumer electronics and in both cases, this range has changed over time. On the other hand, TSMC has operated as a dedicated IC foundry firm since its establishment. While both CPT and Kinpo manufacturer final consumer electronics, both firms have endeavoured to shift their major production from mature products (such as CRT monitors and calculators) to sophisticated electronics, which required higher level technology, such as TFT-LCD and notebook computers. In the case of Kinpo, it set up an individual firm for the new products while Kinpo itself retained the manufacturing of mature products. Indeed, manufacturing of 'old products' remained the primary source of their revenues as CPT and Kinpo both continued to expand the production of mature products and retained their positions as predominant global suppliers for certain consumer electronics. As the profit margin for the mature products began to decline, due to the rising local wages in Taiwan, both firms started to shift the production activities to low-cost locations, such as Malaysia, Thailand and China. Whereas both CPT and Kinpo transferred their production bases abroad, TSMC stayed behind in Taiwan, stimulated in part by government policy.

**Table 6.1: Summary of case study firms**

| | TSMC | CPT | Kinpo |
|---|---|---|---|
| Year of establishment | 1987 | 1971 | 1973 |
| Ownership pattern | Joint venture (between Philips and Taiwanese government) | Wholly owned | Wholly owned |
| Product range | Electronics component (Integrated circuits) | Consumer electronics(CRT monitors, TFT-LCD) | Consumer electronics (calculators, fax machines) |
| Employment | 16,066 (Taiwan) | 18,910 (5,600 in Taiwan) | 5,230 ( 830 in the headquarters in Taiwan) |
| Annual sales | 2003: NT$201 billion | 2003: NT$89 billion | 2003: NT$13.7 billion |
| Exports | 74% (2001) | 86% (2003) | 99% (2003) |
| Major export market | North America: 49% | Asia: 75% (with 68% to China) | Asia: 56%; North America: 31% |
| Manufacturing | Eight plants in Taiwan, three abroad (USA, Singapore, China) | Three plants in Taiwan with two plants in Malaysia and three plants in China | A major plants in China with six plants in Thailand |
| R&D expense | 2003: NT$12.7 billion (6.3% of annual sales) | 2003: NT$3.02 billion (3.4% of annual sales) | 2003: NT$0.59 billion (4.36% of annual sales) |
| R&D centre and activities | A major R&D centre in Taiwan | A major R&D centre in Taiwan | A major R&D centre in Taiwan with two R&D groups in China |

All three firms were large-scale firms with respect to both their employment and annual sales. Only Kinpo had fewer than 10,000 employees in 2004 with merely 830 employees in its headquarters in Taipei. The geographical distribution of their plants and employees revealed the importance of low-cost labour, especially in the cases of CPT and Kinpo which manufactured relatively low-end consumer electronics. While their overseas subsidiaries/plants carried out most of the labour-intensive activities, the major R&D centres all remained at their headquarters in Taiwan.

The three firms were all export-oriented. For both CPT and Kinpo, exports to Asian markets, particularly China, accounted for a significant amount of overall sales. This tendency may be explained by reference to product mix, as both firms served as major suppliers for consumer electronics products of many electronics firms which have plants in Asia. Asia has been the predominant region for consumer electronics manufacturing as most firms have shifted their production to countries like Thailand, Malaysia, Indonesia, and particularly to China in the last decade to take advantage of low production costs. On the other hand, more than half of TSMC's products were exported to North America and Asia accounts for only 6% of its export.

By its focus on the recent behaviour of three LCFs, this thesis reinforces and adds to Hobday's (1995; 1997) pioneering studies. The three latecomer firms in this thesis had made great improvements in their R&D capabilities in the last decade. Nevertheless, they still greatly relied upon foreign MNCs for key components as well as distribution channels. Although Hobday (1995) suggested that some Taiwanese latecomer firms had established OBM in some product areas in the early 1990s, all three case studies firms examined in this thesis were still constrained to OEM/ODM arrangements on which they depended for their exports by 2004.

Indeed the case studies firms considered operating under their own brand names (as OBMs) a highly risky move. The losing experience of some local firms to move towards OBM in the 1990s might explain their great hesitation to carve their own product brands and innovatory electronics items. As the evidence cited in chapter three shows, some local electronics firms in Taiwan retreated back into OEM/ODM in the early 1990s as a result of a price war led by a number of global industry leaders, such as Compaq, AST, and DELL. Since then, most local electronics firms have held back their plans to move beyond OEM/ODM. As of 2004, some Taiwanese latecomer firms, such as TSMC and CPT, have developed state-of-the-art innovation capabilities. Even so, they have remained as suppliers mainly to foreign MNCs under subcontracting and OEM/ODM arrangements. Simultaneously, they gained advantages by expanding their OEM/ODM activities into adjacent low-cost countries in East Asia, especially to China in the past decade. Although Hobday (1995) emphasized the specific contribution of SMEs toward the success of the electronics industry, several local SMEs have grown to become 'large firms' (Hayter et al. 1999) that have displaced the SMEs to dominate the electronics industry in Taiwan. Indeed, scale has become important for the Taiwanese electronics firms and the three latecomer firms examined in this thesis are all large. Indeed, internal scale is crucial to win subcontracts from leading foreign firms as well as to seize market shares. As the case studies firms have become large in scale, however, they have retained some characteristics which have made them different from most foreign MNCs and that can be summarized with reference to Hayter et al. (1999)'s work on 'large firms'. Thus TSMC and CPT have grown to fully exploit economies of scale and scope with respect to product markets but have also retained their concentration on niche markets and an entrepreneurial culture.

## 6.2 Foreign MNCs and other Sources of Technology Learning

Table 6.2 illustrates a diversity of technology learning processes used by the case study firms as they evolved over time. The learning experiences for both CPT and Kinpo at the initial stage reveal the significant role of foreign firms. This observation confirms Hobday's (1995: 35) point that "FDI and joint ventures were an important starting point for electronics, sparking off new export lines and leading to sub-contracting and OEM". The abundant FDI flows in Taiwan during the 1970s exerted a great influence on the development of both firms as well as their technology learning. As CPT received technological assistance from Toshiba which used to be part of joint ventures with CPT's parent firm, Tatung. Kinpo on the other hand, served as a supplier for foreign subsidiaries and gradually accumulated its in-house technology. Notably, foreign MNCs acted as the primary source for CPT to obtain know-how regarding production at the beginning while Kinpo had begun to make a considerable amount of money on in-house R&D.

