

# The Political Economy of Industrial Upgrading : A Case Study of the Taiwanese Personal Computer Industry

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## 1 : Introduction

In a global economy supported by rapid transportation and high-speed communication technology, the whole or part of production process can be easily farmed out to distant production sites and necessary inputs can be purchased from suppliers located in different regions and countries. In such a situation, the importance of a geographical concentration of enterprises which are engaged in the production and related activities of a specific product, so called "**industrial clusters**" (called "clusters", hereafter), is likely to decrease.

Recently, even in Italian industrial districts which are considered a model case of industrial clustering, it is reported that the decentralisation of production stage outside these districts may destroy the traditional self-contained business structure (Cossentino et al. eds. 1996).

Some authors, however, have argued that intensifying global competition increases the importance of location, rather than diminishing it. For example, according to Porter (1998), "The enduring competitive advantages in a global economy are often heavily local, arising from concentrations of highly specialized skills and knowl-

edge, institutions, rivals, related businesses, and sophisticated customers" (ibid. : 90). He also states that the decentralisation of production stages outside a cluster does not necessarily indicate the decreasing importance of location. The cluster's competitiveness is recovered by moving part or all of production elsewhere to offset local wage rising as far as the cluster succeeds in grasping strategic functions and in enhancing innovative capabilities.

Similarly, a growing number of studies on developing countries have shown that small and medium-sized enterprises (SMEs) have been able to overcome growth constraints and reach distant markets, on the basis of local external economies and co-operation between clustering firms (Schmitz, 1995b). In their introduction to the *World Development* (1999, September) "Special Issue : Industrial clusters in developing countries", Schmitz and Nadvi (1999) state that clusters are common in a wide range of countries and industrial sectors. They also assert that close co-operation enhances the ability of firms to cope with intensified pressures from global economy. While the experiences of developing country clusters vary a great deal, they include hitherto little known cases of local SMEs breaking into global markets (Nadvi, 1999 ; Tewari, 1999).

Surprisingly, the relevance of clustering has not been closely examined in Taiwan, though it is probably the biggest success story of industrial growth based on home-grown SMEs<sup>1</sup>. This paper attempts to examine the development of the Taiwanese Personal

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1 Though they do not focus on clustering, there are many studies of SME networking in Taiwan, for example, see Shieh, 1992a, 1992b, 1993 ; Chen, 1994, 1998 ; Luo, 1997 ; Commonwealth Magazine ed., 1993 ; Bielschowsky, 1995 ; Orru, 1991.

Computer (PC) industry focusing on the role of clustering in this rapidly changing industry. Following a brief overview of the Taiwanese PC industry, the next sub-section sets out the main theoretical issue to be explored in this paper and the structure of the paper.

***Overview of the Taiwanese PC industry:*** In the early 1980s when Taiwan set forth on developing its PC industry, few people expected that the country would obtain a dominant status in the world PC hardware production within less than twenty years. The PC industry consists of many sub-sectors making many products of which Taiwan makes up a large portion of the world's total. For example, in 1998, Taiwanese producers supplied more than 50% of the world's monitors, motherboards, keyboards, scanners, mouse, switching power supply (SPS) and cases (i.e. outer frames). Though its share is less than 50%, Taiwan is also a leading supplier of notebook PCs, graphics cards, CD-ROM Drives and so on (see Table 1). Its status as the world's main hardware producer is not visible to the equipment users. This is because many Taiwanese products are supplied with the brand name of computer companies such as IBM, Compaq and Dell. As in other industrial products, the Taiwanese PC industry has developed to a considerable extent through a dependence on OEM (Original Equipment Manufacture) arrangement with foreign companies.

Critical to the Taiwanese success story is that the production of PC and peripherals can be dismantled into different production stages, with each stage being undertaken by independent firms. PC and peripherals consist of a huge array of electronics parts, every

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**Table 1 :** Basic Data of Main Sub-products in the Taiwanese PC Industry (in1998)

Unit : value (million US\$) / number of products (thousand)

Ranking	Total output (value)	Total output (number)	Offshore production (number; %)	World Share (number; %)	OEM/ODM rate (value; %)
1. Notebook PC	8,423	6,088	0	40	84
2. Monitor	7,523	49,915	71	58	65
3. Desktop PC	6,464	14,333	89	17	67
4. Motherboard	4,310	53,220	37	84	27
5. Switching power supply (SPS)	1,498	58,735	91	66	100
6. CD-ROM drive	1,388	30,660	59	34	31
7. Case	1,201	61,930	75	75	58
8. Scanner	818	15,240	38	84	47
9. Graphics card	588	17,368	65	31	23
10. Keyboard	498	60,510	91	65	70
11. Uninterruptive power supply (UPS)	320	2,362	25	-	71
12. Mouse	170	56,900	90	60	69
13. Sound card	133	14,060	67	-	59
14. Video card	40	738	18	-	46

Source : MIC/III, 1999, Yearbook of the Information Technology Industry for 1998 (in Chinese), and MIC/III, 1998, Retrospect and Prospects of the Information Technology Industry, 1998-99 (in Chinese)

one of which can be obtained from specialised suppliers. It is a major advantage of Taiwan that the majority of these supporting firms, including parts suppliers and subcontractors as well as manufacturers of PC/peripherals are located within a small area from *Taipei* to *Hsinchu* (northern part of Taiwan), which I call the "PC cluster"<sup>2</sup>.

- 2 The cluster area includes three prefectures (Taipei, Taoyuan, and Hsinchu) and three cities (Taipei municipality, Keelung, and Hsinchu). According to an official statistical report (Directorate-general of Budget/Executive Yuan, 1998, The Re-

This facilitates an extensive division of labour and co-operation among different units. Under such conditions, there is space for SMEs to attain competitiveness if they focus on one specific sub-product or one (or a few) specific production stages, through relying on a thorough division of labour and dense networks among local supporting firms. According to existing literature (e.g. Powell, 1990), in an industry such as the PC sector, in which flexible, low-cost production and quick response to fast technological and market change are key factors for success, a network form of industrial organisation is especially advantageous. I suggest that Taiwan's success in the PC industry can largely be explained by analysing linkages among local PC producers and related actors in the cluster. These local linkages, however, also need to be analysed in their interaction with global linkage.

As mentioned above, the Taiwanese PC industry has developed relying on OEM mechanism to a considerable extent. This does not mean, however, that Taiwanese manufacturers are charged with only simple assembly or production of PC and peripherals under the careful assistance and supervision of foreign clients. This was the case in the 1980s, but is no longer evident during the 1990s. As of 1998 when I conducted my fieldwork in Taiwan, Taiwanese producers had already accumulated substantial technological capabilities not only in production management but also in product design & development. Nowadays Taiwanese firms usually take the initia-

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port of Industrial and Commercial Census for 1996, Taiwan-Fukien Area, R.O.C.), in 1996, 88% of the establishment units of manufacturing in the PC industry are located in this area.

tive in new model development process even under OEM agreement. When OEM reaches this stage, it is called ODM (Own-Design and Manufacture). It is considered that the shift from OEM to ODM occurred around the late 1980s or the early 1990s.

Since the mid-1990s, partnership with foreign major clients has evolved further. In order to reduce cost and enhance flexible response to markets, major world computer companies have made a "Global Logistics" production and supply model agreement with Taiwanese producers. In this agreement Taiwanese firms are charged with more and more functions in the value chain, which includes not only production and design of products but also storage and inventory control of (half-)finished products and their delivery. In contrast, the major world computer companies tend to focus on some core, profitable tasks such as basic product planning, the production of some key parts, limited involvement in the final assembly of higher value-added products and marketing. In the late 1990s, establishing the Global Logistics mechanism came to be recognised as a necessary condition for establishing partnership with major world clients.

***The main concern — clustering and technological learning:*** The main purpose of this study is to examine how significant the role of clustering is in industrial upgrading process. But, as many existing studies show, geographical proximity in itself is of little consequence. Proximity facilitates interaction but is no guarantee that it takes place, nor that it is of a kind which enhances efficiency and innovation. Therefore, the quality of inter-firm linkages of a cluster is to be examined. My main question is "What

kind of inter-firm linkages do successful dynamic clusters have?" In other words, this paper tries to shed light on the quality of linkages between main manufacturers and other related actors of clusters which enables local producers to successfully grow in the global economy.

Upgrading in the global value chain includes acquiring more knowledge intensive functions such as shifting to the production of quality-sensitive goods, design and R&D. As mentioned above, Taiwanese firms have accumulated substantial technological and other capabilities, which is considered to be one of the merits of clustering.

But the connection between clustering and technological learning has not yet been examined in detail. In order to do so, Bell and Albu (1999) suggests that emphasis needs to shift from "production systems" to "knowledge systems". The previous cluster literature mainly focuses on the production system. According to them, "The production system can be understood to encompass the product designs, materials, machines, labor inputs, and transaction linkages involved in production of goods to a given specification. .... The knowledge system concept on the other hand, encompasses those flows of knowledge, stocks of knowledge and organizational systems involved in generating and managing changes in the products, processes or organization of production" (ibid. : 1723). In other words, the former is related to status quo, namely just continuing existing production mode, while the latter is connected to change-generating mechanism. Therefore, they state, "A description of the production system in this sense tells us nothing about the evolution of the firm or clusters it describes : its history, current trajectory or capacity for

future technological change" (ibid.).

The challenge posed by Bell and Albu may have a common interest with the literature concerned with region-specific technological development system. This includes several lines of studies, which adopt conceptual frameworks such as "regional collective learning" (Keeble and Wilkinson eds., 1999, 2000), "the learning region" (Asheim, 1996 ; Morgan, 1997) and "regional innovation systems" (Cook et al., 1997). According to Keeble and Wilkinson (2000), the learning region and regional innovation systems literature primarily focus on the nature and role of regional non-firm institutions and organisations, while regional collective learning perspective emphasises more on networking and the intensity of interaction between individual firms. Collective learning is the indispensable element of a successful "innovative milieu" (Camagni, 1991), which can be defined as "a dynamic process of the cumulative creation of knowledge freely transferred among economic agents whatever its origin by interactive mechanisms based on shared rules, norms, organisations and procedures" (Cappello, 1999 : 356). Reviewing the experience of European high-technology SME clusters, Keeble (2000) points out three key collective learning processes, namely, new firm and entrepreneur spin-offs, labour market flows of highly-qualified staff and inter-firm networking and collaboration.

