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<i>List of figures</i>	vii
<i>List of tables and boxes</i>	viii
<i>List of contributors</i>	xi
<i>Preface</i>	xiii
<i>List of abbreviations</i>	xvi

1	Multinational corporations and the economy of networks: an overview <i>Juan J. Palacios</i>	1
2	Eras of enterprise globalisation: from vertical integration to virtualisation and beyond <i>Sandor Boyson and Chaodong Han</i>	26
3	Innovation offshoring: root causes of Asia's rise and policy implications <i>Dieter Ernst</i>	58
4	Information and communication technologies and inter-corporate production networks: global information technology and local <i>guanxi</i> in the Taiwanese personal computer industry <i>Kenneth L. Kraemer, Jason Dedrick, William Foster and Zhang Cheng</i>	89
5	The creation of regional production networks in Asia Pacific: the case of Japanese multinational corporations <i>Shujiro Urata</i>	114
6	The internationalisation of firm activities and its economic impacts: the case of South Korea <i>Sanghoon Ahn, Siwook Lee and Cheonsik Woo</i>	139
7	The rise of Mexican multinationals: driving forces and limiting factors <i>Víctor López Villafañe and Clemente Ruiz Durán</i>	163

8	Emerging transnational corporations from East Asia: the case of mainland China <i>Edward K.Y. Chen and Ping Lin</i>	183
9	Multinational production networks and the new geo-economic division of labour in Pacific Rim countries <i>Prema-chandra Athukorala</i>	208
10	Multinational corporations and Pacific regionalism <i>Philippa Dee</i>	232
11	Governing multinational corporations in the Pacific <i>Robert Scollay</i>	267
12	Corporate social responsibility and capital accumulation <i>Djisman Simanjuntak</i>	283
	Index	306

Figures

2.1	The real-time supply chain IT architecture	36
2.2	The core model: real-time alignment of supply and demand	37
4.1	The PC industry value network	90
4.2	PC industry supply chain	94
4.3	ICT use in a supply chain	95
5.1	Japan's outward FDI	115
5.2	Japanese FDI outflow by region, 1989–2004	117
5.3	Japan's outward FDI by sector, 1989–2004	117
5.4	Overseas sales as a percentage of total sales by Japanese MNCs, 1993–2002	120
6.1	South Korean outward FDI, 1980–2003	144
6.2	Total South Korean outbound FDI, 2003, by destination	145
6.3	South Korean outbound FDI in manufacturing, 2003, by destination	146
6.4	FDI and trade in manufacturing	147
6.5	FDI and trade with China, 1990–2003	148
6.6	FDI and trade with the United States, 1990–2003	149
7.1	Mexico direct investment abroad	169
10.1	Inward FDI stocks into broad geographic regions	251
10.2	Inward FDI stocks into socioeconomic groupings of regions	251
10.3	Inward FDI stocks into 'geographic' groupings of regions	252

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4 Information and communication technologies and inter-corporate production networks: global information technology and local *guanxi* in the Taiwanese personal computer industry

Kenneth L. Kraemer, Jason Dedrick, William Foster and Zhang Cheng

INTRODUCTION

Globalisation and the need for competitive advantage are driving many firms and whole industries towards vertical disintegration. Firms focus on their core competence, from which they derive competitive advantage, and outsource their non-core activities to other firms who are specialists in these activities at home and abroad, thereby giving rise to global business networks. The personal computer (PC) industry is one such network, and might be a harbinger for other industries.

In the PC industry, the branded PC-makers concentrate on product design and marketing. They outsource production, distribution and after-sales service and source the major parts needed, components and assembly activities from specialised producers. Working with their main subcontractors on a global basis, the branded PC-makers are vertically disintegrated, yet globally integrated through the use of information and communication technologies (ICTs), which are the backbone of such global integration. The result is the so-called networked corporation.

Ideally then, the networked corporation is supported by a real-time digital network with unbroken links from customer demand to the last supplier in the supply chain. In it, the branded PC-maker and its suppliers have digital access to demand and supply information in order to achieve an optimal balance. This requires digital access to demand information from the end customer or the retailer so that the PC-maker can monitor demand, or even manage demand directly. It also requires access not only to the inventory and manufacturing capability of its subcontractors, but also to the inventory and manufacturing capability of companies further up the supply chain. In theory, these upstream suppliers are motivated to make use of the internet and related applications because they realise that they need to adopt the technology in order to serve global markets and better coordinate with their downstream customers.

But to what extent does the ideal vision of digitally enabled production networks match reality? We examine this question in detail, focusing on the notebook PC industry supply chain. We find that the picture is mixed. The digital production network is a fairly good characterisation of the information systems linking branded PC-makers with their original design manufacturer (ODM) partners, but the rest of the supply chain – the micro production networks¹ below the ODMs – is best characterised as a 'neural network' that is based on human and personal relationships with very limited

use of ICT; hence the subtitle of this paper – ‘Global information technology and local *guanxi*’. *Guanxi* refers to the personal relationships and obligations that underlie social and business interactions in the Chinese culture; given the concentration of the PC industry in Taiwan and China, *guanxi* is the organising principle for the industry’s neural network.²

THE NOTEBOOK INDUSTRY VALUE NETWORK

The PC industry is a complex network of companies involved in different industry segments, from microprocessors and other components, to complete systems, operating systems, and applications. Firms tend to specialise in one of three categories of activities:

- *design or new product innovation*, including R&D, design, market research, and new product development (NPD);
- *production or operations*, including process engineering, manufacturing, logistics, information technology (IT), finance, and human resources; or
- *distribution and customer relations*, including marketing, sales, advertising, distribution, customer service, and technical support.

On the upstream (supply) side (Figure 4.1), the industry comprises branded PC-makers who focus on design, marketing, and sales; contract manufacturers and ODMs who focus on production; and a large array of suppliers who provide parts and

components. This upstream network is multi-tiered and becoming more concentrated organisationally and geographically for economies. On the downstream side, the industry comprises logistics providers, a large array of distributors (wholesalers, retailers, resellers and systems integrators), and service and support. The downstream (demand) side is increasingly distributed in an effort to serve new markets. In this paper, we focus mainly on design and production activities of the PC-maker, the ODMs and upstream suppliers (Figure 4.1, shaded areas).

Division of labour

New product innovation in the notebook industry is led by US firms such as Dell, HP, Apple and Gateway, with competition from Japanese and Asian firms, notably Toshiba, Fujitsu, Sony, Acer and, most recently, Lenovo. Most notebook PCs are produced in the Yangtze River Delta of China by Taiwanese owned and managed firms (Table 4.1).