**Table 6.2: Mechanisms of technology acquisition by the case study firms (1970 ~ 2004)**

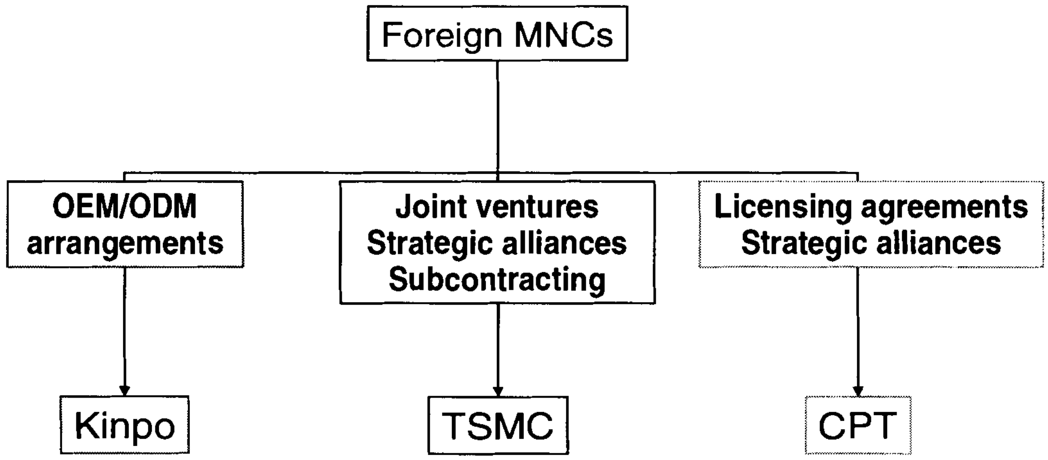
| Time | TSMC | CPT | Kinpo |
|---|---|---|---|
| 1970s | n/a | **Foreign MNCs:**<br>- *Licensing*<br>Foreign MNCs acted as the major source for technology in the form of licensing at this stage | **Foreign MNCs:**<br>- *OEM buyers*<br>Foreign OEM buyers were a source for Kinpo to accumulate its technology<br>**In–house R&D:**<br>Started to invest in R&D to develop its own technology |
| 1980s | **Foreign MNCs:**<br>- *Joint venture*<br>TSMC was a joint venture between Philips and Taiwan government, thus was able to gain direct access to training and engineering support from Philips<br>**ITRI:**<br>- *Technology transfer*<br>ITRI was the incubator of TSMC at the beginning and remained a significant source of technology learning afterward<br>**In–house R&D:**<br>Investment in in-house R&D to adapt technology from Philips and ITRI | **Foreign MNCs:**<br>- *Licensing*<br>- *OEM buyers*<br>CPT continued to rely on foreign MNCs for advanced technology in the form of technology transfer agreements as well as working under OEM arrangements.<br>**In–house R&D:**<br>CPT aimed to improve its products and raise the yield rate (process technology) | **Foreign MNCs:**<br>- *OEM buyers*<br>Kinpo had possessed adequate technological capability through its own R&D, and so the firm attracted more OEM contracts for related production and was able to learn further from its OEM buyers<br>**In–house R&D:**<br>Kinpo continuously put great effort on R&D to improve its products |
| 1990s | **Foreign MNCs:**<br>- *Customers (buyers)*<br>TSMC established a mutual benefited relationship with its foreign customers to acquire technology in exchange for the use of its foundry capacity<br>**ITRI:**<br>- *Cooperative research projects*<br>TSMC remained to cooperate with ITRI to improve process technology in 1990s<br>**In–house R&D:**<br>An increasing emphasis on developing its own technological capabilities was reflected in soaring R&D expenses. | **Foreign MNCs:**<br>- *Licensing*<br>- *Strategic alliances*<br>CPT was able to diversify its products range (TFT-LCD) by means of technical assistance agreements and licensing.<br>CPT has developed strategic alliances with foreign MNCs, mostly Japanese firms, such as Toshiba and Mitsubishi/ADI for advanced technology.<br>**In–house R&D:**<br>CPT began to pay great attention on its own R&D specifically regarding the manufacturing of new products | **Foreign MNCs:**<br>- *OEM buyers*<br>- *Overseas acquisitions and investments*<br>OEM buyers remained an important source for Kinpo to upgrade its technological capabilities<br>Kinpo also started to merge and invest in foreign high-tech firms to gain access to advanced technology.<br>**In–house R&D:**<br>Kinpo continuously put great effort on R&D to improve products, and it established R&D centres overseas to support the R&D activities in its headquarters. |

| Time | TSMC | CPT | Kinpo |
|---|---|---|---|
| 2000~ 2004 | **Foreign MNCs:**<br>- *Customers (buyers)*<br>- *Strategic alliances*<br>Although foreign MNCs remained an important source for technology through OEM arrangements, more learning occurred in the form of strategic alliances<br>**ITRI:**<br>- *Cooperative research projects*<br>TSMC possessed more advanced technology regarding certain IC foundry technology than ITRI<br>**In–house R&D:**<br>With its great input on its R&D, TSMC became a leading firm in this cutting-edge industry | **Foreign MNCs:**<br>- *Licensing*<br>- *Strategic alliances*<br>CPT remained in the technology cooperation contracts with Mitsubishi Electronics.<br>CPT had several license agreements with foreign MNCs, such as Toshiba, Mitsubishi ADI, and Sharp.<br>**ITRI:**<br>- *Licensing*<br>Purchased certain patents from ITRI<br>**In–house R&D:**<br>As a result of the increasing licensing fees which became a great burden for the firm as well as involving in patent infringement lawsuits, CPT has increased to invest in its in-house R&D | **Foreign MNCs:**<br>- *OEM/ODM buyers*<br>- *Overseas acquisitions and investments*<br>Kinpo diversified its product range and became a conglomerate consisting of several big electronics firms; most of the firms among the Kinpo group acted as major suppliers for foreign firms.<br>**In–house R&D:**<br>Kinpo has gradually raised its R&D expenses. After the firm shifted all its manufacturing to China in 2002, the Taipei headquarters was then designated as a R&D centre with links to its two R&D groups in China |

Source: author's research files

In the 1980s while the wave of FDI started to fall and many foreign electronics ceased their manufacturing in Taiwan, foreign MNCs remained important for all three case study firms. Each case study firm accumulated its technological capabilities from foreign firms through various channels. In addition, and unlike the other two case studies, TSMC received technical assistance from the national research institute (ITRI). While TSMC obtained direct access to training and engineering support from Philips under its joint venture, CPT and Kinpo both relied on their foreign buyers to improve their technological capabilities mainly through OEM arrangements. As CPT and Kinpo started to become reliable suppliers during this period, the OEM arrangements led to close long-term technological relationships as foreign MNCs began to depend on the favourable quality and price of their final output.