Perhaps, the most critical challenge of this paper is to pay explicit attention to the technological dimension (i.e. knowledge system) of clustering. This task is carried out by examining the quality of linkages between main producers and other related agents. Following previous cluster studies (e.g. Nadvi and Schmitz, 1994 ;

Nadvi, 1999; Rabellotti, 1995, 1999; Schmitz, 1995a, 1999b), four main linkage categories are examined: (1) backward linkage with supporting firms such as input suppliers and subcontractors; (2) horizontal linkage with other local fellow producers including both co-operative and competitive aspects<sup>3</sup>; (3) forward linkage with actors who are relevant to marketing such as buyers and trade agents (especially, OEM/ODM clients, in this paper); (4) institutional linkage with public agencies and public or private institutions which are engaged in supporting local firms and promoting cluster development.

The discussion is structured as follows. Section 2 provides a framework for assessing the quality of inter-firm linkages of clusters. Regarding each of the four linkage categories, based on existing cluster and related studies, it is outlined what kind of features a linkage is expected to have in well-developed dynamic clusters in contrast to underdeveloped static clusters. In addition I pay explicit attention to learning effect of interaction between actors in each linkage category. Section 3 investigates the quality of inter-firm linkages of the Taiwanese Notebook PC sector, by making the

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- 3 Strictly speaking, horizontal linkage consists of two dimensions - bilateral linkage (relationship between individual firms) and multilateral linkage (co-operation through setting up cluster-wide private self-help institutions such as trade associations). But in this paper, multilateral horizontal linkage is discussed under the category of institutional linkage, because the former often plays a role as a part of the broader support system for local firms which consists of various private self-help institutions and public organisations (including government agencies and government-sponsored institutions).

framework as a reference point. The concluding section summarises the main findings.

## **2: Analytical Framework for Studying the Quality of Inter-firm Linkages of Clusters**

The basic strategy of this paper is to examine the quality of inter-firm linkages of clusters by focusing on each of four categories (i.e. backward, horizontal, forward and institutional linkages) respectively. I also pay explicit attention to technological dimension.

This section constructs an analytical framework for this purpose. The existing cluster and related literature is to be made good use of.

The literature of European and other developed countries' industrial clusters shows the features of linkages that advanced clusters are likely to have. Recent cluster studies on developing countries (e. g. "Special Issue: Industrial clusters in developing countries" of *World Development*, September 1999) are useful because they shows how linkages of relatively less-developed clusters evolve under pressure from the global economy.

### ***2-1: Backward Linkage with Parts Suppliers and Subcontractors***

Though it is usually impossible to purchase all the necessary inputs and producer services within a region, the presence of a critical mass of sophisticated (ideally internationally competitive) supporting firms and close collaboration between them and downstream firms is one of the critical features of advanced dynamic clusters.

In developing countries too, relatively successful clusters dis-

played improving quality of linkage with supporting firms. According to Schmitz and Nadvi (1999) who review the papers in the "Special Issue" of *World Development*, through responding to the competitive pressure of the global economy of recent, in relatively successful clusters "Co-operation with key suppliers and subcontractors increased on issues of quality and delivery and there was more flow of information up and down the chain" (ibid. : 1508).

This trend can be expressed as "moving from *Arm's length Contractual Relation* (ACR) to *Obligational Contractual Relation* (OCR)", borrowing the technical terms from Sako (1992). I utilise her distinction of "ACR and OCR", but modify it as set out in Table 2, in order to examine the quality of backward linkage of clusters.

Next, we must consider how clustering may promote learning through backward linkage. Clustering may promote the vertical disintegration of production process based on process and product specialization, which leads to an expanding and deepening range of input suppliers, subcontractors and other service providers. Each specialised firm is able to focus its energy on technological and managerial development specific to its activities. This leads to the depth of technological capabilities of each firm and coexistence of several approaches to problem solving, and consequently to the wider application of technologies in the cluster as a whole.

Learning may also be facilitated by rapid flows of technological information, interaction and consultation regarding technical and design specification among main producers, input suppliers and subcontractors. These interactions and information flows are more easily realised in clusters than among dispersed entities. According

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**Table 2 : ACR and OCR**

	<b>Arm's length contractual relation (ACR)</b>	<b>Obligational contractual relation (OCR)</b>
<b>Transactional dependence</b>	Buyer has multiple sources. Supplier has many clients. Low trust.	Both buyer and supplier have only one or a few partners. High trust.
<b>Ordering procedure</b>	Bidding takes place. Prices negotiated and agreed before an order is commissioned.	Bidding may not take place. Prices are settled after decision about who gets the contract.
<b>Projected length of trading</b>	Short-term commitment by both buyer and supplier.	Mutual long-term commitment.
<b>Problem solving</b>	"Exit strategy" (threatening to find new suppliers).	"Voice strategy" (to set up a communication system to let things work out with an original supplier).
<b>Communication</b>	Infrequent contact. A narrow channel between buyer's purchasing department and supplier's sales department.	Frequent contact regarding socialising as well as immediate necessary business matters. Extensive multiple channels, between engineers, QC (quality control) personnel, top management, as well as between purchasing and sales managers.

Source : Made by the author based closely on Sako (1992) and partly on Helper (1993).

to Lundvall (1988), when technology is standardised and reasonably stable, geographic clustering is not indispensable for information exchange. But when technology is complex and ever changing, geographical and cultural proximity and the frequency of interaction between users and developers are crucial. He states, "In the absence of generally accepted standards and codes able to transmit information, face-to-face contact and a common cultural background might become of decisive importance for information exchange" (ibid. : 355).

One of the best examples of this accelerated innovation mechanism is found in Silicon Valley of the USA. Many of the new Silicon Valley computer system firms specialise in a limited number of core capabilities and established close long-term partnership with key input suppliers and contract manufacturers, through which they can introduce complex new products rapidly and alter their product mix continually (Saxenian, 1994).

In general, it is expected that in well-developed dynamic clusters, there is an extensive and sophisticated basis of supporting industries. Linkage with these supporting firms displays the feature of OCR. In the technological aspect, main producers and local supporting firms maintain close interaction on quality, efficiency and innovation. Key partners may be involved in new product design & development process and relationship is basically equal and reciprocal being based on each speciality. Contrastingly, in underdeveloped static clusters, it is thought that supporting industries have not yet developed well and the quality of goods and services provided by them is often below necessary standard. Relationship between main producers and supporting firms is more price-driven than quality-driven and shows the feature of ACR, which entails little technical co-operation except unconscious circumstantial interaction.

## ***2-2 : Horizontal Linkage between Local Fellow Firms***

Horizontal linkage among local fellow firms has two dimensions - competition and co-operation (including local external economies and joint action). Among them, competition is considered normal.

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According to Brusco (1992), even in the advanced Italian industrial districts, while co-operation tends to take place between companies at different production stages, strong competition occurs among companies performing a similar work process or producing a similar product. In developing countries too, Schmitz and Nadvi (1999) report that unlike backward linkage, horizontal co-operation remained low and/or increased little under the increasing competitive pressure of global market, at best, increase in the exchange of information and experiences among local fellow firms was observed as a common phenomenon.

Therefore, examining the nature of local rivalry is critical. The importance of local rivalry in propelling firms forward is stressed by Porter (1990). According to him, the successful industries are much more likely to emerge in nations with strong domestic rivalry than in nations in which one or several "national champions" are brought up by protections and subsidies. "In global competition, successful firms compete vigorously at home and pressure each other to improve and innovate" (ibid. : 117). Domestic rivalry need not be restricted to price competition, rather, rivalry in other forms such as efficiency, quality and innovation is conducive to more sustainable national or regional advantage. He also states that the geographical concentration of rivals in a small area strengthens these benefits. In the cluster literature, there is distinction between two kinds of competition - "low road" and "high road". The former "consists of seeking competitiveness through low labour cost, and a deregulated labour market environment", while the latter means "constructive competition, based on efficiency enhancement and innovation" (Sen-

genberger and Pyke, 1991 : 9-10).

Stressing the competitive dimension does not mean that co-operation cannot take place among competitors. Co-operative dimension consists of two types. One is "local external economies" which are based on unconscious and circumstantial interactions. Local external economies are especially prominent in the technological learning. According to Schmitz (1999a), "a typical feature of clusters is the speed with which information travels and successful innovations spread" (ibid. : 474). The knowledge diffused encompasses the information of new design trend, new parts or machinery and these suppliers, know-how on quality control or the improvement of equipment, an idea to break through specific technical difficulties and so on. There are variety of conduits of knowledge flows such as local grapevine, labour mobility, trade papers, spin-offs and imitation of rival's products. Clustering may lower entry barriers and a resulting large number of fellow firms may bring about coexistence of many different technical approaches and the ease of new combinations. Schmitz emphasises that due to rapid knowledge diffusion and the resulting difficulty in appropriating the benefits, local firms may refrain from investing in major innovation, but he also suggests that this is not necessarily the case because the firms "are both recipients and providers of external economies" (ibid. : 475).

Another type of co-operation is "joint action", which involves active and consciously pursued inter-firm linkages that go beyond anonymous market driven contacts. Clustering may make it easy for local firms to do joint action such as joint marketing, co-

operative R&D, common use of specialist equipment and information exchange. As mentioned above, joint action is much less likely to take place in horizontal linkage than in backward linkage. But such conscious co-operation, whether formal or informal, can take place between even rival firms under a certain circumstance. For example, in the technological sphere, according to Schrader (1990), informal technology exchange between competitors can take place if economic cost for the transferring firm is small. Technology exchange is more likely to occur, for example, if receiving firms have easy access to alternative sources and if the transferred technology does not relate to a dimension on which they compete with each other. Schrader also states that informal exchange is preferred especially when the transferred technology leads only to small, incremental improvement, because formal transfer causes high transaction costs.

Based on all these conditions, it is expected that in well-developed dynamic clusters the quality of local rivalry has the feature of "high road" (competition based on efficiency enhancement and innovation). Despite local rivalry, open and co-operative spirit is also ensured in dimensions where they do not compete with each other. In the technological sphere, based on solid knowledge stocks and substantial in-house learning efforts of individual firms, rapid knowledge diffusion and mutual learning is likely to be conducive to flexibly combining and recombining their diverse and complementary technical resources, and to continuously generating new knowledge. Though horizontal relation between local fellow firms are basically characterised by harsh competition, the paradox is that com-

petition demands ceaseless innovation, which in turn requires (conscious and unconscious) co-operation among fellow firms. The appropriability of created technologies for individual firms is not secured, but participating in clustering provides advantages over firms outside it, because it offers a valuable opportunity for monitoring and evaluating advanced R&D performed by other local firms<sup>4</sup>.