Together, the Taiwanese ODMs produce more than 80 per cent of the world’s notebook PCs (MIC 2006), up from just 40 per cent in 1998 (Dedrick and Kraemer

Table 4.1 Extent to which notebook PC-makers outsource production to Taiwanese firms

Top 10 branded notebook companies	Subsidiaries in China	Estimated outsourcing to Taiwanese companies in January 2005 ^a (% of world production)	Shipments by Taiwanese companies, April 2005 ^b (% of world production)	Taiwanese ODM suppliers
Apple		100	5.1	Quanta, Asus, Elite
Dell	Xiamen	92–93	21.6	Quanta, Compal, Wistron
HP	Shanghai	100	19.1	Quanta, Compal, Wistron, Inventec, Arima
IBM ^d	Shenzhen	40	4.2	Wistron, Quanta
Acer		100		Quanta, Compal, Wistron
NEC	Shanghai	100	5.3	Arima, FIC, Wistron, Mitac
Sharp		n.a.	n.a.	Quanta, Mitac, Twinhead
Sony	Wuxi	60	4.0	Quanta, Asus, Foxconn
Toshiba	Hangzhou	>70	9.6	Quanta, Compal, Inventec
Fujitsu-Siemens		50	4.0	Wistron, Mitac, Uniwill, Quanta, Compal

Notes: n.a. = not available; ODM = original design manufacturer.

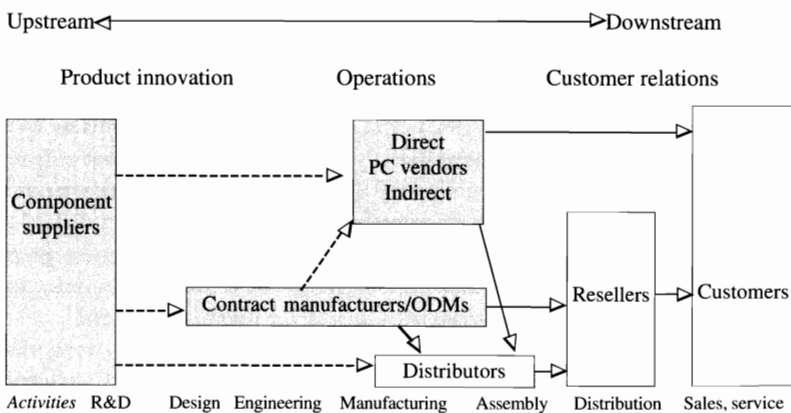
a ‘Taiwan notebook makers to curtail low-price strategy, extend global dominance’, *Digitimes*, 20 January 2005, <<http://www.digitimes.com/news/a20050119A7032.html>>.

b *Digitimes* (2005), ‘Taiwan’s notebooks – 1Q 2005’, *Digitimes*, Wednesday, 17 August 2005, <http://www.digitimes.com/Reports/Report.asp?datepublish=2005/6/3&pages=RI&rseq=400_9/2/05>.

c Yang and Hsia (2004) quote this table from a report by the Ministry of Economic Affairs, Taiwan (cited in Yang 2005).

d Prior to the acquisition of IBM’s PC business by Lenovo.

Figure 4.1 The PC industry value network



Notes:

--- Components, subassemblies, box-builds.

— Complete systems.

Source: Adapted from Curry and Kenney (1999).

2006). Now that IBM has sold its PC company to Lenovo, no US PC company produces its own notebooks. Lenovo now has its own notebook production but, like other Chinese notebook brands, also sources lower-end products from the Taiwanese ODMs.

Firm size in the production network

The notebook production cluster in China is a multi-tiered structure with ten key ODMs and hundreds of upstream suppliers. Moreover, at each level of the supply chain, there are a few large and many more small and medium-sized firms forming micro production networks (Table 4.2). Based on various reports in the literature, we estimate that, out of 1,200 Taiwanese firms in the Yangtze River Delta, around 200 are directly related to the PC industry.³ Many of the other firms might also be upstream suppliers to the industry.

FRAMEWORK: DIGITAL AND SOCIAL NETWORKS

The digital networks of the global corporation overlie physical production networks and are complements to the social networks that plan and control operations. Digital networks enable global firms to improve the information flows from customers to suppliers and the information flows needed to manage the physical flows of material forward from suppliers to customers.

The key value of using IT in the supply chain is to substitute information flows for physical flows wherever possible and to provide 'integrated' information flows that reduce problems, or help to optimise the system. Consequently, research and practice have sought to create the 'ideal' integrated supply chain that would integrate information flows both internally and externally, and both upstream and downstream (White *et al.* 2004; Norris *et al.* 2000; Johnson and Whang 2002; Swaminathan and Tayur 2003; Sambamurthy *et al.* 2003).

During the 1990s, firms made major investments in upgrading internal IT through enterprise resource planning (ERP) systems, which were critical to integration in firms operating through multiple divisions or geographical locations. They enabled the firm to operate as a single enterprise, and also created a stable platform for inter-firm integration (Markus 2002; Markus *et al.* 2000).

With the advent of the internet, firms began to shift from firm-specific applications (electronic data interchange, EDI) to external integration, adding more flexible web-based applications for e-business, especially for e-coordination. Such applications automate business processes between a focal firm and suppliers, including e-purchase orders, online catalogues and online linkages with suppliers to exchange information regarding fulfilment (for example, order and inventory information).⁴

Moreover, firms have tried to extend these applications beyond a focal firm, such as the PC-maker and its ODM contractors, to the suppliers of the contractors, and to the suppliers of their suppliers further up the supply chain. Most new applications have been private networks driven by large firms for their own production ecology (for example, Dell and HP in the PC industry). Others have been promoted by industry associations; for example, the RosettaNet organisation in the PC industry creates standards for inter-firm business processes and promotes them to the industry.⁵ Still

Table 4.2 Firm size in the notebook industry (2004 revenues, \$ million)^a

(a) Notebook-makers Top 10 companies		(b) Original design manufacturers Top 10 companies	
	Revenue		Revenue
Dell	49,205	Quanta	10,222
HP	79,905	Compal	6,660
Toshiba	54,543	Wistron	3,673
Acer	7,036	Asustek	2,459
IBM	96,293	Inventec	4,139
Fujitsu	44,512	Uniwill	682
NEC	45,375	Mitac	1,591
Sony	66,775	Arima	570
Apple	8,279	FIC	1,209
Asustek	2,459	ECS	525
(c) Suppliers (top Taiwanese PC suppliers by component category)			
Supplier	Revenue	Supplier	Revenue
Memory			
Nanya Tech	1,277	Power supplies	
Winbond	984	DeltaElectronics	1,462
Mosel	818	Com2B	4,909
PSC	1,810	LiShin	55
LCDs			
AUO	5,186	Potrans	51
ChiMei	3,230	Optical storage	
ChungHwa	2,471	Quanta Storage	315
Quanta Display	1,834	Lite-On	1,532
HannStar	1,221	PanInternational	244
Motherboards			
Compeq	403	BTC	416
Unimicron	522	Ultima	n.a.
Gold Circuit	311	Keyboards	
HannStar Board	85	Sunrex	74
Vertex	103	Darfon	148
Career Tech	218	Chicony	396
Tripod	286	Lite-On	1,532
Connectors			
Foxconn ^b	13,285	Cases	
Speedtech	95	Catcher	47
Battery		Waffer	80
E-One Moli	64	Unec	175
Simplo	284	Loyalty Founder	103
Solomon	255		
Gallopwire	69		

Notes: LCD = liquid crystal display; n.a. = not available.