**Figure 6.1: Foreign MNCs as source for technology learning**




As shown in Table 6.2 and Figure 6.1, each firm has followed a different route regarding their technology learning. At the same time, they have continued to acquire advanced technology from foreign MNCs. However, the in-house R&D efforts of each firm have gradually increased as they came to fully recognise the importance of developing their own technologies as well as their own patents.

While foreign MNCs continued to act as a significant source for technology learning into the 1990s, TSMC and CPT both began to pay close attention to their in-house R&D activities. Meanwhile, Kinpo purchased overseas companies as well as progressively invested in its own R&D. During the 1990s, CPT attempted to transform itself to a devoted manufacturer of highly sophisticated consumer electronics, namely the TFT-LCD, through making a momentous technical assistance agreement as well as licensing agreement with Mitsubishi. With respect to the manufacturing of new products, CPT acquired technical support from Mitsubishi Electronics in various forms, including personnel training, information on product designs as well as advice on equipment and material procurement. This technical assistance and transfer agreement notably included 'transplants' of the first TFT-LCD plant. More specifically, Mitsubishi Electronics provided all the necessary knowledge as well as fine tuned the machinery and equipment for the development of CPT's first TFT-LCD plant, and engineers from Mitsubishi Electronics not only helped to supervise the start-up of new operations but assisted to train the local personnel. Surprisingly, after adopting the technology from Mitsubishi

Electronics, CPT was soon able to improve its process technology and build a second plant on its own, which according to the manager from CPT, was different from the original model plant from Mitsubishi Electronics regarding the production process.

## 6.3 The Formation of ESS and the International Division of Labour

The geographical distribution of the major functions of each firm is briefly summarised in Table 6.3. In terms of the spatial division of labour, each firm reveals the increasing impact and vital role of locally based latecomer firms. As each firm gradually grew to become significant manufacturers as well as notable suppliers for consumer electronics that operate internationally, they began to shift their manufacturing activities to other lower cost countries. However, their new R&D centres remained in Taiwan, apart from Kinpo.

**Table 6.3: The geographical distribution of firm's functional sectors**

| | TSMC | CPT | Kinpo |
|---|---|---|---|
| Headquarters | Taiwan (Hsinchu Science Park) | Taiwan (Taoyuan) | Taiwan (Taipei) |
| R&D centre | Taiwan (Hsinchu Science Park) | Taiwan (Taoyuan) | Taiwan (Taipei) |
| R&D support centre | n/a | n/a | China (Shanghai and Beijing) with 400 employees |
| Location of Manufacturing | - Taiwan: Eight plants with16,066 employees<br>- China: One plant in Shanghai<br>- Singapore: One plant<br>- USA: One plant | - Taiwan: Three plants with 5,605 employees<br>- China: Three plants with 8,015 employees<br>- Malaysia: Two plants with 5,290 employees | - China: One plant with 4,000 employees<br>- Thailand: Six plants with 6,100 employees |

Source: author's research files

In terms of R&D activities, only Kinpo has set up overseas R&D centres in Shanghai and Beijing to support its major R&D centre in Taiwan. In response to concerns about spillovers of technology from its overseas subsidiaries to rivals, Kinpo has tried to divide its R&D projects into various parts and assign different activities to different R&D groups. It hopes that such fragmentation will lead to the integration of all R&D efforts.

All three firms have established plants overseas; China particularly became the most favourable location after the Taiwanese government loosened the restrictions over investment in China in 1992. TSMC finally set up its first lower-level foundry in China (Shanghai) even though the Taiwanese government still exercises great restraint on outward FDI from designated industries, such as advanced IC foundries (12-inch wafer) and the latest generation of TFT-LCD panels manufacturing. In the case of CPT, standardized mature products were made in its overseas plants while new and sophisticated products were manufactured in their latest plants in Taiwan. Significantly, CPT began to shift part of its TFT-LCD production to its plants in China while the most advanced production remained in Taiwan. Kinpo, on the other hand, was a relatively extreme case as it had ceased all manufacturing activities in Taiwan and continued to expand production at its China plants.

The findings from the case studies revealed the increasingly important role of the locally based large firms in Taiwan. In the past few decades, Taiwan has been a notable performer among the Asian latecomers with the share of indigenous firms in the output of the electronics industry. As locally based latecomer firms became increasingly important within the global market, they have started to exert a great influence on the international division of labour through their FDI in other countries. Whereas foreign MNCs from industrialised countries remained important with respect to the source of technology learning, latecomer firms have shown a strong tendency to displace the foreign MNCs as the drivers of a changing international division of labour, at least in East Asia. Scott's (1987) observation that the international division of labour within Asian has become more complex, and connected to a broader global division, remains valid. With the expansion of in-house R&D and manufacturing investments in China Taiwanese firms have developed a more sophisticated role in this evolution.

## 6.4 Conclusion

As Hayter and Edgington (2004) suggest, latecomer firms seek to progressively improve their technological capabilities by moving back along the product life cycle and the cases of CPT and Kinpo confirm the reverse product cycle model with their specific technology learning routes to a certain extent. Both firms began with manufacturing mature products mainly under OEM arrangements while exploiting low-cost unskilled labour force. Moreover, working under OEM arrangements permitted greater assimilation of their technological capabilities. Over time, both firms' in-house technology became more advanced and promoted the manufacture of more sophisticated products even as the firms gradually lost their advantage regarding the production costs. While both CPT and Kinpo put significant efforts on in-house R&D and made remarkable advances in technological competence, they still lacked sufficient capabilities for product innovation. In fact, all the case study firms have showed a strong tendency to 'take over' the outcome of leading firms' R&D. Thus, they acquired technologies for new and sophisticated products and improved their product design as well as process technologies, and finally made themselves become the indispensable suppliers for their former teachers, the foreign MNCs. As a result, these firms continued to depend upon foreign MNCs to advance their technological capabilities through licensing, OEM/ODM arrangements and strategic alliances.

Although all the case study firms endeavoured to develop technological capabilities and invested a considerable amount in in-house R&D, they failed to establish sufficient capabilities for product innovation and move further back along the product cycle model to the final stage. To a certain degree, they have begun to compete with foreign leaders at the technology frontier. However, as of 2004, they still acted as suppliers for other firms under OEM/ODM arrangements.