Contrastingly, it is surmised that the quality of local rivalry indicates the "low road" nature (competition based largely on low labour cost and price cutting) in underdeveloped static clusters. A closed and antagonistic atmosphere is widely observed. In the technological aspect, it is thought that knowledge stocks accumulated within individual firms are not rich and in-house technical investment is not active, in which situation knowledge diffusion and mutual learning among local fellow firms, if any, is more likely to just replicate and re-circulate existing knowledge than to generate new

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- 4 Such a situation is called "forced risk-taking" by Gemser and Wijnberg (1995). They state, "The element of forced risk-taking is present as long as technological opportunity is sufficiently plentiful, barriers to entry are low enough to make potential competition a real threat to established firms and, in particular, appropriability of technological knowledge is not too secure to prevent follow-up innovation or imitation efforts by competitors". They state that in a situation of fast technological changes, firms can enjoy a quick diffusion of state-of-art technology through participating in the network and defeat firms outside it, though they cannot secure individual appropriability conditions.

technologies<sup>5</sup>. Difficulty in appropriating the benefits of innovation tends to make local firms refrain from technical investment. Moreover, the wide-spread practice of imitation brings about the over-supply of similar products by many local firms, which easily leads to mere price competition and technological stagnation of the cluster as a whole.

### ***2-3 : Forward Linkage with External Buyers***

According to Porter (1990), the presence of sophisticated and leading-edge users within the same nation or region creates a valuable opportunity for local producers to anticipate the future trend of global market and to discover unexploited market segments before outside competitors do so. But local producers in developing and late industrialising countries are usually dislocated from leading-edge markets and demanding users, thus, forward linkage with external buyers and trade agents who bridge this gap are critical<sup>6</sup>.

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- 5 According to Bell and Albu (1999), "knowledge-using" elements (i.e. "using, replicating and re-circulating knowledge that is already established within the production system") and "knowledge-changing" elements (i.e. "acquiring, creating, processing and accumulating new knowledge") should be separated, because "A great deal of knowledge exchange, use and replication can occur within a rather inward-looking cluster system-creating the impression of dynamism at the individual firm level-but nevertheless leaving the cluster as a whole technologically static" (ibid. : 1724).
- 6 "Linkage with external buyers" mentioned in the cluster literature usually means linkage with dynamic markets and demanding users of foreign countries. But there are cases in which domestic markets play an important role. For example, according to Tewari (1999) who studies the Indian woollen knitwear clus-

Forward linkage also functions as a conduit of knowledge flows. The review of several recent cluster studies of developing countries presented by Schmitz and Nadvi (1999) highlights the importance of knowledge flows from outside. While poorer stagnant clusters had a closed inward-looking structure, relatively advanced clusters "relied heavily on knowledge from the outside and its rapid diffusion inside" (ibid.: 1511). Though there are various kinds of outside knowledge sources, the role of external buyers (and trade agents) is critical among them. One of the advantages of clustering is to attract such external buyers. Through contact with them, local producers can understand the level of technology and quality needed to compete for demanding users. Buyers and trade agents sometimes provide a variety of specialised producer services including model shops, technical assistance, training staffs, information of production and process innovation and inspection of product quality (Schmitz and Knorringa, 1999). OEM is an example of learning from external buyers.

According to Hobday (1995) who focuses on the electronics industry, firms of East Asian NIEs (Newly Industrialising Economies) including Taiwanese one are considered latecomer firms, defined as manufacturing firms which face two sets of competitive disadvantages - technological and marketing ones. A latecomer does not possess easy access to the world centres of science and innovation and

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ter of Ludhiana, linkage with dynamic segments of the domestic market was a crucial factor that helped firms adapt quickly to more demanding markets later, while linkage with the export market of ex-Soviet Union was not helpful to this change.

a healthy surrounding national system of innovation. In addition, a latecomer is dislocated from the mainstream international markets and demanding users. Latecomers can overcome these disadvantages through subcontracting and OEM under which arrangements they successfully couple export and technological learning.

Here a short explanation of OEM is provided based on Hobday (1995, 1997) and Gereffi (1999). OEM is a specific form of subcontracting, under which supplying firms make a whole product (not undertaking one or several steps of production process) according to the design specified by the buyer, then, the product is sold under the buyer's brand name. OEM has many advantages for local supplying firms. Firstly, it offers local firms access to distant market without making heavy investment in marketing and distribution. Secondly, through OEM local firms have an opportunity to learn first hand the preference of foreign buyers and become acquainted with international standards concerning price, quality and speed of response. Thirdly, local firms can upgrade technical capabilities and attain managerial and organisational know-how. It is because OEM often involves the foreign partner in the selection of equipment and key inputs, and the training of management and technical staff, as well as providing advice on production, financing and management. Fourthly, it generates substantial backward linkages in the local economy because OEM buyers are expected to develop reliable sources of many parts and materials.

Relying on OEM, through time, local firms are able to accumulate product design capability as well as production skills. OEM that reaches this stage is called ODM. Under ODM system the lo-

cal firm carries out some or all of product design as well as production according to a general design layout supplied by the buyer. As with OEM, products are sold under the buyer's brand name. ODM signifies some advance in production engineering and product design, but it applies mainly to incremental rather than advanced innovation based on competitive R&D capabilities. Today, many local firms of East Asia NIEs that pioneered OEM/ODM are advancing to OBM (Own-Brand Manufacture) in the electronics and apparel industry, though OEM/ODM still remains important.

What should be stressed here is that such upgrading process does not occur automatically. Though latecomer firms have opportunities for acquiring technology systematically, they must take the painstaking and difficult process of trial-and-error learning and making substantial investment in training and engineering in order to assimilate foreign technology. In addition OEM clients may have alternative sources and may take away orders from ill-performed suppliers.

OEM is one of the various types of industrial upgrading. More generally, industrial upgrading is about advancing into activities which offer higher return. There are mainly two kinds: (1) shifting to manufacturing more sophisticated products (i.e. product upgrading) and (2) acquiring new functions in a value chain such as design and marketing (i.e. functional upgrading) (Schmitz and Knorringa, 1999). Therefore, in examining forward linkage, I want to focus on what a market segment local producers are mainly connected to (concerned with product upgrading) and what functions local firms have acquired (concerned with functional upgrading). It is ex-

pected that in underdeveloped static cluster local firms tend to be incorporated into a price-sensitive (low-end) market segment and relationship with buyers shows dependent nature (i.e. occupying only non-strategic functions, asymmetrical profit distribution and bargaining power). In technological learning, static clusters possess only poor intra-cluster knowledge sources and support from external buyers is critical. But firms in such clusters find it hard to develop effective trade linkages and learning tends to be confined to a narrow range of functions such as basic production skills for low-end goods, due to the low ability of local firms to assimilate external technology and/or buyers' reluctance to teach.

Contrastingly, it is thought that well-developed dynamic clusters have linkage with a quality-sensitive (high-end) market segment and local firms tend to enter inter-dependent relationship with external buyers (i.e. sharing strategic functions, symmetrical profit distribution and bargaining power). In dynamic clusters, local firms are expected to actively try to accumulate resources and seek for such value chain which enables them to occupy more valuable functions. In the technological dimension, due to substantially enriched intra-cluster knowledge sources, the importance of buyer support has decreased with time. Technical co-operation becomes more bilateral. Local firms aggressively try to adopt and learn external technologies, which is particularly relevant for improvement of product quality and for functions such as product design & development.

#### **2-4 : Institutional Linkage**

The concern here is with linkage to local support institutions, both public and private. Since the support institutions are part of the industrial policy context in which clusters operate, it may be helpful to lay out how they fit into this context. The role of government policy which influences the working of clusters has two dimensions : (a) the macroeconomic policy framework mainly decided by central government, (b) the meso and micro level policy to support local firms and to promote regional development, which is usually conducted by regional and local governments, in many cases, in co-operation with local self-help institutions<sup>7</sup>. Though it does not mean that central government could be ignored, the industrial district experience contributed to a shift in the European industrial policy debate toward more concern with the role of regional and local governments and institutions.

In advanced European industrial districts, local firms (especially, SMEs) are encouraged by a well-developed support system, which are composed of various service providers including development banks, universities and other higher educational institutions, trade unions, trade associations, training centres, technical institutes and marketing consortia as well as local/regional governmental agencies. Such support system may offer small firms the wide range of services including credit, training and various "real serv-

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7 According to Schmitz (1999a), "a review of the European industrial district experience showed less government intervention than expected. Where public intervention was evident, it tended to work through local self-help organisations" (ibid. : 476).

ices"<sup>8</sup>, many of which are to be sector and region-specific (for European cases, see Schmitz and Musyck, 1993; Pyke, 1994). These service programs must adequately respond to client demands and, at the same time, must lead the local industry and facilitate upgrading.

In the technological dimension, it is not rare that knowledge institutions such as public research institutes and universities make an important contribution to the evolution of local learning/innovation network through various ways such as creating the cultural and psychological identity of locality which is a precondition for collective learning, training scientists, engineers and managers, conducting advanced R&D and generating technology-based spin-offs (Smith and De Bernardy, 2000). Besides public research institutes and universities, private self-help co-operation relating to learning is found in practices such as joint setting up of technology service centres and training centres and so on. Trade associations can offer a forum for the exchange of ideas and can become an alternative provider of collective services. In successful European industrial districts, the pervasive network of various technical service centres supports local SMEs (Pyke, 1992, 1994). In Silicon Valley, universi-

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8 The concept of "real services" is offered by Brusco (1992). "The idea is to prioritise 'real services' as against financial incentives, and to offer companies the services they need rather than the money to purchase those services on the market" (ibid.: 186). He mentions several examples of real services such as providing information regarding the technical standards enforced by law in foreign countries, the software required to design and manufacture products, the testing of manufacturers' inputs, the translation of tenders advertised in foreign countries, and so on.

ties (e.g. Stanford University, the University of California at Berkeley) and community colleges play an important role not only by supplying many high-quality engineers and entrepreneurs but also by promoting research collaboration between them and private companies (Saxenian, 1994). Besides Silicon Valley, universities or research institutions are indispensable as a source of advanced knowledge and highly-skilled human resources in many other industrial districts such as Greater Boston and Austin of the USA (Higashi, 2001), Cambridge of the UK (Keeble et al., 1999), Grenoble of France (De Bernardy, 1999), and North Jutland of Denmark (Dalum, 1995).

It is expected that dynamic clusters have strong institutional linkage, benefiting from a well-developed support system which provides the wide-range of services based on close communication between institutions and firms. In the same vein, in dynamic clusters, public and private knowledge institutions become an indispensable part of the local learning/innovation network. They can create a common cultural background for collaborative technical interactions through formal and informal networks of former students and researchers. They keep close contact with local firms and play an important role as a provider of technical services, as a source of forefront knowledge and high calibre human resources. Contrastingly, in static clusters, institutional linkage is weak, the support system is undeveloped and support institutions play a very limited role. In static clusters, knowledge institutions do not exist, if any, their activities are limited to a narrow range. Moreover, communication between institutions and local firms is probably not close, thus, ac-

tivities of these institutions are often unfit to meet the demand of local firms<sup>9</sup>.