- a Foreign multinational suppliers such as Intel, Seagate, Western Digital are not included, although they manufacture in China or elsewhere in Asia, because their use of information and communication technology is similar to that of the PC-makers and they are not part of the China-Taiwan cluster.
- b Hon Hai (Foxconn) is a major supplier in a number of categories, including connectors, motherboards, and cases, and is a major contract manufacturer for many electronic products. There are no data available on the breakdown of its revenues by product, but Foxconn connectors are shown separately here because FoxconnConnectors is listed on the Taiwanese Stock Exchange as a separate company.

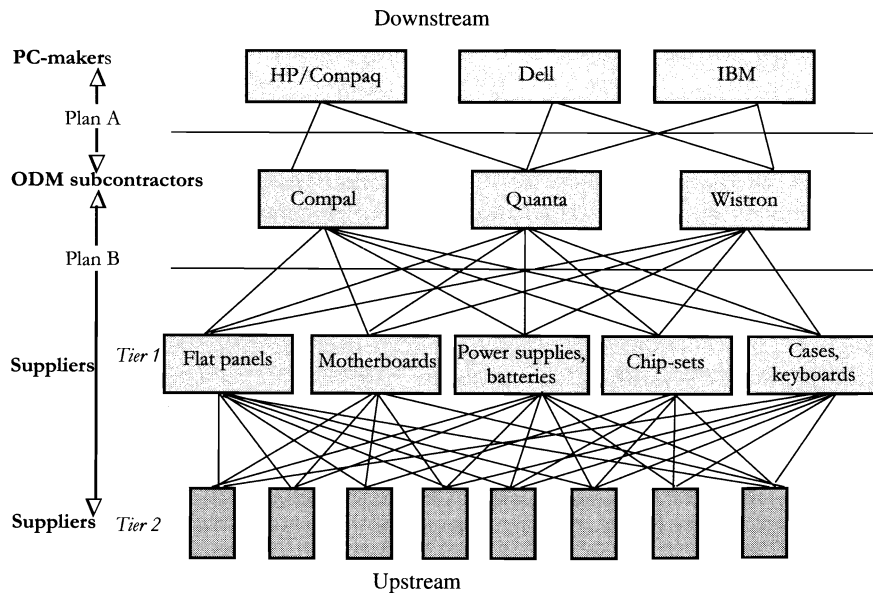
Sources: For notebook-makers, the ranking and revenue are based on Daoud and Lovende (2005: Vol. 1, Table 8, p. 12) (4Q04 data). For original design manufacturers and suppliers, information is from Compustat (2004 sales); Hoovers (2004 sales: see <<http://www.hoovers.com>>); and Taiwan Stock Exchange Corporation (2004 sales: see <<http://www.tse.com.tw/en/>>).

others have been promoted by governments. For example, the Taiwanese government recognised that the complexity and costs of these digital networks were beyond the capabilities of most small- and medium-sized enterprises (SMEs) and created two plans (A and B) to create electronic information linkages using the RosettaNet system and XML between PC-makers and ODMs on the one hand (Plan A) and between the ODMs and their suppliers on the other hand (Plan B). The intended result of such efforts is a large digital network, created by linking the micro production networks of particular focal firms and their business partners with one another as illustrated in Figure 4.2.

Social networks

The digital networks described above rely on codified business processes and related information. However, much of what occurs to make production networks function is not codified but tacit, and relies on social networks and various kinds of personal and direct relationships: face-to-face communication, information sharing, negotiation, and development of personal regard and trust (Granovetter 1985). Moreover, reliance on social networks might be stronger where firm relationships are based on family

Figure 4.2 PC industry supply chain



Note: ODM = original design manufacturer.

and personal relationships such as Chinese business networks versus formal and market-oriented relationships in Western firms. Consequently, it is important to examine the relative use of digital and social networks in global production chains.

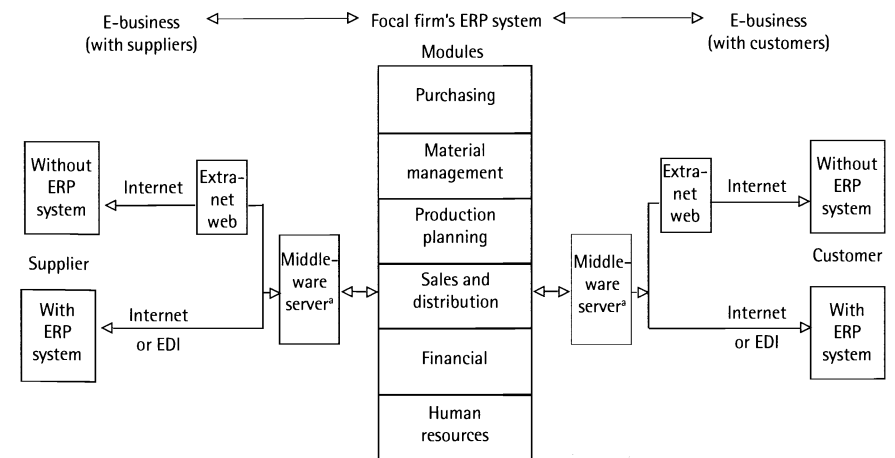
Methodology

We do so by examining the notebook PC industry in Taiwan and China. The time-based nature of competition among firms and the industry's global footprint provide strong motivation for building digital networks both globally and locally (Dedrick and Kraemer 1998). The industry is unique in that it has been an early adopter of industry-wide standards (the RosettaNet system and XML) for inter-firm coordination. Thus, its experience might be a harbinger for other industries and might provide useful insights (Malakooty 2005).

We assess digital integration of the notebook industry supply chain indirectly by examining whether firms have in place ICTs that would provide capabilities for integration. Figure 4.3 presents a simplified picture of how internal systems such as ERP fit physically with internet-based applications or e-business technologies such as EDI, extranets or email.

In the middle of the figure is a focal firm's ERP system. It might include one or more modules such as purchasing, material management, production planning and

Figure 4.3 ICT use in a supply chain



Notes: EDI = electronic data interchange; ERP = enterprise resource planning; ICT = information and communications technology.

a RosettaNet, Standard and XML language.

Source: Adapted from Hsu and Kraemer (2006).

control, sales and distribution, finance, human resources and possibly others. On the supplier side, information generated by an ERP system can be shared via the internet directly with suppliers' ERP systems using middleware software that is based on industry predefined standards such as EDI or RosettaNet and the XML language. If a supplier does not have ERP or another internal system that can be linked, it can still receive and exchange business information through EDI, an extranet website or email. In the simplest case, an ERP system might generate an email notifying a customer or supplier of new information posted to a website. Thus, firms may have multiple levels of automation in place simultaneously: highly automated, semi-automated, web-based, fax-based, email, or manual systems.