Some researchers believe that the main barrier to Taiwanese firms moving into the technology intensive stage of the product cycle model is due to a lack of capital for their in-house R&D activities (Hobday, 1995, 1997; Ernst, 2000). The findings from this research, however, suggest other explanations. The assumption of a shortage of capital for R&D obviously does not apply to large firms such as TSMC and CPT. Table 6.1 indicates that both firms invested a considerable amount in their in-house R&D as TSMC and CPT spent NT$ 12.7 billion (about US$ 384.8 million) and NT$ 3.02 billion (about US$ 91.5 million) respectively by 2003.

The point is all three firms put great emphasis on making improvements in product, design and process technologies. The main goal of those firms has been to improve their products, to reduce production costs and to raise the yield rate rather than to invent 'new products'. As a result, those firms have made themselves indispensable manufacturers and suppliers instead of innovative leading firms of brand new electronics products.

Aside from the failure to achieve radical product innovation, another reason which may explain why latecomer firms in Taiwan remain followers is the lack of their own brand names. Apart from TSMC that has designated itself as an IC foundry-only firm since establishment, both CPT and Kinpo have continued operating under OEM/ODM arrangements. As the vice president of Kinpo noted, "Developing our own brand name is risky as it will take a long time to promote a new brand to the market. Meanwhile we might lose our (OEM) customers if we compete directly with them in the market". To avoid the risk of launching own-brand products, both firms remained operating under the OEM/ODM arrangements.

As Taiwanese latecomer firms have become multinational corporations themselves and have invested in R&D, have remained controlled in Taiwan and their growth has had a major impact on their country. Still their manufacturing activities have been closely integrated with most countries in East Asia. As regards technology learning, they have attempted to follow the trajectory of the 'reverse product cycle model' and to develop enter state-of-the-art innovation capabilities in the electronics industry. Latecomer firms have made a difference in Taiwan and they continue to be a local driving force in the IDL.

# REFERENCE LIST


Altvater, E. (1992). Fordist and post-fordist international division of labour and monetary regimes. In M. Storper and A. J. Scott (Eds.) Pathways to industrialization and regional development. London ; New York, Routledge: 21-45.

Amsden, A. H. (1989). Asia's next giant : South Korea and late industrialization. New York, Oxford University Press.

Amsden, A. H. and Chu, W. (2003). Beyond late development : Taiwan's upgrading policies. Cambridge, Mass., MIT Press.

Aoki, M., Kim, H.-K. and Okuno, M. (1997). The role of government in East Asian economic development : comparative institutional analysis. Oxford and New York, Clarendon Press.

Ap and Bloomberg. (Nov 12th, 2004). "Morris Chang puts price on 65nm." Taipei Times. Taipei: 10.

Appelbaum, R. P. and Henderson, J. W. (1992). States and development in the Asian Pacific rim. Newbury Park, California, Sage Publications.

Asanuma, B. (1989). "Manufacturer-Supplier Relationships in Japan and the Concept of the Relation-Specific Skill." Journal of the Japanese and International Economies **3**: 1-30.

Athukorala, P. and Hill, H. (2002). Host-country impact of FDI in East Asia. In B. Bora. (Eds.) Foreign direct investment : research issues. London, Routledge: 168-194.

Bell, M. and P., K. (1993). "Technological accumulation and industrial growth: Contrasts between developed and developing countries." Industrial and Corporate Change **2**(2): 157-210.

Bellak, C. and Cantwell, J. (1998). Globalization tendencies relevant for latecomers: some conceptual issues. In M. Storper, S. Thomadakies and L. J. Tsipouri. (Eds.) Latecomers in the global economy. London, Routledge: 40-75.

Bernard, M. and Ravenhill, J. (1995). "Beyond product cycles and flying geese-regionalization, hierarchy, and the industrialization of East Asia." World Politics **47**: 171-209.

Blomstrom, M. (1986). "Foreign Investment and Productive Efficiency: The Case of Mexico." Journal of Industrial Economics **35**: 97-110.

Blomstrom, M. and Persson, H. (1983). "Foreign Investment and Spillover Efficiency in an Underdeveloped Economy: Evidence from the Mexico Manufacturing Industry." World Development **11**: 493-501.

Bluestone, B. and Harrison, B. (1982). The deindustrialization of America : plant closings, community abandonment, and the dismantling of basic industry. New York, Basic Books.

Bora, B. (2002). Foreign direct investment : research issues. London, Routledge.

Borrus, M. (1993). "The regional architecture of global electronics: trajectories, linkages and access to technology." Business and the Contemporary World **5**(2): 151-174.

Borrus, M., Ernst, D. and Haggard, S. (2000). Introduction: cross-border production networks and the industrial integration of the Asia-Pacific region. In M. Borrus, D. Ernst and S. Haggard. (Eds.) International production networks in Asia : rivalry or riches? London ; New York, Routledge: 1-30.

Bridge News. (Sep 18th, 1999). Kinpo electronics announced selling its Cal-comp stocks. Bridge News. Taipei: 18.

Cal-comp Electronics. (2004). http://www.calcomp.com.tw/, Cal-comp.

Cantwell, J. (1994). Introduction. In J. A. Cantwell. (Eds.) Transnational corporations and innovatory activities. London, Routledge: 1-25.

Cantwell, J. and Molero Zayas, J. (2003). Multinational enterprises, innovative strategies and systems of innovation. Cheltenham, UK ; Northampton, MA, Edward Elgar.

Caporaso, J. A. (1987). The international division of labour: A theoretical overview. In J. A. Caporaso (Eds.) A Changing international division of labor. Boulder London, L. Rienner ; F. Pinter: 1-42.

Chang, H.-J. (2003). Industrial policy and East Asia: the miracle, the crisis and the future. In K. S. Jomo (Eds.) Manufacturing competitiveness in Asia : how internationally competitive national firms and industries developed in East Asia. New York, Routledge: 18-40.

Chaponniere, J. R. and Lautier, M. (1998). Industrial policy for catching up: the case of Taiwan. In M. Storper, S. Thomadakies and L. J. Tsipouri (Eds.)Latecomers in the global economy. London, Routledge: 224-253.

China Post. (July 28th, 1992). various issues. China Post. Taipei: 9.

Chiu, Y. P. (2002). Outsourcing of Knowledge-The Cases of MNCs' Subsidiaries in Taiwan. Taipei, National Chengchi University.