### **2-5 : Type of learning**

This framework mainly sheds light on the quality of inter-firm linkages. But the "type of learning" of individual firms is also incorporated, because technological capabilities of individual firms are highly correlated with the quality of inter-firm technological interactions of clusters. According to Cohen and Levinthal (1990), it is said empirically that firms that conduct their own R&D are better able to use external technological information. They state, "the ability to evaluate and utilize outside knowledge is largely a function of the level of prior related knowledge" that has already been accumulated in the firm (ibid. : 128). It implies that active learning of individual firms leads to the enrichment of inter-firm technical interaction of cluster and vice versa.

Types of learning within individual firms are expected to change from by-product nature (i.e. doing-based learning) to purposeful search. Skills based only on doing-based learning have be-

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9 According to Bell (1993), the role of technology institutions can be divided into three types : (1) disseminating and supporting existing best technological practice within local industry, (2) acquisition and dissemination of existing technology that is new for local industry, and (3) technology development and innovation. He states that in developing countries industry's demand for disseminating existing technology (i.e. (1) and (2)) significantly exceeds the demand for new, innovation-related technology (i.e. (3)). So, in developing countries, research institutes should pour more resources into the former type of services.

come progressively inadequate as a basis for generating technical change. Nowadays, it is indispensable to make a substantial and constant investment in learning new technologies and generating innovation in order to catch up with continuously changing technological frontiers (Bell and Pavitt, 1995). It is thought that static clusters display high proportion as a by-product from doing, while dynamic clusters show high proportion generated by purposeful search.

### ***2-6: Framework for Assessing Inter-firm Linkages of Clusters***

This final sub-section offers a framework for assessing the quality of inter-firm linkages as the synthesis of the result of previous sub-sections (see Table 3). This framework serves as a reference point for the next empirical section. Here only a few remarks regarding the strategy for applying this framework to case studies are made.

Firstly, this framework depicts how the quality of inter-firm linkages varies between static and dynamic clusters, which can be regarded as the extremes of the broad spectrum of development level. You can assess the degree of development of a certain cluster which you are studying by viewing where it is located on the spectrum. But this framework is not offered as a precise measure for grading various clusters. This should be seen as just an experimental tool for discovering an obstacle to cluster development and its solution.

Secondly, the framework does not include cultural factors even though it is recognised that they can affect cluster development. Also technological features that differ from industry to industry are

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**Table 3 : Framework for Assessing Inter-firm Linkages of Clusters**

Linkages of clusters	How does the quality of inter-firm linkages vary between static and dynamic clusters?	
	Static clusters	Dynamic clusters
1) Backward linkage with inputs suppliers/subcontractors	Arm's length contractual relation (ACR)	Obligational contractual relation (OCR)
Technical interaction	Little technical co-operation beyond unconscious circumstantial interaction	Close co-operation over quality, efficiency and innovation
2) Horizontal linkage with fellow firms	Local rivalry based on low labour cost and price cutting (low road) ; closed and antagonistic atmosphere	Local rivalry based on efficiency enhancement and innovation (high road) ; open and co-operative atmosphere
Technical interaction	Knowledge diffusion is mainly relevant to existing technology and easily leads to technical stagnation of cluster as a whole	Rapid knowledge diffusion is conducive to continuous innovation and advantage over outside firms
3) Forward linkage with external buyers	Price-sensitive (low-end) segment ; dependent relationship (occupying only non-strategic functions, asymmetrical profit distribution and bargaining power)	Quality-sensitive (high-end) segment ; inter-dependent relationship (sharing strategic functions, symmetrical profit distribution and bargaining power)
Technical interaction	Buyer support is critical, but difficult to attract buyers ; if any, learning is confined to a narrow range of functions such as low-end production skills	Buyer support is not critical and tech. co-operation becomes more bilateral ; learning is relevant to complex functions such as product design & development and further improvement of product quality
4) Institutional linkage	Undeveloped support system, playing a very limited role	Well-developed support system, providing the wide-range of services
Knowledge institutions	Non-existent or limited range of activities ; insufficient communication with local firms	Playing an important role as a node of local learning/innovation network, supplying technical services, forefront knowledge and human resources
5) Type of learning	High proportion as a by-product from doing	High proportion generated by purposeful search

Source : Made by the author

In each row, phrases in quadrangles of grey colour are relevant to the general tendency and phrases in quadrangles of white colour are concerned with the technological dimension (i.e. knowledge system).

not considered. It is difficult to judge how significant the influence of these factors on the quality of inter-firm linkages is. They are not addressed in this paper in order to limit the complexity of the analysis.

### **3: The Quality of Inter-firm Linkages of the Taiwanese PC Cluster**

The main empirical task of this paper is to examine the quality of inter-firm linkages by keeping in mind the above-mentioned framework as a reference point. If linkages of the Taiwanese PC cluster have features similar to the right-hand column of this table (dynamic clusters), we can safely say that clustering of Taiwan is active and plays an important role in the development of the PC industry. The analysis of this section is largely based on the information attained from my own fieldwork carried out in Taiwan mainly in 1998. The PC industry consists of not only PC systems including Desktop PCs and Notebook PCs but also many peripherals/components such as monitors, motherboards and keyboards. Each of these peripherals/components is regarded as an independent "sub-sector" of the PC industry, because these are supplied by specialised producers and are sold as independent products to end-users as well as PC system assemblers. Though it is expected that inter-firm linkages are different between sub-sectors, it is very hard to conduct a detailed examination of all these sub-sectors respectively. Therefore, this paper focuses on the Notebook PC (called NB for

short, hereafter) sub-sector<sup>10</sup>, because it is the largest sub-sector of the Taiwanese PC industry (see Table 1).

The structure of this section is as follows. In sub-section 3-1, an overview of the NB sector is provided. Sub-section 3-2 investigates backward linkage between NB producers and input suppliers and subcontractors. In sub-section 3-3, I explore features of horizontal linkage among local fellow NB producers. Forward linkage with external buyers and linkage with government agencies and supportive institutions are analysed in sub-section 3-4 and 3-5 respectively. Sub-section 3-6 deals with learning process in individual firms.

### ***3-1 : Overview of the Notebook PC Sector***

NB is a relatively new less mature sub-product in the PC industry, which became known after the early 1990s. Taiwanese producers had already begun to produce laptop PC which was the forerunner of NB in the end of the 1980s. After a period of trial and error, the Taiwanese NB industry started to grow rapidly in 1991. In 1992

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10 This paper is based on my own DPhil thesis submitted to Sussex University (Kishimoto, 2001). In the thesis, I conduct three sub-sector analyses - Motherboard, Monitor, and Notebook PC sub-sectors. For the thesis, I conducted total 55 interviews : 17 with Motherboard firms (MB1-17), 19 with Monitor firms (Mo1-19), 14 with Notebook PC firms (NB1-14), and 5 with key informants (KI1-5). All of these interviews were conducted in co-operation with *Dr. Luo Jar-Der* (associate professor of Graduate School of Information Sociology, Yuan Ze University - Zhong-Li, Taiwan) and his assistants (*Mr. Yeh Yong-Zhu* and *Mr. Hsu Wei-Jie*), and *Mr. Su Zhe-Xian* who joined in this survey as my assistant.

Taiwan accounted for nearly one-third of the world market. The production of NB is more difficult than the production of Desktop PC. NB production involves crowding many parts into a very limited space. Fine pitch assembly technology such as SMT (Surface Mount Technology) is more required here. Producers also must devise methods to scatter heat that CPU (Central Processing Unit) causes and prevent EMI (electromagnetic interference). Taiwanese producers could overcome these technical problems based on the solid experience of Desktop PC and monitor production. Besides this, the role of public organisations also deserves mentioning. Computer & Communication Research Laboratories (CCL) of Industrial Technology Research Institute (ITRI), with the assistance of the Taiwan Electric Appliance Manufacturers Association (TEAMA), sponsored the "Notebook PC Strategic Alliance" in 1990 and forty-six producers joined in this. The alliance is often regarded as an unsuccessful case, because this failed in avoiding excessive competition among participants and in establishing a common standard of NB design and its key parts/components. But they succeeded in developing a mass production design sample of 386 SX Notebook PC within only seven months and in impressing technological capabilities of the Taiwanese PC industry in the world (San, 1995).

There are several conspicuous industrial and technological features of the NB sub-sector. Firstly, unlike motherboard for Desktop PC, there are no specific common standards for the layout of motherboard of NB. So, the design and production of motherboard of NB is normally carried out internally without relying on subcontracting or purchasing from specialised motherboard suppliers

which practice is normal in the Desktop PC sub-sector.

Secondly, the NB sector is a relatively new and less matured sub-sector in the PC industry. Though recently it is often said that NB design is becoming mature, the sector is still growing steadily and there is more room to add new functions than other sub-products. So, producers of other matured sub-sectors often try to advance into the NB business when they diversify. Meanwhile, as the profit margin of producing NB is depressed because of rising competitive pressure, NB makers also try to diversify. They embark on not only other kinds of products such as PDA (personal digital assistant) and cellular phone but also key parts of NB (e.g. TFT-LCD and Battery).

Thirdly, because of fast product change and technological complexity, NB is not suitable for offshore production. The rate of offshore production is nearly zero as of 1998. Parts/components for NB are less standardised and they entail fast technological and price changes, thus, it is critical for NB producers to locate within the cluster area and to keep close contact with parts suppliers.

Fourthly, entering into the NB business is difficult for small-scale firms, because this needs much more starting capital than in other sub-sectors. Scale-merit which is emphasised in the PC industry in general applies especially to the NB sector. Due to such conditions, concentration in NB production is higher than that in other sub-sectors<sup>11</sup>. As emphasised by one of the respondents (NB

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11 The output of top five producers accounted for 74% of the total output of Taiwanese firms in the NB sector, but it accounted for 45% and 55% in Monitor and Motherboard sectors respectively in the second quarter of 1998 (MIC, 1999, Yearbook of the Information Technology Industry for 1998).

10), financial capacity is critical for competing in this sub-sector.

As far as could be ascertained in the fieldwork, there were more than twenty NB producers as of 1998. The output of top five firms accounted for around 70% of the total output of Taiwanese makers. We have twelve sample firms in the questionnaire survey. Among them, four firms were ranked in top ten (one of them was in top five). Another eight firms were relatively minor or very small players. Among the twelve firms, two had production plants outside the cluster area (NB1, NB8), though they located some important departments such as purchasing and R&D within the cluster. The reason for this was only that their businesses had started from that region. The NB sector is accompanied with fast technological changes. Moreover, because parts/components of NB is less standardised than in many other sub-sectors, NB producers need to keep closer contact with parts suppliers. So, it is usually said that you fall behind in business competition if you do not have a plant within the cluster area. Respondents of these two firms indicated that operating outside the cluster area made it more difficult to gather information and have effective relationship with their suppliers (NB2, NB8).