We used the framework described by Figure 4.3 to develop a protocol for interviews with executives and information systems managers. We conducted 45 interviews in 20 companies across four tiers in the PC industry to gain an understanding of extant ICT capabilities for integration. We interviewed four branded PC-makers, five ODMs, ten tier 1 suppliers and two tier 2 suppliers (Table 4.3). The semistructured field interviews were conducted in 2004 and 2005 with PC-makers in the United States and with ODMs and suppliers on site in Taiwan and China. Many interviews were with information systems executives, although some were also with senior executives, product development managers, procurement managers, and sales managers. The researchers were accompanied by a local Chinese researcher who participated in the interviews and helped with translation when needed. Immediately after the interviews, each would write up a different interview and then check the others' write-up with their own notes. Differences were resolved through discussion or follow-up questions where appropriate. As part of the interview, respondents were shown Figure 4.2 delineating the tiers in the supply chain in order to establish a framework for the interview. Each firm was asked about its use of ICT internally, and about its use of ICT externally with customers and suppliers.

We compared the interview results with secondary data on the formal electronic linkages actually implemented in Taiwan's Plan A/B program (DOIT 2006), which focused on the Taiwanese ODMs and their suppliers. As will be seen later, our results are consistent with the final report on the Taiwanese plans. We further complemented the interviews with our previous interviews and studies of the computer industry (Dedrick and Kraemer 1998, 2005, 2006).

DIGITAL NETWORKS IN THE NOTEBOOK PC INDUSTRY

Great progress has been made in developing digital networks within the PC industry since 1990, but most of that progress has been internal to PC-makers and the ODMs, or between the PC companies and the ODMs. There has been much less progress in extending digital networks upstream from the ODMs to tier 1 and tier 2 suppliers. These suppliers are beginning to use ICTs internally, but traditional Chinese human and business networks appear to be more significant for external linkages. Thus, the supply chain can be said to be characterised by global ICT between the branded PC-makers and the ODMs, and by *guanxi*, or personal relationships, assisted by modest ICT use, in the local networks.

Table 4.3 List of firms interviewed

Name	PC-related business	No. of interviewees	Location
<i>PC-maker</i>			
IBM PC division ^a	PC-maker	4	US, Japan, China
Dell	PC-maker	4	US
HP	PC-maker	3	US, Japan
Lenovo	PC-maker	3	China
<i>ODM/subcontractor</i>			
Quanta	ODM	8	Taiwan, China
Compal	ODM	3	Taiwan, China
Arima	ODM	2	China
Wistron	ODM	3	Taiwan, China
Asus	ODM	2	China
<i>Tier 1 supplier</i>			
Western Digital	Disk drives	1	US
Acon	Cables and connectors	2	China*
Sinbon	Notebook FPD cable, connectors	1	China*
TWS(Total Wireless)	Battery packs	1	China*
ACeS International	Connectors	1	China*
Auras Technology	Thermal modules, CPU coolers	1	China*
Darfon	Keyboards	1	China*
Laird Technologies	EMI thermal interface, wireless antenna	1	China*
Unimicron	PCB-maker	1	China*
Delta	Power supply, batteries	1	China*
<i>Tier 2 supplier</i>			
Copartner	Cables and connectors	1	China*
Top Chem	Chemicals for PCB manufacturing	1	China*

Notes: CPU = central processing unit; EMI = electromagnetic interference; FPD = flat-panel display; ODM = original design manufacturer; PCB = printed circuit board.

a All interviews were prior to the purchase of IBM's PC division by Lenovo in December 2004.

Source: Interviews conducted in 2005 by William Foster and Z.C. Chang (interviews marked *) or (all others) Jason Dedrick and Kenneth L. Kraemer.

ICT in the PC-makers

As the PC-makers turned to outsourcing production, they mostly engaged in major efforts to install packaged ERP systems and focused on purchasing, supply chain management, and customer relationship management. Nearly all retained their internal, customised order management systems, which provided the digital interface between orders, supply, production and distribution. These were especially valuable as the PC-makers moved from in-house operations to outsourcing, because they helped to control the fulfilment of orders.

As they outsourced production, some PC-makers discontinued their own material management and shop-floor management systems, relying instead on the systems of the contract manufacturer or ODM. The shift to outsourcing also created a need for inter-organisational systems for sharing customer demand information with suppliers and receiving information on inventory and production so that the PC-makers could better manage new product introductions and fulfilment on ever shorter cycles.

The critical applications for PC-makers, however, are the order management and forecasting systems. These can be custom-built, such as the Dell Order Management System, or can be commercial enterprise applications such as SAP-F (fulfilment). They are the key systems for integrating internal operations. In turn, they may be integrated directly with customers and suppliers through ERP-to-ERP exchanges, through EDI or RosettaNet applications, or through web interfaces or extranets.

Results from the field interviews (see Table 4.4) with leading PC-makers show that such firms have implemented the key internal systems and that they use a variety of approaches to external integration. EDI is most widely used because it has been around the longest, but RosettaNet procurement applications are also used. Extranets for customers and suppliers are used by all, as is email and attached files for information exchange.

ICT in the original design manufacturers

The ODMs have followed the PC-makers in upgrading their internal systems (Table 4.4). Most ODMs implemented mainstream ERP systems in the late 1990s, but continue

to use their custom shop floor management systems. These systems helped the ODMs to internally integrate their new manufacturing operations in China with their headquarters in Taiwan. They also helped the ODMs to manage the sheer volume of notebooks that they were producing. For example, the largest ODM (Quanta) manufactured 15 million notebooks (1.25 million per month, 52,000 per day) in 2005.⁶ This scale of operation cannot be maintained without considerable automation. In addition, most ODMs are manufacturing many different configurations for multiple customers, each configuration requiring multiple parts. Thus, most ODMs see ICT as essential to their operations, as do the PC-makers who rely on their capabilities.⁷

The external systems used by ODMs are shaped on the one hand by the requirements of the PC-makers and on the other hand by the limitations of their suppliers. On the downstream side, the ODMs need the capability to inter-operate with multiple IT systems because each PC-maker has different systems and the ODMs have to be able to communicate with each directly. However, our interviews indicate that the ODMs' internal ICT generally does not match that of the leading PC-makers; therefore most PC-makers do not allow the ODMs to perform tasks such as direct-shipping from the factory to the end customer.

The ODMs receive forecasts and orders from the PC-makers via EDI or the internet. Most ODMs are carrying out 2–4 procurement processes using the RosettaNet system. This is because RosettaNet has been required by some suppliers (for example, Intel) and PC-makers, and has been promoted by the Taiwanese government. In particular, the Plan A/B program provided financial inducement for ODMs to implement RosettaNet applications with their customers. ODMs say that they also use RosettaNet applications to communicate with their tier 1 and tier 2 suppliers, but actual use appears to be very limited, as will be seen below.⁸

On the upstream side, the ODMs realise that their small suppliers do not have the technical expertise to implement EDI or RosettaNet, even though RosettaNet is touted as a cheaper and simpler standard. Instead, most ODMs have developed a secure website that each supplier can access. The ODM places forecasts and orders for each on the web and the tier 1 and tier 2 suppliers access the information via the internet.