Chung, C. (1997). Division of Labour across the Taiwan Strait: Macro Overview and Analysis of the Electronics Industry. In B. Naughton and University of California Institute on Global Conflict and Cooperation (Eds.)The China circle : economics and electronics in the PRC, Taiwan, and Hong Kong. Washington, D.C., Brookings Institution Press: 210-253.

Chunghwa Picture Tubes Ltd. (2004). http://www.cptt.com.tw/. Taoyuan, CPT.

Chunghwa Picture Tubes Ltd. (various years). CPT Annual report. Taoyuan, CPT.

Cohen, R. and Kennedy, P. M. (2000). Global sociology. Basingstoke, Macmillan Press.

Compal Electronics. (2004). http://www.compal.com/index_En.htm, Compal.

Cooke, I. M. and Mayes, P. (1996). Introduction to innovation and technology transfer. Boston, Artech House.

Council for Economic Planning and Development, Taiwan (various years). Taiwan Statistical Data Book. Taipei, CEPD.

Cumings, B. (1984). "The Origins and Development of the Northeast Asian Political Economy: Industrial Sector, Product Cycles and Political Consequences." International Organization **38**(3).

Dedrick, J. and Kraemer, K. L. (1998). Asia's computer challenge : threat or opportunity for the United States & the world? New York, Oxford University Press.

Dicken, P. (2003). Global shift : reshaping the global economic map in the 21st century. London ; New York, Sage.

Edgington, D. W. (1997). The rise of the Yen, hollowing out and Japan's troubled industries. In R. F. Watters and T. G. McGee (Eds.) Asia Pacific: New geographies of the Pacific Rim. Vancouver, UBC Press: 170-189.

Edgington, D. W. (1999). "Firms, governments and innovations in the Chukyo region of Japan." Urban Studies **36**: 305-339.

Edgington, D. W. and Hayter, R. (2000). "Foreign Direct Investment and the Flying Geese Model: Japanese Electronics Firms in Asia." Environment and Planning A **32**: 281-304.

Electronics Research and Service Organization, Taiwan (1994). ERSO: The first twenty years. Hsinchu, ITRI, Electronics Research Organization.

Ernst, D. (2000). What permits David to grow in the shadow of Goliath? The Taiwanese model in the computer industry. In M. Borrus, D. Ernst and S. Haggard (Eds.) International production networks in Asia : rivalry or riches? London ; New York, Routledge: 110-140.

Executive Yuan, Taiwan (1988). Taipei, Science and Technology Advisory Group of the Executive Yuan.

Feagin, J. R., Orum, A. M. and Sjoberg, G. (1991). A Case for the case study. Chapel Hill, University of North Carolina Press.

Fok, J. T. Y. (1991). Electronics, Doing Business in Today's Hong Kong. American Chambers of Commerce, December.

Fröbel, F., Heinrichs, J. and Kreye, O. (1980). The new international division of labour : structural unemployment in industrialised countries and industrialisation in developing countries. Cambridge ; New York, Cambridge University Press.

Gee, S. (1981). Technology transfer, innovation, and international competitiveness. New York, Wiley.

Gereffi, G. (1994). The organization of buyer-driven global commodity chains: How U.S. retailers shape overseas production networks. In M. Korzeniewicz and G. Gereffi. Westport, Conn.(Eds.) Commodity chains and global capitalism., Greenwood Press: 95-122.

Gereffi, G. (1996). "Commodity chains and regional division of labour in East Asia." Journal of Asian Business **12** (**1**): 75-112.

Gereffi, G. and Asian Development Bank. (2002). The international competitiveness of Asian economies in the apparel commodity chain. Manila, Philippines, Asian Development Bank.

Gerschenkron, A. (1962). Economic backwardness in historical perspective : a book of essays. Cambridge, Belknap Press of Harvard University Press.

Giroud, A. (2003). Transnational corporations, technology, and economic development : backward linkages and knowledge transfer in South East Asia. Cheltenham, UK ; Northhampton, MA, Edward Elgar.

Guerrieri, P. (2000). International competitiveness, regional integration, and corporate strategies in the East Asian electronics industry. In M. Borrus, D. Ernst and S. Haggard (Eds.) International production networks in Asia : rivalry or riches? London ; New York, Routledge: 31-56.

Hayter, R. (1982). Technological capability in the forest product sector of British Columbia : an exploratory inquiry. Burnaby, B.C., Simon Fraser University.

Hayter, R. (1997). The dynamics of industrial location : the factory, the firm, and the production system. Chichester ; New York, Wiley.

Hayter, R. (1997). comments on 'The dynamics of industrial location : the factory, the firm, and the production system', SFU Website.

Hayter, R. and Edgington, D. W. (2004). "Flying geese in Asia: The impacts of Japanese MNCs as a source of Industrial learning." Tijdschrift voor Economische en Sociale Geografie **95**(1): 3-26.

Hayter, R., Patchell, J. and Rees, K. (1999). "Business segmentation and locationi revisited: Innovation and the Terra Incognita of large firms." Regional studies **33**(5): 425-442.

Henderson, J. (1997). The Changing International Division of Labour in the Electronics Industry. Regionalization and labour market interdependence in East and Southeast Asia. D. C. Campbell. London, Macmillan: 92-126.

Higgott, R. (1987). The Dilemmas of Interdependence: Australia and the International Division of Labour in the Asia-Pacific Region. In J. A. Caporaso(Eds.)A Changing international division of labor. Boulder London, L. Rienner; F. Pinter: 147-186.

Hirsch, S. (1967). Location of industry and international competitiveness. Oxford, Clarendon Press.

Hobday, M. (1995). Innovation in East Asia : the challenge to Japan. Aldershot, Hants, England ; Brookfield, Vt., E. Elgar.

Hobday, M. (1997). “Latecomer catch-up strategies in electronics: Samsung of Korea and Acer of Taiwan.” Asia Pacific Business Review **4** (2/3): 48-83

Hoesel, R. (1999). New multinational enterprises from Korea and Taiwan : beyond export-led growth. London ; New York, Routledge.

Hong, Y.-Y. (2003). Innovation engine: ITRI, the driving force for the success of Taiwan's industry (in Chinese). Taipei, Tian-Xia magazine.

Horaguchi, H. and Shimokawa, K. (2002). Japanese foreign direct investment and the East Asian industrial system : case studies from the automobile and electronics industries. Tokyo ; Berlin, Springer.

Hou, C.-M. and Gee, S. (1993). National Systems Supporting Technical Advance in Industry: The Case of Taiwan. In R. R. Nelson (Eds.) National Innovation Systems: A Comparative Analysis. New York, Oxford University Press: 384-413.