### **3-2: *Backward Linkage***

This sub-section, firstly, offers an overview of relationship between NB producers and supporting firms such as suppliers of parts and equipment and subcontractors, then, examines linkage with key parts suppliers in detail.

**Overview of relationship with supporting firms :** NB is a more complicated product and includes more key parts than the other sub-sectors. In our questionnaire survey, we focused on several specific parts such as CPU/Chipset<sup>12</sup>, RAM (Random Access Memory), TFT-LCD (Thin Film Transistor-Liquid Crystal Display), CD-ROM Drive, HDD (Hard Disk Drive), Case, PCB (Printed Circuit Board) and Battery (see Figure 1).

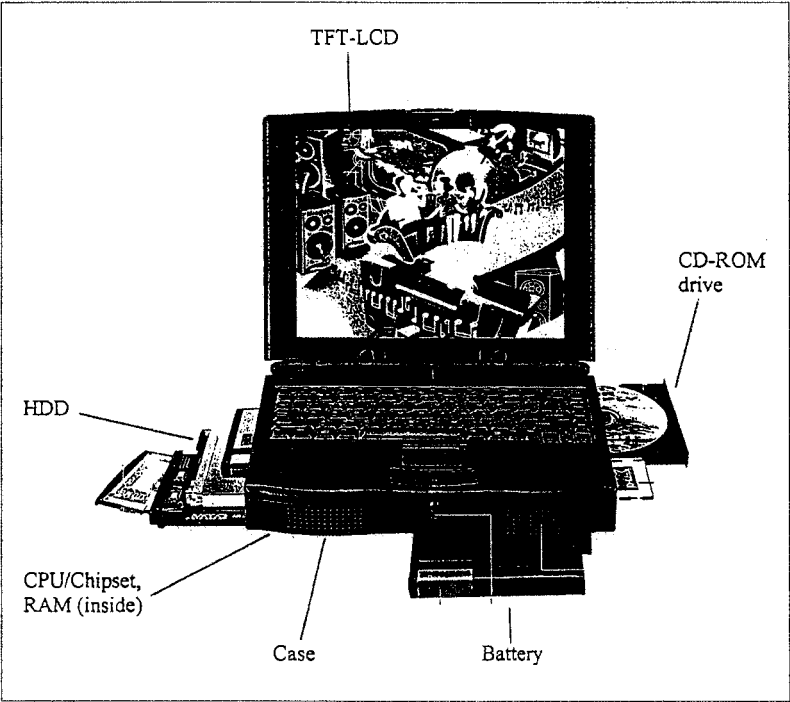
Like the other sub-sectors, Taiwanese NB producers normally purchase all the necessary parts from specialised suppliers. The difference is that the portion of purchasing from foreign suppliers is very high in the NB sector (see Figure 2). Locally produced parts make up only around 10% of the total material cost of NB. LCD, FDD(Floppy Disk Drive), HDD, CD-ROM drive and Battery were purchased from foreign companies (especially, Japanese suppliers). The supply of CPU was nearly dominated by Intel. But SRAM, PCB, Case, were purchased locally. Chipset were partly obtained domestically at that time. Despite this, foreign suppliers had a branch office or agents within the cluster, and they held enough engineering supporting capability and keep close contact with Taiwanese customers (KI1).

Among key parts, CPU and LCD are especially important. Suppliers of CPU/Chipset, especially Intel, have considerable influence

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12 CPU is the "brain" of PC. It accumulates the basic functions of computer - basic processing unit, main storage, control storage, input-output control unit and so on - on a semiconductor chip. Chipset is a kind of LSI (Large Scale Integration) that delivers and translates electronic signals between CPU and other components.

Figure 1 : Picture of NB and its Main Parts



Source : Author's survey

Figure 2 : A Breakdown of Material Cost of NB

11%	10%	8%	- Locally produced parts
25%	25%	23%	- Imported parts
19%	25%	34%	- CPU
45%	40%	35%	- LCD
Low-end products	Middle-end products	High-end products	

Source : MIC, 1999, Retrospect and Prospects of the Information Technology Industry, 1999-2000 (in Chinese)

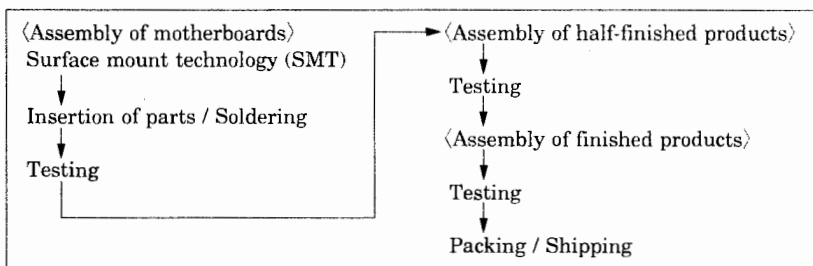
on the design & development of NB. In addition, interaction with suppliers of other key parts such as LCD and HDD are also important. Especially LCD is crucial, because this accounts for about 40% of the total material cost of NB. Design & development of new NB model is influenced by not only upgrading of CPU/Chipset but also upgrading of other key parts.

In regard to relationship with equipment suppliers, normally all the necessary production equipment is purchased from specialised machine suppliers. There is little room for improvement by NB producers except minor changes of peripheral sections. In NB production, roughly speaking, there are three kinds of equipment : testing machines for R&D stage, relatively precise equipment such as SMT and AI (Automatic Insertion) for processing motherboards and other conventional machines for the assembly of NB. Generally speaking, testing machines are purchased from both foreign (Japanese and US's) and domestic suppliers. Precise processing machine such as SMT is usually bought from Japanese companies. Other conventional machines can be obtained locally. Because the supply of important equipment is concentrated on several specific foreign companies, there is not a large difference in production equipment among Taiwanese NB producers. These foreign suppliers have a branch office or an agent within the cluster in order to make it easier to support Taiwanese customers. There do not seem to be particular interactions between NB producers and machine suppliers beyond standardised services such as teaching how to operate it, offering training sessions and repair/adjustment service.

Finally, the relation with subcontractors is to be examined. The

production process of NB is broken down into many steps, but these can be simplified into several main steps as Figure 3 shows. The main task of the first half of the process is the assembly of motherboard. The production of motherboard of NB is more difficult and needs more minute assembly than in the production of a motherboard of Desktop PC. The assembly of PC system by combining a motherboard and other parts/components is the core of the latter half of the process. Formerly when NB was shipped, this was as a finished product with all the necessary parts/components loaded. But as Global Logistics mechanism has become a business standard, recently producers start to ship half-finished goods which include only case, keyboard, motherboard, LCD and so on, and store them in a warehouse near market, then, assemble finished goods just before delivering them to customers. Other key parts such as CPU, HDD and DRAM which are expensive and easily fluctuate in price are loaded at the final assembly step in order to flexibly respond to users' choice as well as to avoid a loss caused by sudden price drop of them (this explanation is largely based on DigiTimes, 20 July 98).

**Figure 3 : Main Production Steps of NB**



Source : Made by the author based on an interview with NB14 and other literature

Of twelve sample firms, ten firms farmed out (or had farmed out) one or more production steps to subcontractors. This fact seems to prove the importance of subcontracting in the NB sector, but this is not necessarily the case. According to the fieldwork, subcontracting played a limited role in this sector. The production of NB is less standardised and includes a very precise processing. Therefore it is relatively difficult to divide the production process and farm out some steps. Moreover, because NB design is less standardised and includes more firm-specific technologies, NB makers prefer making it internally. They may farm out only a few routine steps in the assembly of motherboard or the production of small accessory cards.

***Linkage with key parts supplier:*** Here, I focus on relation between NB producers and parts suppliers. Among many parts, in our questionnaire survey we focused on relation with suppliers of CPU/Chipset, RAM, LCD, CD-ROM Drive, HDD, Case, PCB and Battery. Among them, excepting CPU, LCD is especially important, as mentioned above. In view of this, we investigated relation with LCD suppliers in more detail than the other key parts. The result of our survey is presented using the categories of "Table 2: ACR and OCR" as far as possible.

***(1) Transaction dependency :*** Parts for NB are less standardised and closer co-operation with suppliers is needed. But NB producers usually have dealings with two or more suppliers of each part except CPU which supply is nearly dominated by Intel<sup>13</sup>. In many

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13 In some cases producers cannot help relying on only one supplier. For example, when only one supplier can produce a part

cases, they make one supplier the main source of each part, but try to avoid depending on this too much. When we asked about relation with LCD suppliers, they said that they tended to keep partnership going without interruption though the amount of dealings may fluctuate. This is needed in order to respond to clients' demand, because the product of each LCD supplier is different in quality and price. Moreover, because LCD is expensive and its supply is not necessarily stable<sup>14</sup>, some NB producers make a strategic alliance with a supplier. Minor NB makers may be unfavourably prioritised when a shortage develops. But according to one respondent, if you have a strategic alliance, you have advantage in price negotiation and supply priority. But this is inconvenient because you must buy substantial amount and cannot change order afterwards and you may not be allowed to deal with other suppliers (NB 3).

Taiwanese NB producers have held a right to manage dealings with suppliers even when they serve OEM/ODM clients. But recently the situation has started to change. Around 1998 major world clients such as Dell and Compaq started to negotiate directly with suppliers of LCD and other important parts, and consign the purchased parts to OEM/ODM partners in order to reduce cost (Dig-

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which meets the necessary technical standard at that time, and when only one supplier responds to special order though it is not technically very difficult (NB12).

- 14 Traditionally the supply of LCD has displayed periodical shifts between oversupply and shortage. One cycle lasts 12~15 months. It is called "Crystal Cycle" (DigiTimes, 30 November 98).

iTimes, 14 January 99, 1 June 99).

(2) Ordering procedure : According to one respondent, in dealings with suppliers of key parts, personal connection plays a very small part. As regards LCD, CD-ROM Drive, HDD and Battery, there are only a limited number of suppliers in the world. Dealings with such suppliers are started from a formal firm-to-firm base and are normally taken charge of by a purchasing department. Though personal connection may occasionally give an opportunity to start dealings, the relation is managed according to objective standards such as price and quality without being influenced by personal considerations (KI2). The process of adopting a supplier is as the following : purchasing staff select candidate suppliers based on requests from R&D staff, then, through testing by R&D and QC (quality control) staff, a supplier is adopted as a partner. After that, purchasing staff negotiate delivery timing and price.