ICT in lower tier suppliers

Although a few foreign or large Taiwanese suppliers of components match the PC-makers and ODMs in their use of ICT (see 'Foreign firm' column, Table 4.5), most tier 1 and tier 2 suppliers are SMEs whose ICT use is far below that of the ODMs. They rely instead on face-to-face meetings and personal ties that they have developed over many years. Some consider ICT limiting:

If the customer needs it, we can do things in the system. After the deal is over, we will return to normal operation. Western systems can cause Chinese companies to lose flexibility to respond to customers. (Authors' interviews with company B; see Table 4.5)

Most ICT used by tier 1 suppliers is focused on internal integration aimed at better linkages between their manufacturing operations in China and their design and headquarters operations in Taiwan. All tier 1 suppliers we interviewed either had ERP

Table 4.4 Use of ICT applications by PC-makers and ODMs

ICT applications	PC-maker				ODM			
	A	B	C	D	E	F	G	H
<i>Internal</i>								
Product data management	×	×	×	×	×	×		
Sales/order/distribution management	×	×	×	×	×			
Material/inventory management	×	×	×	×	×		×	
Production/shop floor management	×	×			×	×	×	×
Human resources	×	×	×					
Finance/accounting	×	×	×	×	×			
<i>External</i>								
Customer extranet	×	×	×	×		×	×	×
Supplier extranet	×	×	×	×	×	×	×	×
E-procurement (EDI/RosettaNet)	×	×	×	×	×	×	×	×
Email	×	×	×	×	×	×	×	×

Notes: EDI = electronic data interchange; ICT = information and communications technology; ODM = original design manufacturer. A blank in this table means 'no such application'.

Source: Interviews conducted by the authors in 2005.

Table 4.5 Information technology in tier 1 and tier 2 suppliers^a

	Foreign firms ^b		Taiwanese firms										
	Tier 1	Tier 1	A	B	C	D	E	F	G	H	I	J	K
ICT applications													
<i>Internal</i>													
Product data management	×											×	
Sales/order/distribution management	×	×										×	×
Material inventory management	×	×	×									×	×
Production/shop floor management	×	×	×									×	
Human resources													
Finance/accounting	×	×	×	×	×	×	×	×	×	×	×	×	×
<i>External</i>													
Customer extranet	×			×		×	×			×			
Supply extranet						×	×	×	×	×			
E-procurement (EDI/RosettaNet)	×												
Email	×	×	×	×	×	×		×	×	×	×	×	×

Notes: EDI = electronic data interchange; ICT = information and communications technology.

a A blank means 'no such application'.

b Foreign multinational corporation supplier of disk drives.

Source: Interviews conducted by the authors in 2005.

systems or were in the process of implementing them (Table 4.6). However, most do not have shop floor automation, material requirement planning, customer relationship management, or supply chain management applications in place (Table 4.5). The ERP systems are mainly limited to finance and used to help CEOs coordinate and manage the costs associated with multiple product lines being produced at multiple manufacturing sites.

Thus, tier 1 companies are using IT for internal operational management rather than for supply chain coordination. This is very different from the ODMs that have invested heavily in systems linked to the PC-makers and, to a lesser degree, systems linked to the tier 1 suppliers.

A few suppliers currently communicate with a select group of international customers using the RosettaNet standards, but generally tier 1 suppliers are not set up to implement EDI or RosettaNet because of the considerable cost and complexity involved.⁹ Most of these suppliers have websites for showing their product availability, but they currently use fax and phone to transact business.

The tier 1 suppliers all used email for communicating on a daily basis, but distrusted it for orders from customers. They wanted a signature, so they tended to use a fax machine. Some used email to negotiate prices and receive orders from international

Table 4.6 Enterprise resource planning (ERP) systems of tier 1 and tier 2 companies

	Company	ERP system
Tier 1	A	Taiwanese ERP (Dingxin)
	B	Taiwanese ERP (Dingxin)
	C	SAP ERP
	D	Taiwanese ERP (DSC)
	E	Taiwanese ERP (DSC)
	F	BPCS with a lot of customising
	G	Taiwanese ERP
	H	Oracle ERP
	I	SAP ERP
Tier 2	J	PRC ERP
	K	No ERP

Source: Foster *et al.* (2006).

markets. In this case, the capability of email to transcend time and distance limitations outweighed its disadvantages. When buying from international suppliers, tier 1 companies generally ordered through the supplier websites.

ICT use in the two tier 2 suppliers was even less advanced than that in tier 1. One said:

As far as the manufacture of cables is concerned, we usually find our new suppliers online. But after finding them, we will turn to the traditional communication method again – place orders by fax and then confirm by phone. (Authors' interviews with company J; see Table 4.5)

They said they negotiated prices in person because:

I like to look in the eye of my suppliers when negotiating price. (Authors' interviews with company J; see Table 4.5)

And they placed orders to suppliers only by fax:

We don't use IT when placing orders. We need signatures on orders. And if we use email, it will involve some legal problems. (Authors' interviews with company J; see Table 4.5)

The other tier 2 provider had a number of PCs and was content to run his business using spreadsheets. For email, he used a local Chinese portal (authors' interviews with company K; see Table 4.5).

ICT in the local network

Beyond efforts of the firms themselves, the governments in both Taiwan and China have sought further automation and linkages in the local network, including linkages with customs and tax authorities.

The local authorities in the Yangtze River Delta have been motivated to help the Taiwanese ODMs as a means of attracting more foreign direct investment (FDI) to their cities. Intensely competitive for FDI, several cities (Kunshan, Suzhou, Wujiang, Songjiang) have developed large industrial parks and implemented 24x7 customs operations and automated ICT systems for customs processing and tax collection in the export processing zones. These operations and ICTs enable clearance in several hours compared to several days elsewhere (Wang and Lee, forthcoming).

As mentioned above, the Taiwan Ministry of Economic Affairs developed the Plan A/B program in an effort to ensure Taiwan's place in global production networks.

Three foreign multinational corporations (MNCs) participated in Plan A (IBM, HP and Compaq) to implement automated procurement linkages. Fifteen Taiwanese firms (ODMs and large component suppliers) developed machine-to-machine electronic linkages with 3–22 suppliers, many involving the same suppliers (Anon. 2002; DOIT 2006). The linkages focused entirely on purchasing activities – requests for quotations, orders, order changes, and order cancellations (Table 4.7). Although there are claims that the two plans involve more than 4,000 participants, our field interviews indicated that most local linkages are to the websites of ODMs and the larger tier 1 suppliers rather than being automated linkages of business processes.