Jomo, K. S. (2003). Manufacturing competitiveness in Asia : how internationally competitive national firms and industries developed in East Asia. New York, Routledge.

Kim, L. (1997). Imitation to innovation : the dynamics of Korea's technological learning. Boston, Harvard Business School Press.

Kinpo Electronics. (2004). http://www.kinpo.com.tw/english/index.htm, Kinpo.

Kinpo Electronics. (various years). Kinpo annual reports. Taipei, Kinpo Group.

Koike, K. and Inoki, T. (1990). Skill formation in Japan and Southeast Asia. Tokyo, University of Tokyo Press.

Kuhn, R. L. (1982). Mid-sized firms : success strategies and methodology. New York, N.Y., Praeger.

Kuhn, R. L. (1985). To flourish among giants : creative management for mid-sized firms. New York, John Wiley.

Kumar, N. (1998). Globalization, foreign direct investment and technology transfers : impacts on and prospects for developing countries. London ; New York, Routledge.

Lall, S. (1990). Building industrial competitiveness in developing countries. Paris, France, Development Centre of the Organisation for Economic Co-operation and Development.

Lee, C.-S. and Pecht, M. (1997). The Taiwan electronics industry. Boca Raton, Fla., CRC Press.

Li, C. Y. (2001). The spillover effect of FDI on Taiwanese manufacturing Industries. Taipei, Taiwan, National Taiwan University.

Liberty Times News. (Sep 29$^{th}$, 2003). The TFT-LCD industry (in Chinese). Liberty Times. Taipei: 32.

Lipietz, A. (1986). New tendencies in the international division of labour: regimes of accumulation and modes of regulation. In A. J. Scott and M. Storper (Eds.) Production, work, territory : the geographical anatomy of industrial capitalism. Boston, Allen & Unwin: 16-40.

Malerba, F. (1992). "Learning by Firms and Incremental Technical Change." The Economic Journal **102**: 845-859.

Massey, D. B. (1984). Spatial divisions of labour : social structures and the geography of production. London, Macmillan Education.

Mathews, J. A. and Cho, D.-S. (1999). "Combinative capabilities and Organizational learning in Latecomer firms: the case of the Korean semiconductor industry." Journal of World Business **34**(2): 139-156.

Mathews, J. A. and Cho, D.-S. (2000). Tiger technology : the creation of a semiconductor industry in East Asia. Cambridge ; New York, Cambridge University Press.

Mody, A. (1990). "Institutions and dynamic comparative advantage: the electronics industry in South Korea and Taiwan." Cambridge Journal of Economics **14**: 291-314.

Moosa, I. A. (2002). Foreign direct investment : theory, evidence and practice. Oxford ; New York, Palgrave.

Nakamura, H. (1990). New mid-sized firm theory. Tokyo, Tokyo Keizai Shinpansha.

Naughton, B. (1997). Economic Policy Reform in the PRC and Taiwan. In B. Naughton and University of California Institute on Global Conflict and Cooperation. The China circle : economics and electronics in the PRC, Taiwan, and Hong Kong. Washington, D.C., Brookings Institution Press: 81-110.

Naughton, B. and University of California Institute on Global Conflict and Cooperation. (1997). The China circle : economics and electronics in the PRC, Taiwan, and Hong Kong. Washington, D.C., Brookings Institution Press.

Patchell, J. and Hayter, R. (1995). "Skill Formation and Japanese Production Systems." Tijdschrift voor economische en sociale Geografie **86**: 339-356.

Poon, T. S.-C. (2002). Competition and cooperation in Taiwan's information technology industry : inter-firm networks and industrial upgrading. Westport, Conn., Quorum Books.

Quadrio Curzio, A. and Fortis, M. (2002). Complexity and industrial clusters : dynamics and models in theory and practice. Heidelberg ; New York, Physica-Verlag.

Reed Electronics Research. various years (1994-2003). Yearbook of World Electronics Data. Wantage, Reed Electronics Research.

Rodrigo, G. C. (2001). Technology, economic growth and crises in East Asia. Northampton, Mass., Edward Elgar Pub.

Sato, Y. (1997). "Diverging development paths of the electronics industry in Korea and Taiwan." Developing Economies **35**(4): 401-421.

Saunders, M., P. Lewis and A. Thornhill (1997). Research Method for Business Students. Harlow, Pearson Education.

Schive, C. (1990). The foreign factor : the multinational corporation's contribution to the economic modernization of the Republic of China. Stanford, CA, Hoover Institution Press.

Schive, C. and Simon, D. (1986). Taiwan's information industry: the role of the state in the development of high-tech industry. In F. W. Rushing and C. G. Brown (Eds.) National policies for developing high technology industries : international comparisons. Boulder, Colo., Westview Press: xiv, 247.

Scott, A. J. (1987). "The semiconductor industry in South-East Asia: organization, location and the international division of labour." Regional studies **21**(2): 143-160.

Scott, A. J. and Storper, M. (1986). Production, work, territory : the geographical anatomy of industrial capitalism. Boston, Allen & Unwin.

Scott, A. J. and Storper, M. (1992). Industrialization and regional development. In M. Storper and A. J. Scott (Eds.) Pathways to industrialization and regional development. London ; New York, Routledge: 3-20.

Seidman, I. (1998). Interviewing as qualitative research : a guide for researchers in education and the social sciences. New York ; London, Teachers College Press.

Simon, H. (1960). The new science of management decision. New York, Harper Row.

Skak, M. (1987). The new international division of labour and East-south relations. In J. A. Caporaso(Eds.) A Changing international division of labor. Boulder, London, L. Rienner ; F. Pinter: 123-146.

Stopford, J. (1995). Building Regional Networks: Japanese Investments in Asia. London, London Business School.

Storper, M. (1998). Industrial policy for latecomers: products, conventions, and learning. In M. Storper, S. Thomadakis and L. J. Tsipouri (Eds.) Latecomers in the global economy. London, Routledge: 13-39.

Storper, M. and Scott, A. J. (1992). Pathways to industrialization and regional development. London ; New York, Routledge.

Storper, M., Thomadakis, S. and Tsipouri, L. J. (1998). Latecomers in the global economy. London, Routledge.

Taiwan, Industrial Technology Research Institute (1999). Taiwan's prospect for development the TFT-LCD industry. Hsinchu, ITRI.

Taiwan, Industrial Technology Research Institute (2000). Study of Taiwan's semiconductor companies. Hsinchu, ITRI.