(3) Projected length of trading and problem solving : In this sector, long-term commitment is preferred regardless of nationality of suppliers. We also questioned how they coped with problems when they had large discontent with relationship with LCD suppliers. No respondent said that they would immediately break off dealings. In the normal procedure, they first have a meeting immediately to discuss how to solve the problem, then, they may change the order of priority considering supplier's response. It is rare to result in the termination of partnership excluding the case where the response of supplier is dishonest or problems continue to occur. This is also the case for other key parts. NB producers routinely investigate and compare cost and the ratio of inferior good of each supplier, and

may change priority according to their performance (NB1). Respondents did not deny the possibility of breaking off partnership when a major problem occurs. But breaking off partnership is in reality very difficult except in Case and PCB, because they must keep connection with suppliers in order to provide after-sales services. There is less need for after-sales services regarding Case and PCB (NB7).

(4) Communication : When we asked about how they keep contact with suppliers of LCD, most respondents said that there were frequent periodical and non-periodical meetings. In many cases, they had multiplex communication channels including not only purchasing staff but also R&D, QC staff, and even top management level. But the content of meetings is mainly concerned with routine matters such as price, quality, delivery timing and the introduction of new product. This is basically the same in relation with suppliers of other key parts.

As BTO (build-to-order) has become a business standard recently, the delivery of parts is becoming more and more frequent, approaching "Just-in-Time" (NB1, NB3). Some NB producers started to establish a computerised supply chain planning system involving their suppliers. Based on EDI (electronic data interchange), they can realise more efficient inventory control and lower stocks. According to one respondent, managing linkage with suppliers has become more and more important and they even invested in suppliers or provided financial assistance (NB4).

(5) Technical interaction : Despite close communication, as far as our survey revealed, there was no substantial technology transfer and co-operation except that several respondents mentioned co-

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operation with (or receiving technical data from) CPU/Chipset suppliers (NB 2, NB5 and NB7). We asked about co-operative relation with LCD suppliers in detail and the result is shown in Table 4. The table shows us that there are few technical and other types of interactions except the exchange of market information. Only one respondent said that there was some experience of technology transfer. Generally it is said that parts of NB are less standardised and co-operation between NB producers and parts suppliers is more necessary than in more mature sub-sectors. But our survey reveals that most parts/components except PCB and Case are semi-standardised and only need a minor modification based on requests from each NB manufacturer (NB4).

**Table 4 :** Co-operative Relation with LCD Suppliers

<u>Sample = 11 (excluding one no-answer firm)</u>
The number of firms that do not have any kind of co-operative relation = 6
The number of firms that have one kind of co-operative relation = 4
The number of firms that have two kinds of co-operative relation = 1
<u>Types of co-operation (one respondent can select one or more categories) :</u>
Credit/financial aid = 0
Stock holding/joint venture = 0
Technology transfer = 1
Co-operative R&D = 0
Exchange of market information/joint analysis of market situation = 5
Train workers/engineers = 0

Source : Author's survey

### **3-3 : Horizontal Linkage**

Horizontal linkage between fellow producers has three dimensions : a) competition, b) indirect incidental co-operation (local external economies) and c) consciously pursued co-operation (joint action).

Horizontal relation among fellow producers are basically characterised by strong rivalry. Harsh price competition and fighting for clients is conspicuous in the NB sector like in many other sub-sectors.

Foreign clients take advantage of this to beat down prices (NB7). But this does contribute to enhancing the cost management capability of Taiwanese producers.

The NB sector is relatively new and innovation is more important as a key factor for out-competing rivals than in more mature sub-sectors. But when I conducted fieldwork in Taiwan, there had already appeared some signs that the NB sector was becoming mature. For example, the design and performance of NB was becoming more and more similar among local producers, partly because they all used CPU and Chipset made by Intel. Therefore, the outcome of business contest is increasingly decided by scale economies and financial power (NB7, NB10). Small and medium-sized producers start to be dismissed<sup>15</sup>, while the NB sector is still expanding steadily and attracting many new entrants. Some small-scale producers try to accept investment from (or are merged into) a business group to gain ample funds (NB7, NB10). It is expected that the concentration of production will be enhanced further just as in the Desktop PC sector and overseas production will start in earnest before long.

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15 Small-scale producers have many disadvantages. For example, purchasing smaller amounts of parts entails higher unit price. Quality is less stable because they can only make small number of trial products (Large firms make 500~1000 units, but small firms make only 50~100 units). They are also inferior in the provision of after-sales services (NB7).

Mutual learning through informal and indirect routes make a crucial contribution to technical upgrading of the cluster as a whole. Theoretically clustering may facilitate spread of successful innovation and human capital formation via labour mobility or spin-offs as examples of local external economies. This is applicable to the PC industry in general, but especially so in the NB sector. Studying products of competitors is one of the important knowledge sources for product design & development. Particularly revealing is the interview with a manufacturer according to whom studying each other leads to reducing technical risk and to having more opportunities to test many different approaches for a sector as a whole (NB7). Such a practice is favourable in a sector with rapid technical change. For example, there are many different types of new Chipsets and the technology of them displays rapid change. Thus, the more NB producers have the trial of a certain Chipset and the more widely this information spreads, the smaller the risk of adopting this becomes. "The largest difficulty of NB design is that more and more functions must be crowded into a limited space. Unlike Desktop PC, NB is small. So, you can have an inspiration through studying each other, and the idea can be utilised in the next model. This is not necessarily imitation. Some improvements are added. Such a practice is advantageous for everyone" (NB7).

In the interviews, frequent reference was made to the very high turnover rate of R&D staff in this sub-sector. "They attempt to move to other firms that offer better pay after finishing each project" (NB6). Because the NB sector is still expanding rapidly, many new entrants try to entice R&D staff by higher pay (NB7). Accord-

ing to one respondent, it is often observed in the NB sector that a whole R&D team as a unit, not individually, changes firms. There are two types. One type is that a team leader suggests moving and his men obey this, and another is that his men move and the leader cannot help following them (NB3). How to detain them is “a kind of management art” (NB14). Higher pay, better welfare and offering company's shares are usually mentioned as means to detain. An outflow of human resources is a loss for individual firms but contributes to the spread of technology and the prosperity of the Taiwanese NB sector as a whole (KI1), though, as one respondent states, the poaching firm does not always achieve a good result because of the difference of company's culture (NB13).

As regards more conscious co-operation, joint action among fellow producers is rare in the NB sector. According to a respondent, there was no successful collaborative R&D, joint purchase of inputs and so on, though there had been some attempts. Trade associations also have not been able to iron out differences of interest (NB 2). Order transfer is relatively popular in other sub-sectors such as Monitor and Motherboard, but this is very rare in the NB sector, though the transfer of spare parts is a widespread practice (NB14). This is because the design of NB is less standardised and the production of NB includes complicated technologies and it is more difficult to keep a stable quality standard, thus, entrusting production to other producers is difficult.

### **3-4: Forward Linkage**

This sub-section examines forward linkage with external buyers (es-

pecially, OEM/ODM clients), by shedding light on several important aspects such as the position of Taiwan in the world NB market, relationship with external buyers and technical interaction with external buyers respectively.

***The position of Taiwan in the world market :*** The share of Taiwan in the total world output has steadily increased (40% in 1998) and Taiwan became the largest supplier of NB surpassing Japan in 1999. According to a respondent, Japanese makers are superior in QC and product design & development capabilities. They also have a good grip on key parts. But Taiwanese producers are superior in the speed of product design & development, cost management and production flexibility (KI1). In 1997, "Low-cost PC" began to be popular in the Desktop PC sector and the trend spread to the NB sector soon. One of the reasons for the recent growth in Taiwan is that Japanese NB producers have accelerated OEM/ODM order to Taiwan in order to respond to the cost reduction pressure.

But it does not necessarily mean that Taiwan specialises in a low-end segment. The NB industry as a whole is seen as a high-technology sector and is developing rapidly. Taiwanese makers can promptly introduce new products including high-end goods and alter their product mix continually. It is important to remember that there are only three countries in the world (i.e. Japan, the USA and Taiwan) which can keep a substantial share in the world output in this industry.

***Relationship with external buyers :*** Despite such large share in the total world output, this does not necessarily guarantee large profit distribution and strong bargaining power from the view point

of individual producers. Though this sector is more profitable than mature sub-sectors such as Monitor and Motherboard, recently profit margin is depressed by rising competitive pressure. Harsh price competition and fighting for clients is observed in this sector as well as many other sub-sectors, which enables foreign clients to beat down prices.

In the NB sector, the OEM/ODM rate is very high (84% in 1998). OEM/ODM clients include both major world computer companies and other non-major clients including distributors. Taiwanese products make up 32% of the sales of the world top ten vendors and 62% of the sales of non-top ten vendors in 1998<sup>16</sup>. Orders from major clients tend to concentrate on the top five or six producers in Taiwan (the first-tier firms). Partnership differs between companies, but roughly speaking, it is changing from long-term one-to-one dealings (at least regarding each grade of products) to short-term many-to-many relations (DigiTimes, 7 October 99 ; 26-29 February 00). The profit margin of OEM/ODM from major clients is originally relatively low, though the size of order is large. Recently major world clients try to have a direct grip on purchasing key parts in order to secure enough key parts and to increase the control of production cost. This reduces the chance for Taiwanese producers to make a profit (DigiTimes, 1 June 99 ; 27-29 November 99). In con-

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16 MIC, 1998, *Retrospect and Prospects of the Information Technology Industry, 1998-99* (in Chinese). A breakdown of the top ten changes over time. In the third quarter of 1999, the world top ten NB vendors are Toshiba, IBM, Compaq, Dell, Fujitsu, NEC/PB NEC, Sony, Acer, Apple and Gateway (DigiTimes, 19-21 February 00).

trast, dealings with small clients provide a higher profit, though order size is small. The second and third-tier Taiwanese producers largely rely on orders from such small clients. But under the pressure of "low-cost-PC", non-major vendors' markets have been eliminated, because price difference between brand NB and non-brand NB has reduced. Reflecting this, the percentage of the first-tier makers in the total output of Taiwanese producers has increased. For example, the output (number of products) of top 5 producers accounted for 55% in 1996 but it made up 70% in 1998<sup>17</sup>. Own-brand sales seem to experience more difficulties than in many other sub-sectors.