Table 4.7 Electronic integration between ODMs and their suppliers

Program B participating firms ^a	Number of tier 1 suppliers that ODMs link with electronically	Implemented PIPs ^b
ASUS	22	3A3, 3A7, 3A8
Mitac	12	3A3, 3A7
Tatung	12	3A3, 3A7, 3A8
Acer	10	3A3, 3A7
Delta	10	3A3, 3A7, 3A8, 4A4
Inventec	10	3A3, 3A7, 3A8
Twinhead	8	3A3, 3A7, 3A8, 3A9
Compal	5	3A3, 3A7
Sampo	7	3A3, 3A7, 3A8, 3A9
Microstar	15	3A3, 3A7, 3A8, 3A9
Compeq	6	3A3, 3A8, 3A9, 3C6
Primax	5	3A3, 3A7, 3A8, 3A9
ADI	3	3A3, 3A7
Arima	5	3A3, 3A7
First International Computer	5	3A3, 3A7
<i>Total</i>	<i>135</i>	

Notes: ODM = original design manufacturer.

- a Most of these firms are ODMs, but a few are large component suppliers (Compeq, Tatung, Delta, Sampo, Microstar, Primax, ADI). Quanta, which is the largest ODM, did not participate.
- b PIPs are 'partner interfact processes': 3A3 = request purchase order; 3A7 = notify of purchase order; 3A8 = request purchase order change; 3A9 = request purchase order cancellation; 3C6 = notify of remittance advice; 4A4 = notify of planning release forecast.

Source: DOIT (2006). Data last updated 28 February 2002.

Promotion of RosettaNet has been extended to China, with the backing of China's Ministry of Science and Technology, but the take-up is not clear. A recent RosettaNet Global Conference in Beijing featured presentations by foreign MNCs such as Dell, HP, IBM, Intel, Sony, Arrow Electronics, Fairchild Semiconductor, and Nokia. There were presentations about a demonstration project for extending linkages among Taiwanese firms beyond the Plan A/B program to other levels and to money flows in addition to information flows (Liang 2005; Hainian 2005), but there was not a single project presented about mainland Chinese firms. Thus, the development of the lower tier linkages in the supply chain is still in the education and promotion stage.

In summary, there is a strong, sophisticated digital network between the global PC-makers and Taiwanese ODMs in China, but the digital network more or less stops at the ODM level. Most tier 1 suppliers access the ODMs' website for forecast information and exchange information via email and attached files (spreadsheets, CAD files, Word files), phone and fax. The tier 2 suppliers we interviewed rely mainly on phone and fax. Efforts to promote greater linkages in the local network by Taiwan and China authorities do not appear to have much traction as yet, but local authorities have created ICTs for customs and tax processing in the export processing zones to speed up logistics.

These findings are consistent with recent research that has described the production networks in China as 'institutionally embedded but technologically de-linked' (Wang and Lee, forthcoming). The quote is a reference to the fact that local Chinese officials and Taiwanese entrepreneurs have developed customs and tax processing procedures for facilitating logistics in order to meet the demands of global PC-makers, but there has been no technology transfer to mainland Chinese firms.

The same might be said about the digital networks of the notebook PC industry in China. The Taiwanese ODMs use internal ICT to manage operations in multiple locations. The tier 1 and tier 2 suppliers are also internally focused – on financial and shop floor management to meet ODM demands. The local Chinese officials focus only on ICT that is specific to their own industrial park and that facilitates customs processing for their clients and tax collection for their own reinvestment needs. Given the dynamism of the industry, no one is yet able to make ICT investments in the micro production networks, in developing ICT capabilities in the lower tier suppliers, or in a broader digital network as envisaged by Taiwanese and, recently, Chinese officials. Given the limited state of ICT, and the narrow focus of most applications, a key question is: what makes the local elements of global production networks work?

SOCIAL NETWORKS IN PC INDUSTRY PRODUCTION

Anne Stevenson-Yang, a long-time observer of the IT supply chain in China and Taiwan and former Director of the US Information Technology Office (USITO) in Beijing, characterised the China–Taiwan PC supply chain as 'a human neural network that optimizes production and minimizes costs' (Foster *et al.* 2006). She was referring to the way in which human and business networks interact with one another in Chinese production networks.

There are many aspects of social relationships in the PC industry that are common across the entire electronics industry: the importance of family, school and corporate

ties; the linkages among overseas Chinese employed in foreign multinationals; the entrepreneurial culture; the financing of new firms by family members and industry leaders; the importance of *guanxi* in all relationships; and so on. However, we focus here on personal relationships, trust, and informal information sharing as substitutes for contracts, inter-organisational information systems, and formal information sharing. We refer to these as *guanxi*, or personal relationships, versus market-based relationships. We find that whereas more formal market-based connections characterise relationships between the PC-maker and ODMs, *guanxi* and informal information sharing characterise those between ODMs and suppliers.¹⁰

Relationships between PC-makers and ODMs

The relationships between PC-makers and ODMs for production activities are based on formal contracts, and thus can be considered market based. The PC-maker develops concepts and specifications for a new notebook and then formally requests bids for development and manufacturing. The branded notebook companies usually have three or four ODMs in their supplier list (Table 4.1) and divide their product line among the suppliers, who compete on price (Dedrick and Kraemer 2005). The result is uncertainty and risk for ODM notebook-makers, as the branded PC companies tend to routinely switch between vendors for individual products.

In addition, the largest PC-makers usually contract directly with suppliers for key components and have them consigned to the ODM. At least one PC-maker conducts reverse auctions for individual parts. They contract directly because their size gives them greater bargaining capability and market power with suppliers. In contrast, the smaller PC-makers tend to let the ODMs procure the components due to their greater buying power, but look for some sharing of the price gain from the ODM.

The relationships for design and development are also formal and contractual, although they depend on the role the ODM plays in design. We estimate that about 20 per cent (Apple, Toshiba, Sony and Lenovo) do much of their own design; another 20 per cent rely nearly completely on the ODM to innovate and to design the notebooks; and about 60 per cent co-design notebook models with the ODM. The major PC companies also have their own design personnel and product managers who monitor the ODMs during the development process.

Although these relationships are market based, there is still considerable personal interaction between the branded notebook company and the ODM when they co-design new products. The PC-maker's branded industrial design and knowledge of the market must be blended with the ODM's knowledge of new technologies, physical development possibilities and manufacturing realities. However, even these interactions are structured by a design process complete with gates, performance metrics, and potential penalties.

Relationships between ODMs and their suppliers

Social networks are much more important than formal contracts between the ODMs and tier 1 and tier 2 suppliers. One reason is that it is simply the culture of business in China. As one tier 2 provider said: 'I have known the President of [one of Taiwan's largest contract manufacturers] for 30 years; we look out for each other.' The ODMs

expect their suppliers to provide them with whatever they need, but they also look out for their suppliers. They will collaborate to find cheaper materials and methods to meet the continual demands of the branded PC firms for price reductions. They will negotiate face to face on sensitive matters such as pricing and sharing of missed production, overstock, and warranty costs.