Taiwan, Industrial Technology Research Institute (2000). Performance evaluation of the program for promoting cooperative competitiveness. Taipei, IEK, ITRI.

Taiwan, Ministry of Economic Affairs (various years). Customs import tariff and classification of import and export commodities of the Republic of China. Taipei, Board of Foreign Trade, MOEA.

Taiwan, Ministry of Economic Affairs (various years). Industrial Production Statistics Monthly, Taiwan Area, Republic of China. Taipei, MOEA.

Taiwan, Ministry of Economic Affairs (various years). Statistics on overseas Chinese and foreign investment. Outward investment, outward technical cooperation, indirect

Mainland investment, Guide of Mainland industry technology, Republic of China. Taipei, Investment Commission, MOEA.

Taiwan, Ministry of Economic Affairs (various years). Survey of foreign direct investment and analysis of its contribution to Taiwan's economic development. Taipei, Investment Commission, MOEA.

Taiwan, Ministry of Finance (2004). DGBAS Website, http://www.mof.gov.tw/statistic/.

Taiwan, Ministry of Finance (various years). Monthly statistics of Exports and Imports. Taipei, Ministry of Finance.

Taiwan National Science Council. (various years). Yearbook of Science and Technology. Taipei.

Taiwan Semiconductor Manufacturing Company Ltd. (2004). http://www.tsmc.com/english/default.htm, TSMC. **2004**.

Taiwan Semiconductor Manufacturing Company Ltd. various years (1999-2003). TSMC Annual report. Hsinchu, TSMC.

Takayasu, K. and Ishizaki, Y. (1995). "The changing international division of labor of Japanese electronics industry in Asia and its impact on the Japanese economy." Pacific Business and Industries **27**: 2-41.

Tang, C. M. (2001). Foreign Direct Investment and Technology Transfer: Evidence from Taiwan Manufacturing Industries. Tainan, Taiwan, National Cheng Kung University.

United Nations Conference on Trade and Development. (1999). Foreign direct investment and the challenge of development. New York, United Nations.

United Nations Conference on Trade and Development. (2001). Promoting linkages. New York, United Nations.

United Nations Conference on Trade and Development. (2004). The shift towards services. New York, United Nations.

United Nations. Economic and Social Commission for Asia and the Pacific. (1999). Development of the export-oriented electronics goods sector in Asia and the Pacific. New York, United Nations.

Urata, S. (1998). Japanese Foreign Direct Investment in Asia: Its Impact on Export Expansion and Technology Acquisition of the Host Countries. In J. H. Kumar, R.E. Lipsey J.P. Agarwal and S. Urata (Eds.) Globalization, foreign direct investment and technology transfers : impacts on and prospects for developing countries. London ; New York, Routledge: 146-170.

Valentine, G. (1997). Tell me about it : using interviews as a research methodology. In R. Flowerdew and D. Martin (Eds.) Methods in human geography : a guide for students doing a research project. Harlow, Longman: xv, 296.

Veltz, P. (1991). New models of production organisation and trends in spatial development. In G. Benko and M. Dunford (Eds.) Industrial change and regional development : the transformation of new industrial spaces. London ; New York, Belhaven Press: xvi, 329.

Vernon, R. (1966). "International Investment and International Trade in the Product Cycle." Quarterly Journal of Economics **80**: 190-207.

Vernon, R. (1971). Sovereignty at bay : the multinational spread of U.S. enterprises. New York, Basic Books.

Wang, K. (2002). High-tech industrial clusters in the Asian countries : the case of the electronics industry in the Hsinchu-Taipei region. In A. Quadrio Curzio and M. Fortis (Eds.) Complexity and industrial clusters : dynamics and models in theory and practice. Heidelberg ; New York, Physica-Verlag: viii, 307.

Wilkinson, B., Gamble, J., Humphrey, J., Morris, J. and Anthony, D. (2001). "The New International Division of Labour in Asian Electronics: Work Organization and Human Resources in Japan and Malaysia." Journal of Management studies **38**(5): 675-695.

World Bank. (1993). The East Asian miracle : economic growth and public policy. New York, N.Y., Published for the World Bank by Oxford University Press.

Wortzel, L. H. and Wortzel, H. V. (1981). "Export Marketing Strategies for NIC and LDC-based Firms." Columbia Journal of World Business **Spring**: 51-60.

Wu, R.-I. and Tseng, M.-S. (2003). Taiwan's information technology industry. In K. S. Jomo (Eds.) Manufacturing competitiveness in Asia : how internationally competitive national firms and industries developed in East Asia. New York, Routledge: 75-105.

Yin, R. K. (1993). Applications of case study research. Newbury Park, Calif., SAGE Publications.

Yin, R. K. (1994). Case study research : design and methods. Thousand Oaks, Sage Publications.

Yong, P. E. (2003). Behind POSCO'S success: the role of government in technology capability building. In K. S. Jomo (Eds.) Manufacturing competitiveness in Asia : how internationally competitive national firms and industries developed in East Asia. New York, Routledge: 41-74.

Yu, P.-L. and Zhang, J. (2001). Made by Taiwan : booming in the information technology era. River Edge, NJ, World Scientific.

Zhang, Y. (2003). Pacific Asia : the politics of development. New York, Routledge.

# APPENDICES

## Appendix A: List of Respondents

The following list includes respondents who were interviewed in-depth. The interview dates and the position of each respondent in winter 2003 are below.

### 1. Taiwan Semiconductor Manufacturing Co., LTD. (TSMC)

Personal Interview

Date: Oct 3rd, 2003

Interviewee: Jack (Wei-Zhong) Feng

Position: General Secretary in Human Resource development

### 2. Chunghwa Picture Tubes, Ltd. (CPT)

Personal Interview

Date: Oct 15th, 2003

Interviewee: Lin Yen-Chung

Position: Manager of Corporate Management Division

### 3. Kinpo Electronics, Inc.

Personal Interview

Date: Oct 21st, 2003

Interviewee: Pearce Chiu

Position: Vice president & special assistant to chairman

## Appendix B: Sample Interview Questions

The following is a sample of the interview questions that were applied to the respondents listed on last page. These questions were used as a guideline only.