When I conducted the fieldwork in Taiwan, most Taiwanese NB producers had already advanced into ODM stage. In addition, the Global Logistics mechanism became a business standard in this sector. More and more Taiwanese NB producers have established final assembly plants (where assembling finished products by combining half-finished products with several key parts), warehouse and even repair centres in important market such as the USA and Europe. This involves the introduction of ERP (Enterprise Resource Planning) and computerised SCM (Supply Chain Management System) as a precondition. Some producers have established a final assembly plant near the warehouse of an important OEM/ODM client. Furthermore, it is expected that "TDS (Taiwan Direct Ship)" will be the main current in the future. TDS means that Taiwanese producers shoulder all the steps of the value chain from production to the

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17 MIC, 1998, *Retrospect and Prospects of the Information Technology Industry, 1998-1999* (in Chinese).

delivery of goods to end-users without passing the hands of OEM/ODM clients. As the production of goods has provided a shrinking profit margin, Taiwanese makers hope to have more chances to make profits from various related services with TDS (DigiTimes, 8 March 00).

**Technical interaction with external buyers :** OEM/ODM clients include not only major foreign computer companies but also non-major vendors. The latter does not seem to offer any technical assistance. Major clients may offer it. Of twelve sample firms, nine had OEM/ODM order. Among them, five firms were in partnership with major foreign companies such as IBM, Compaq, Hitachi and so on. They received some assistance, which was all related to technical matters, see Table 5.

As confirmed in our fieldwork, foreign clients are one of the most important knowledge sources in product design & development process. But it does not mean that Taiwanese NB makers rely on substantial technical support from clients now. According to a respondent (interviewed in September 1998), ODM had become the main stream “in the last two years” and there was rarely OEM at that time. In OEM stage, clients made a substantial contribution to upgrading the control of production process (KI1). Similarly, other respondent, whose firm had been in partnership with a major Japanese computer company for four years, admitted that the partnership had contributed to their technical upgrading a lot. Especially regarding the quality of products, request from the client was very strict and they nearly copied the QC procedure of this Japanese client, through which they substantially improved the quality of their

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products (NB14). But in ODM stage, the design of new model is carried out by Taiwanese firms without relying on clients' assistance, though strict requests from clients may contribute to the improvement of production and QC technologies (KI1). Among the technical assistance mentioned in Table 5, many cases seem to imply that clients only request to adjust products or production process or there is only minor technical interaction. One respondent said that there was no substantial technology transfer from OEM/ODM clients in the NB sector recently (NB7). Other respondents said that they approached the level of Japanese products even in QC (NB2, NB13)<sup>18</sup>.

**Table 5 :** Assistance from OEM/ODM Clients

<u>Sample = 9 (excluding firms which do not receive OEM/ODM order)</u>
The number of firms that do not receive any assist from clients = 4
The number of firms that receive one kind of assist = 0
The number of firms that receive two kinds of assist = 2
The number of firms that receive three kinds of assist = 1
The number of firms that receive four kinds of assist = 2
 <u>Types of assistance (one respondent can select one or more categories):</u>
Advanced payment or other financial aid = 0
Technical assistance for QC = 5
Technical assistance for the improvement of production process = 3
Train workers/engineers = 0
Co-operative R&D/technology transfer for new product development = 3
Technical assistance for product improvement = 4

Source : Author's survey

- 18 This statement on QC may be too proud. According to an article of DigiTimes, RMA of Toshiba (Japan) NB is less than 0.9% and RMA of Taiwanese NB producers is 5~10%. RMA is the percentage of products that are sent back to the producer for re-

### **3-5: *Institutional Linkage***

In Taiwan, there are various government agencies and public/private institutions which are related with the PC industry<sup>19</sup>. Table 6 introduces the profile of relatively important ones.

Among them, MOEA is especially important. Under MOEA's various administrative branches, there are ten-odd foundations which carry out technology development projects and other service providing. Among these foundations, the Industrial Technology Research Institute (ITRI) and the Institute for Information Industry (III) have a close connection with the PC industry. MOEA also takes charge of public enterprises.

Besides these government agencies and government-sponsored institutions, there are several trade associations which have connections with the PC industry, for example, computer associations of several cities and prefectures such as Taipei Computer Association (TCA), Taiwan Electrical and Electronic Manufacturers' Association (TEEMA), Taipei Electronic Components Suppliers' Association (TECSA) and Information Service Industry Association of R.O.C. (CISA). Among them, TCA is the largest and the most influential one in the PC industry.

In the early 1980s, the information technology (IT) industry (including the PC, semiconductor and other sectors) was designated as a "strategic industry" which was eligible for special public assis-

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pair within one year (DigiTimes, 15 July 99).

- 19 According to my research, supportive institutions and assistance programs specializing in each sub-sector are rare. Therefore, this sub-section examines the institutional linkage of PC industry as a whole.

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**Table 6 :** Introduction of Important Supportive Institutions Related to the PC Industry

Supportive institutions	Introduction
<b>Industrial Development Bureau (IDB)/ Ministry of Economic Affairs (MOEA)</b>	MOEA is charged with national economic administration and economic construction including industry, commerce, trade, energy and mining. IDB is one of the thirteen administrative agencies of MOEA, whose function is concerned with industrial development policies, management of industrial zones, financial and taxation system related to industrialisation etc.
<b>Industrial Technology Research Institute (ITRI)</b>	ITRI is the first and largest non-profit autonomous industrial technology research institute, which was established in 1973 under MOEA. Its core mission is to undertake applied research relevant to national needs and to transfer technologies to the private sector. ITRI also introduces technology from foreign countries, digests it and then, transfers it to the private sector. As of 2001, under ITRI, there are seventeen divisions and centres.
<b>Electronics Research &amp; Service Organisation (ERSO) / ITRI</b>	ERSO was created in 1974 under ITRI and has since been involved in every generation of semiconductor development. This also took charge of computer development projects in the 1980s. Recently ERSO has engaged in R&D projects regarding liquid crystal display, the sub-micron process and microelectronic technology.
<b>Computer &amp; Communication Research Laboratories (CCL) / ITRI</b>	CCL was separated from ERSO in 1990 to handle R&D of computer and communication technologies. Its present main R&D concerns are in multimedia computer system, wireless communication and HDTV.
<b>Market Intelligence Centre (MIC) / Institute for Information Industry (III)</b>	III was founded in 1979 under MOEA to serve the government in supporting the promotion of information technology industry. Its main functions include assisting the government in mapping out development plans, studying and introducing advanced software technologies, promoting computer usage, training computer professionals, etc. MIC is in charge of providing market and technology intelligence through various publications and conferences.
<b>China External Trade Development Council (CETRA)</b>	CETRA was established in 1970 as a non-profit parastatal agency for export promotion. Its main functions are to provide information, organise participation in trade fairs and carry out market research. By 1998, it had established overseas branch offices or trade centres in 35 cities.
<b>Taipei Computer Association (TCA)</b>	TCA consists of manufacturers of computer, peripheries, software and dealers/agents of these. This was created in 1974 and now is the largest association in the computer industry, with more than 8,000 members in 1998.

Source : Made by the author based on various sources.

tance. Since then, government agencies and government-sponsored institutions have carried out a lot of policies and assistance programs to promote the IT industry. This includes fiscal and financial programs to facilitate investment, encouragement of strategic R &D, training programs, international marketing promotion, technical services and so on.

In addition, trade associations also conduct various supportive activities for member firms. Among several related associations, TCA provides its members with the wide range of services, for example, sponsoring exhibitions, organising (sub-) sector-specific social gatherings or alliances for a specific purpose among member firms, offering trade information, legal advices, education and training services, developing overseas market, promoting computer skills, offering suggestions in policy planning by government, assisting the execution of various IT-related governmental projects, issuing certifications and so on.

Our research reveals several conspicuous features in institutional linkage in the Taiwanese PC industry. Firstly, despite seemingly the wide-range of supporting activities, business people do not have a high opinion of their contribution. There are several reasons why such a gap exists. (a) State intervention varies across the various sectors of the IT industry and unlike in the semiconductor sector in which the government played the role of an entrepreneur as well as a manufacture, the PC sector received only modest state support. The role of state was basically limited to fixing an institutional and legal infrastructure and adjusting incentive structures (Wang, 1995-96). (b) The communication with the private sector is

not enough. The economic policy of the country has been controlled by the government without accepting initiative from the private sector until recently. Trade associations which should bridge a gap between them are also needed to make more effort to keep close contact with member firms in order to win their trust. (c) Government agencies and associations simply cannot effectively respond to demand from the rapidly expanding and changing private sector. Especially, many of SMEs seem to feel that they have more difficulties in enjoying government assistance, though the Taiwanese government has not sought to favour large firms.

Secondly, there are more than ten universities and colleges possessing an engineering and/or science department around the northern part of Taiwan. A plentiful supply of high-quality human resources from these is one of the most important advantages of being located within the cluster. Besides supplying rookies, universities and institutions also offer experienced personnel opportunities for receiving re-education, though many respondents said that on-the-job training was critical. In addition, regional universities play an important role in creating the cultural and psychological identity of locality which is a precondition for knowledge interaction in terms of informal regional networks of former students and classmates.

Thirdly, however, unlike the semiconductor industry, services and assistance of knowledge institutions are not critical in the development of the PC industry. Spin-offs from universities and research institutions also seem to be much less important as a source of new innovative firms. As our survey reveals, the majority of sample firms stated that they had few or at best occasional contacts

with ERSO/TRRT, CCL/ITRI and universities/colleges, and that such research institutions and trade associations had very small importance as a knowledge source for new product design & development. There are several reasons for this. The speed of their R&D is too slow. Technologies developed by them cannot be commercialised immediately. Entrusting R&D to them needs a lot of money which one company cannot shoulder. Besides these, public research institutes tend to aim at forefront and key technologies. The design and production technologies of PC and its peripherals (it means hardware production, not refer to software and technology- and capital-intensive key parts) have already "matured" in many cases, as many business people said, thus, private firms also do not need technological assistance from research institutes very much.

### ***3-6: Learning Process in Individual Firms***

The type of technological learning within individual firms is expected to change from one of "by-product" nature to one with purposeful research as a cluster enhances vitality (see Row 5 of Table 3). It is also thought to be the case that the level of technological capabilities accumulated within individual firms is highly correlated with the extent of inter-firm technological interaction of the cluster. Taiwanese NB producers in general have already attained substantial technological capabilities including not only full-blown production skills but also product design & development capabilities. And, as mentioned in previous sub-sections, Taiwanese NB producers have frequent technical interactions with related actors such as key parts suppliers, fellow firms and external buyers. Thus, it is no

doubt that Taiwanese producers have made considerable investment in innovation, without just relying on doing-based learning.