Another reason that personal relationships are so important is that the IT systems used by suppliers are all different and primitive. Whereas the ODMs have modern ERP systems, most suppliers use home-grown systems or highly customised local packages that cannot be linked easily (Table 4.6). One tier 1 supplier said:

Our major problem is that different companies use different systems; they do not link together and we can't build the linkages due to cost and skill needed. (Authors' interviews with company A; see Table 4.5)

The number of linkages for tier 1 and tier 2 suppliers is usually large; there are usually 50–100 customers and suppliers rather than a few dozen as with the ODMs. Consequently, it is easier to use human-to-human interfaces aided by phone, fax, and email for collaboration than to build more automated inter-organisational ICT connections.

Still another concern of suppliers is security:

We are afraid of secrets getting out. Turnover is high and some key person may know the password and get access to our system for a competitor and do something to hurt our company, so we worry about that. (Authors' interviews with company A; see Table 4.5)

Lastly, this same supplier said:

... customers are more focused on quality, cost and capability, not IT. (Authors' interviews with company A; see Table 4.5)

In fact, as indicated earlier, suppliers use ICT for internal financial and production management rather than external linkages. They are content to use the ODMs' websites or extranets for demand information, and consider them superior to more automated forms (EDI, RosettaNet) because of their greater richness, detail, and time span.

Tier 1 suppliers must manage inventory in a manner that reduces costs but ensures that they can meet the needs of their ODM customers. They are more likely to keep raw materials in stock than finished products, as raw materials can be used for multiple products. They operate on a hybrid of build to stock and build to order. According to a tier 1 provider:

For cable assembly we build to order as we follow different designs according to the customer's request; for standardised connectors we can build to stock to adjust production loading. But mainly we build to order for better production and financial control. (Authors' interviews with company A; see Table 4.5)

In general, the tier 1 suppliers are very flexible and will give the ODMs what they want when they want it even if it means that their employees will have to work 15-hour days instead of 10–12-hour days. Also, tier 1 suppliers are not hesitant to outsource

work to the company of a trusted friend or relative in order to meet an ODM's requirement.

The tier 1 suppliers are generally small and centrally managed by an owner who relies on their own network of personal relationships to navigate and carve out their company's position in the supply chain. These hundreds of tier 1 and 2 suppliers interact like a neural network, matching demand with supply and making sure that there are no shortages in the supply chain. Due to the efficiency and effectiveness of this system, the ODMs are able to be very responsive, in turn, to the branded PC-makers.

How personal relationships work

Suppliers reduce risk due to volatility, competition and price pressure by developing personal relationships and business relationships based on proximity and face-to-face communications. As put by one supplier:

If talking face to face, people can construct a closer relationship. It is not only the Taiwan way, but the Chinese way. (Authors' interviews with company A; see Table 4.5. Similar statements were made in interviews with companies B, F and J)

Establishing and maintaining these relationships carries through, with suppliers locating offices near major customers, with frequent sales contacts with customers, with face-to-face price and market share negotiation, and with changes occurring within this structure. To overcome the issue of location, one company

... sets up offices close to big customers ... and does the business in a traditional way. To avoid losing touch with customers, each salesman only deals with 3 major customers. (Authors' interviews with company B; see Table 4.5)

The purpose of such close contact is for the salesman to collect information, verify it with multiple sources and make the correct interpretation of its implications for the supplier:

The salesman goes to the customer site almost daily. He visits sourcing, engineering, quality control, or production control to collect information, to validate messages from various sources for information that is true and valuable, and to increase our chances [to win the business]. For example, sometimes a buyer may ask for a lower price but promise you a larger order quantity in exchange, or ask you to prepare a large stock of inventory [as a hedge against the volatility of orders]. The salesman then may go to the customer's engineers to verify the offer by asking whether the company has received any big orders recently. (Authors' interviews with company B; see Table 4.5)

Beyond verification, the purpose of such close contact is to increase the chances that the company will actually receive an order. This involves ensuring that the company's product is qualified for procurement and negotiating price and market share. ODMs qualify at least two suppliers for any product, so the salesman and supplier's engineers provide information needed by the ODMs' engineers to qualify

the product, and do so quickly lest they look for others. After qualification, the salesman will focus on price negotiation and market share. As put by this same company:

At this time, a good relationship can make a big difference. With a good relationship, the customer may assign 60 per cent of their order with us. However, with a much closer relationship, the share can be 80 per cent. So the relationship is very important. (Authors' interviews with company B; see Table 4.5)

It turns out that such negotiations are fragile, however, when market conditions change. Here, personal relationships and face-to-face communication are important, first to just know about changes in time to act quickly and, second, to ensure a favourable outcome for the supplier:

The market share may change quickly, so the salesman should keep in touch with customers, at least to know whether the true share changes or not. What we know from the order is the volume, but not the order share [of the customers' total volume]. With a good relationship and trust, the salesman can get the share information from the customer's buyer (maybe during a nice meal or by sending a small gift), or know about some pending changes (volume, requirements) in time. In this way, the company can react quickly to the change to avoid losing volume or market share. (Authors' interviews with company B; see Table 4.5)

Perhaps the most sensitive negotiation stems from price pressures after negotiation. Branded PC-makers often demand reductions from ODMs, which in turn demand reductions from the suppliers. But not all suppliers are equal. The ODM cannot pass on, say, a 10 per cent reduction to a key supplier such as Intel or Microsoft, so other suppliers with no market power may face a 20 per cent reduction. If the supplier knows about the coming change, it may try to negotiate for greater quantity at the expense of its competitor. Alternatively, the supplier may negotiate to substitute 'over-quality' material with cheaper material on the grounds that the original specification guarded against a quality defect that would rarely occur in practice. An example given by one supplier is a connector that was required to be pulled in and out 2,000 times without failure but that was rarely unplugged. The supplier said:

When customers require lower cost, the companies can negotiate to change the spec but keep the function OK. In this way, the company and the customer share the benefit from changing materials. There are some situations where the customer might not know about this change, but eventually he will know. But, the customer usually accepts it since the supplier can help it cut down cost. (Authors' interviews with company A; see Table 4.5)

Finally, personal relationships are important during production in order to deal with demand fluctuation. The ODMs' suppliers must negotiate with their suppliers to give priority to their requirements over others in production, or to have the supplier work overtime. One interviewee said:

When suppliers cannot supply in time, it is most efficient to call them directly or send staff there. Usually a factory has many orders from different customers to

fulfill. It is workable to change the order of batch production or to arrange overtime work to meet our needs. (Authors' interviews with company B; see Table 4.5)

We do the same for our customers. We had an order from BenQ that was 1.5 times our factory's manpower capacity. As solution, the whole factory worked from 8am to 1am for three months until enough workers were trained to pick up the additional workload. Chinese people are used to change pressure, and willing to work longer for more money. (Authors' interviews with company B; see Table 4.5)

Clustering and geographic location of activities

The direct, personal relationships that are part of the business culture in both Taiwan and Mainland China are facilitated by executives clustering in housing neighbourhoods and business associations and suppliers clustering around the ODMs.

In Taiwan, many of the presidents of the ODMs and lead suppliers live in the same neighbourhoods so it is relatively easy for them to meet informally. The headquarters of many ODM suppliers are near the Taipei–Hsinshu area, so many deals are done face to face. In China, executives and managers of the Taiwanese and foreign firms (customers and suppliers) tend to live in the same gated housing communities and belong to the same private clubs, thereby facilitating informal interaction among senior executives there.