**A. Background Information on Firm as a Whole**

1. Name and position of respondent: ______________________
2. Name of the company:______________________
3. Ownership: ______________________
4. Product range: 1990 ______________________________

   2002______________________________________________
5. Number of employees: 1990_________ 2002______________
6. Head-office employees: 1990__________2002______________
7. Research and development (R&D) employees: 1990________ 2002________
8. Since 1990 has your R&D group patented any products (or processes? Yes_____ No

   ____
9. If yes, how many? _____ And are these patents: Very important _______

   Important ____ Somewhat important ____ Not too important _______
10. Indicate the location of your factories in Taiwan: ________________
11. For each of these factories, estimate number of employees in 1990 and 2002:
12. For each of these factories indicate year of establishment:
13. For each of these factories outline the general nature of the product-mix:
14. If possible, estimate the sales and exports of your firm:

    1990: Sales_______ Exports____

    2002: Sales_______ Exports____

    (Alternatively estimates of production volumes can be provided)
15. What were your main export markets (in percentages of exports) in:

    1990: US____ % Asia ______% Other _____%

    2002: US____ % Asia ______% Other _____%
16. Do you have branch plants outside of Taiwan? Yes __ No ___
17. If yes to question 16, if possible, indicate locations of these factories, year f start-up and their product mix in 2002.

**B. Information on Selected (one or two) Factories**

I would also like to obtain information on one or preferably two factories if at all possibly. Ideally, at least one of these factories should be manufacturing relatively sophisticated products.

The second factory might manufacture older products. For these factories I would like to obtain information on their employment structures in 1990 and 2002.

Employment profile

1. Name and location of factory: ______________________________
2. Name and position of respondent: _________________________
3. Production volumes (or values): 1990 ___________________

   2002 ________________________________
4. Number of employees (total): 1990 ____ 2002 ______
5. Number of males 1990 and 2002 ______ Number of females 1990 and 2002 _______
6. Number of white collar or professional workers: 1990 ___ 2002 ____
7. Number of blue collar workers: 1990 _____ 2002 ____
8. Occupational structure of blue collar workers:

| | 1990 | 2002 |
|---|---|---|
| Production workers | | |
| a) skilled | | |
| b) semi-skilled | | |
| c) unskilled | | |
| Tradesmen | | |
| Other | | |

9. With respect to production workers indicate entry level qualifications (if any):

   1990_________________________ 2002 _________________________

   a) Do you evaluate [2002] new production workers before you hire them? Yes___ No ___

      If yes, how: ________________________________________

   b) What changes have occurred in these evaluations, if any, since 1990? _________

   c) Is it difficult to recruit new workers? _________________. Is it easier or more difficult [since 1990] now to recruit new workers? ___________________ Explain any changes:

      ____________________________________________________

   d) Approximately, what is the average age of your production workers?

   e) 1990 ___ 2002 ____

   f) Approximately, what is the average number of years of school education reached by your production workers? 1990 ______ years 2002 ______ years

   g) Are newly hired production workers given any basic training prior to starting their jobs? 1990: yes ___ no ____ 2002: yes ____ no _____ If yes how long is this training? 1990 _____ 2002 ______

   h) How long does it take for a production worker to learn his/her job properly?________ weeks/months?

i) Are workers expected to perform one highly specialized task: yes ____ no ___ or do workers rotate among several jobs? Yes ______ No _________.

j) What changes, if any, have occurred in job rotation practices since 1990: ________ How many different jobs is a production worker expected to do when fully trained? 1990 _______ 2002 _________ How long does it take a production worker to become fully trained: 1990 ______ months/years 2002 _________ months/years

10. Indicate the main changes, and their reasons, in the nature of work in this factory since 1990:
11. Have production workers had to learn new skills since 1990? Yes __ No __
12. If yes, what are these skills? ________________________________
13. Do production workers participate in any off the job training? Yes __ No __
14. If Yes in question 22, what is the nature of this training and how many workers are involved?
15. Do any of your production workers have training certificates of some kind? Yes __ No:__.
16. Do production workers perform any supervisory duties? 1990: yes ____ no _____ 2002: yes ___ no _____
17. Do you expect your production workers to help solve problems such as when:
    Machines break down: Yes ___ No ________
    The product mix is changed: Yes ___ No ________
    New technology is introduced: Yes ___ No ____
18. What do you think of the problem solving abilities of your production workers?
    Excellent ___ good _____ satisfactory ____ poor _____
19. Have the problem solving abilities of your production workers improved since 1990?
    Yes ___ No ____ If yes, comment: ___________________________
20. If possible, give examples of how production workers have helped solved problems in this factory. ________________________________________________

21. Identify the main group of tradesman and technologists

| | 1990 | 2002 |
|---|---|---|
| electricians | | |
| welders | | |
| computer technicians | | |
| other (specify) | | |

22. Is any group that is listed above unionized?

    Yes___ No___ If yes, the name(s) and number of the union:______________________

23. What are the qualifications of tradesmen? ________________________________

24. Indicate the nature of training in 2002 by tradesmen:

    On the job: __________________________________________

    Off the job: __________________________________________

25. Indicate how the nature of the skills of tradesmen have changed since 1990: ____

26. Do you have an apprenticeship programme? 1990: Yes ____ No ___ 2002: Yes ____ No ___

27. If your answer is 'no' in question 34 how are your tradesmen trained and what are their qualifications? 1990 ____________________________________

    2002: _________________________________________________________

28. In this factory, is some form of 'kaizen' practiced?

29. At this factory, what new products, if any, have been introduced since 1990:

30. Were any of these products developed by your R&D department: Yes ___ No ___ If yes, indicate the product _______________

31. At this factory, what new products, if any, have been manufactured under license since 1990: ___________________________________

32. Since 1990 has this factory been in direct contact with the firm's R&D group? Yes _No __ If yes, outline the nature of these contacts (purpose, duration) __________

33. Does this factory maintain an engineering group: Yes __ No __ If yes, what is the functions of this group? _____________ Have these functions changed since 1990?

    ____________________________________________________________

34. How many suppliers in Taiwan provide this factory with components? 1990: ____2002_____

35. Do these suppliers operate on a just-in-time system?

    1990: Yes __ No __2002: Yes __ No __

36. What percentage [2002] of these suppliers provide:

    a) a relatively low value component ___%

    b) sophisticated high value components ____%

    Outline any changes in these percentages since 1990: _______________

37. Indicate, if any, the number of suppliers this factory helps with:

Worker training: 1990: ____ 2002: ______ (Add example if possible)

Precise product specifications ________________________________

38. Indicate, if any, the number of suppliers this factory helps with:

Details of product specification: 1990: ____ 2002: ______ (Add example if possible)

39. Indicate, if any, the number of suppliers this factory cooperates with in developing components: 1990: ____ 2002: ______ (Add example if possible).

40. Does this factory rely on any suppliers to develop new components? Yes __ No __

(Add example if possible)