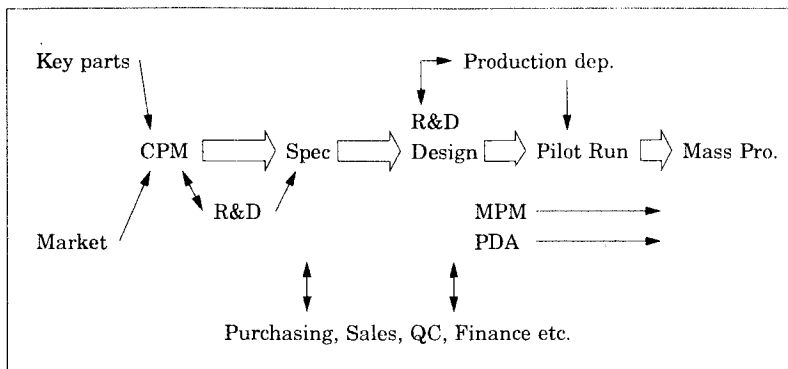
The result of our survey reveals that all the sample firms have established a specialised R&D department and in-house learning effort is seen as critical. The NB sector is a relatively new sector. But it was established based on the experience of producing Desktop PC and so on. So, NB firms normally had specialised R&D staff from the very beginning. Training of technical staff is largely conducted on "on-the-job (OTJ)" base. There are some opportunities for joining in extra-firm training sessions and workshops held by key parts suppliers and public supportive institutes.

NB is a relatively new product, but according to one respondent, because recently NB technology has also become gradually mature and most NB producers adopt the same key parts such as CPU/Chipset made by Intel, there is no great difference in the design of NB (NB10). This is accelerated by mutual learning and follow-up innovation which is a wide-spread practise in the PC industry in general but especially the case in the NB sector.

We had interview sessions with three business people (NB 7, NB13 and NB14) and one analyst of the PC industry (KI1) and asked about the whole process from new model design & development to mass production of NB in detail. The basic idea of this process is introduced in Figure 4. The following explanation is largely based on these interviews.

As the NB sector has advanced into ODM stage, the process of new product (model) design & development is basically undertaken by Taiwanese producers. First, depending on the analysis of new

**Figure 4:** From Product Design & Development to Mass Production of NB



Source : Made by author based on interviews with NB7, NB13, NB14 and KI1.

key parts (upgrading of CPU, Chipset, LCD, HDD and so on) and market situation (or demand of ODM clients), specifications are made. This task is mainly carried out by the Component Product Manager (CPM) consulting R&D staff. CPM is also charged with the control of the whole process. Second, being based on this specification, the R&D department starts design, first by itself, and afterwards by consulting staff from the production department. Third, a pilot run is carried out by the production department maintaining interaction with R&D staff. The Manufacture Product Manager (MPM) supports this step by co-ordinating related activities including purchasing parts. In addition, staff of Product Development Assurance (PDA) are assigned the task of discovering bugs within products that R&D staff have overlooked. Finally, after solving the bugs, mass production is started. The product development process goes ahead in a parallel and integrated manner. This is to say that staff of all other related departments such as parts purchasing, QC

(quality control), sales and finance join in the meeting and submit requests to R&D department from each viewpoint. There is such a meeting not only in the early stage of R&D but also in every step of product development and they go ahead with their own tasks harmoniously. According to one respondent, it takes about six months to develop a new model. They are superior to Japanese competitors in the speed of development. Japanese firms need nine to twelve months (NB13). When we asked about why this was possible for Taiwanese producers, another respondent said that they curtail time mainly in the steps of first product planning and R&D. This is attributed to the quick decision of lines (having the feature of "sink or swim") and the long working hours of R&D staff (NB7).

How do extra-firm actors such as key parts suppliers and ODM clients influence this process? According to one respondent, some ideas for R&D may be derived from key parts suppliers, especially Chipset suppliers (NB2). Partnership with Intel is important in this sub-sector. Intel grades the importance of partnership with each NB firm according to partner's reputation and the amount of previous dealings. If you are graded in the most important partner (called "Direct Communication" circle), you have some advantages. For example, you are supplied technical information promptly and are offered ample samples of new CPU/Chipset (NB3). The influence of ODM clients, if any, is most important in the first planning step. Major clients may submit demands and opinions in deciding a specification. They have market information and keep a good connection with key parts suppliers. Minor clients do not have a voice. They only choose what meets their demand from products offered by

Taiwanese producers (KI1). In the later production steps, clients may offer some demand and assistance in QC and production control, though Taiwanese NB firms have already attained substantial capabilities in these spheres too.

#### 4 : Conclusion

Our expectation is that the development potential of a certain cluster is decided by the quality of inter-firm linkages to a substantial extent and that inter-firm linkages of successful (and non-successful) clusters should have specific features which are depicted in the "Framework for Assessing Inter-firm Linkages of Clusters" (Table 3). This concluding section summarises the main findings of the previous section by contrasting them with Table 3.

**Backward linkage :** Linkage with key parts suppliers basically display the OCR nature though there are some deviations :

(1) [Transaction dependency] NB makers usually have dealings with two or more suppliers of each part except CPU, but in many cases they make one supplier the main source of each part. Parts suppliers sell their products to many makers. As regards LCD, CD-ROM Drive, HDD and Battery, there are only a limited number of suppliers in the world. (2) [Ordering procedure] A supplier is adopted as a partner if it can meet required conditions regarding technology, quality, lead-time, production capacity as well as price. Bidding does not take place. Price and other conditions are renegotiated from time to time. (3) [Projected length of trading and problem solving] Long-term commitment is preferred regardless of the nationality of suppliers. They basically take "voice strategy" in

problem solving. It is rare to result in the termination of partnership excluding the case where the response of supplier is dishonest or problems continue to occur. NB makers may periodically estimate the performance of suppliers and change priority accordingly. (4) [Communication] Frequent contact through multiple channels including R&D, QC and even top management level as well as sale and purchasing staff is observed. (5) [Technical interaction] Key parts suppliers are the most important knowledge source for new NB model design & development. But it does not necessarily mean that they are deeply involved in the process of product design & development. Despite close communication regarding price, quality, delivery timing and other routine matters, there seemed little substantial technological co-operation or technology transfer except that several respondents mentioned co-operation with (or receiving technical data from) CPU/Chipset suppliers.

**Horizontal linkage:** Local rivalry displays a mixed nature of high road and low road and the former seems more prominent. On the one hand, harsh price competition and resorting to scale economies to offset decreasing profit is observed. And foreign clients take advantage of this to beat down prices further. On the other hand, this sector is relatively new and technology-intensive. There is more room to add new functions than mature sub-products and product change is fast. Thus, innovation is one of the key factors which decide the result of business contest. Harsh price competition leads not only to price cutting but also to enhancing cost management capability of Taiwanese producers as a whole.

An open and co-operative atmosphere is observed though co-

operative interaction takes place mainly through informal or indirect conduits. Joint action among fellow NB firms is not popular. I have rarely heard of joint action such as co-operative R&D, joint marketing, joint purchase of inputs, order transfer and so on.

Rapid knowledge diffusion and mutual learning through informal and indirect routs make a critical contribution to accelerating innovation in this sector. Such practice can lead to reducing risk and to having more opportunities to test many different technical approaches for a cluster as a whole. This is especially important in a sector with rapid technical change. The high turnover rate of technical staff facilitates this. In conclusion, horizontal linkage contribute to continuous innovation and to clustering firms' advantage over outside firms.

**Forward linkage:** Forward linkages with external buyers of the NB industry display many features of dynamic clusters with some qualifications. Firstly, Taiwan is the largest supplier in the world. Japanese makers are superior to Taiwanese competitors in QC and product design & development capabilities, but Taiwanese producers also possess enough product design capability to introduce the wide-range of new products including high-end goods continually. Secondly, the OEM/ODM rate is very high in this sector. The relationship with major OEM/ODM clients can be seen as inter-dependent in the sense that Taiwanese producers have attained more and more functions including not only production but also product design & development and logistics. But it seems dependent if we see the fact that profitable functions such as marketing are still controlled by OEM/ODM clients. Under the pressure of

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"Low-cost-PC", profit derived from manufacturing NB is decreasing. In this sector, own-brand sales seem to be very difficult. It is because NB is expensive and technically complex, thus major brand names (associated with the image of good quality and after-sales service) are preferred by users.

In the technological dimension, foreign buyers are one of the most important knowledge sources in new model design & development process. Major clients may join in the step of deciding a specification. In addition, our survey reveals that Taiwanese NB producers receive some technical assistance from clients. But in reality, the Taiwanese NB sector already reached ODM stage and the process from new model design & development to mass production is basically controlled by Taiwanese producers. And technical assistance does not seem very substantial, though strict requests from major clients may contribute to the improvement of production and QC technologies. In conclusion, technical support from ODM clients is not critical and technical interaction with them is largely relevant to further product/process improvement.

***Institutional linkage:*** The government has promoted the IT industry as a strategic industry and a leading exporter since the early 1980s, but the PC industry has received only modest state support. Despite seemingly well-developed supportive system, its contribution is not highly evaluated by business people. In the technological dimension, regional knowledge institutes (especially universities) make an important contribution in creating the cultural and psychological precondition for knowledge interaction and supplying high-quality human resources. But they seem to have

only a small influence in providing technical services and in collaborating with local firms in research and technology development. On the whole, the activities of knowledge institutions have at best medium impact on the evolution of local learning/innovation network.

***Learning process in individual firms:*** The NB sector is relatively new sector but this did not have to construct a technical base from scratch. Technologies and know-how were attained from the experience of other sub-sectors such as Desktop PC and Monitor. Though the newest trend or idea is learned from foreign advanced producers, Taiwanese producers have attained enough capabilities to catch up with this after a short time lag. Several years ago, Taiwan reached ODM stage and attained not only full production skills including scale-intensive production capability, production control and QC, but also product (new model) design & development capability. They normally have a specialised department for R&D, production control and QC respectively. Therefore, it is no doubt that Taiwanese producers have made significant investment in learning and do not just depend on doing-based learning. Though major OEM/ODM clients may offer some technical assistance or requests, the whole process from new model design & development to mass production is basically controlled by Taiwanese producers. As for QC, OEM/ODM clients are a very important source of know-how.

On the whole, clustering in the Taiwanese PC industry shows many features of “dynamic clusters” depicted in Table 3 and this implies that clustering plays a significant role in the industrial upgrading of this sector. But there are some limitations. Technical trend is largely initiated by key parts suppliers and the supply of

most key parts depend on foreign companies. Harsh price competition may exhaust energy and resources for making large investment in innovation. Though Taiwan is the largest supplier in the world in this sector, this does not necessarily guarantee increasing profits and bargaining power. The OEM/ODM rate is very high and own-brand sales seem to be more difficult than in many other sub-sectors. Taiwanese makers have already accumulated enough capabilities to undertake the whole process from new model design & development to mass production, but the newest trend and idea is still learned from foreign sources.

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