The notebook production network, which was clustered in Taipei–Hsinchu, moved *en masse* to China after the Taiwan government removed investment restrictions in November 2001.¹¹ Although urged on by the branded PC companies, the ODMs were also seeking cheaper production labour, land and materials because their margins were very thin. In fact, the ODMs had already established some supplier networks in China ahead of the change in policy. Some had been in southern China since the early 1990s serving the desktop industry, and moved some production east. Others moved directly to the mainland ahead of the ODMs, and still others came with them (Yang and Hsia 2004; Chase *et al.* 2004). The key point is that their supply networks were in place as the ODMs moved.¹² Thus, the organisational network from Taiwan was fully in place, long-term relationships also remained in place, and Taiwanese executives, managers and professionals were able to continue to negotiate face to face.

At the factory level, personal relationships are further facilitated because suppliers must be no more than a few hours from their major customers. Related firms tend to cluster near their major customers at each tier of the supply chain. For example, a cable and wire manufacturer noted:

We make wires and cables from raw materials provided by upstream companies. Then the downstream companies will assemble what we made. Eventually they will then be assembled in PCs ... One of the reasons that we came to mainland China is that many factories in Taiwan have come here. One of the things we heard from other suppliers is that the biggest challenge in China is logistics. It is easier to produce overnight [have people work overtime], but it is harder to get

the material to the factory. So a lot of suppliers locate their factories near the factories of their customers. (Authors' interviews with company A; see Table 4.5)

SUMMARY AND CONCLUSION

In the highly competitive notebook industry, the efficiency and effectiveness of its supply chain can make the difference between whether a PC-maker survives or thrives. Small differences in product quality, product costs, inventory costs and availability can be worth millions of dollars to the branded firms. In order to maximise the effectiveness and efficiency of the supply chain, PC-makers and their ODMs are using IT to minimise inventory and time to market, while ensuring that customers get the product they want at a competitive price. These companies use ICTs to support sales, order and distribution, procurement, material and inventory management, production planning and shop floor management, and finance and human resources.

Most ODMs use websites to provide tier 1 companies with forecast information and some push out orders through EDI, the RosettaNet system, or their website. However, there is a dramatic difference between the use of ICT in the ODMs and that in tier 1 and tier 2 suppliers. These suppliers primarily use ICT for financial controls to help them manage multiple production sites in China from their headquarters in Taiwan. Most communication takes place through face-to-face contact, phone, fax or email, or by accessing a website. Very few use EDI, XML or other more automated systems to interact.

The tier 1 suppliers are generally chosen by the ODMs not on the basis of their ICT capabilities, but rather on their ability to fulfil orders and on longstanding personal and business relationships. Most tier 1 and tier 2 suppliers do not feel pressured by the ODMs to invest substantially in ICTs, although they have received some support from the Taiwanese government for such investments.

In short, the structure of ICT in the notebook supply chain is asymmetric. The two-way digital supply chain that runs between the branded PC-makers and the ODM manufacturers becomes a one-way stream between the ODMs and tier 1 suppliers and is non-existent between tier 1 and tier 2 companies and further upstream.

Thus, the coordination of production among the ODMs and their suppliers is not very automated or even very digital – unless dialling the phone is considered digital. Instead, coordination relies on social networks and personal and business relationships. Many of these relationships go back 10–30 years and are based on a common identity. Thus, the notebook industry is a classic example of a Chinese business network, but in this case the network is based on a shared Taiwanese identity that was literally transferred intact from Taiwan to mainland China.

Even though most production is now done in the People's Republic of China (PRC), very few companies that are not Taiwanese or foreign owned and operated participate in this network. In particular, companies that are indigenous to the PRC are not part of the notebook manufacturing network. By comparison with societies such as the United States, Chinese society is characterised by a high level of mistrust (Fukuyama 1995); however, there is an exceptional level of trust in China if you have

an in-group relationship. The notebook industry and the Taiwanese business networks that support it provide a way of coordinating production under a high degree of uncertainty and the weaknesses of a legal system that does not generally resolve contractual conflict well.

ICTs can increase the speed, efficiency, and precision of inter-organisational communications. However, by taking people out of the loop and replacing them with computers, ICT can dampen the responsiveness of a production network. Hundreds of manufacturers communicating continually via cell phones or in person with their suppliers, customers and each other create a very sensitive system. What is lost is the ability for PC-makers to have the kind of clear visibility up the supply chain that they would like to better ensure supply and quality and to control pricing. Beyond their immediate suppliers (ODMs and large component suppliers), the supply chain becomes quite obscure for the PC-makers.

In conclusion, the notebook industry relies on a production network consisting largely of Taiwanese companies whose activities are concentrated in Taiwan (management, R&D, product development, IT) and the Yangtze River Delta (manufacturing, process engineering, sustaining support). This network is connected to the branded PC-makers through Western-style business transactions, including formal contracts and heavy use of ICT. Among the Taiwanese network, however, there is much heavier reliance on personal and informal relationships, or *guanxi*, to coordinate production, logistics, development, and other activities.

NOTES

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- 1 The concept of micro production networks was first articulated by Errst and Kim (2002) to refer to the sub-networks below the lead or flagship firms and their immediate contractors – in our case the PC-makers and ODMs.
- 2 As pointed out by Myrna Austria at the conference, *guanxi* is not unique to the Chinese PC industry; direct and personal relationships are part of the business culture not only in China and Taiwan, but in East Asia in general. Thus, this work has implications more broadly.
- 3 Wang and Lee (forthcoming: Table 1, p. 27); TPI (2000a, 2000b, 2000c).
- 4 The information systems and operations management literature distinguishes three categories of e-business applications: e-coordination, e-sourcing and e-communities. While much of the literature (Johnson and Whang 2002) and press tends to focus on e-sourcing (auctions) and e-communities (electronic exchanges), there is actually far greater use of e-coordination (Johnson and Klassen 2005; Johnson and Leenders 2004).
- 5 The auto and aircraft industries have made similar efforts to develop standards and systems for inter-firm coordination.
- 6 Michael McManus, Taiwan Notebook Industry Overview, Digitimes Systems, Taipei, Thursday, 8 September 2005 (with reporting and research by David Tzeng, Joanne Chien and Huang Kung Tien).

- 7 According to a person from Gateway interviewed in 2004, PC-makers audit the ODMs' ICT capabilities before contracting with them.
- 8 As recently as mid-2005, inter-firm linkages with tier 1 suppliers via RosettaNet remain very limited. Most activity is still at the stage of pilot experiments involving a few firms and a few processes (see Hainian 2005).
- 9 The costs appear to be enormous for small firms. For example, one RosettaNet service provider whose estimate might be expected to be low put the total cost for a small firm to link to two back-end systems of a larger firm (for shipment notification and inventory report processes) at \$310,000 over three years (see Hainian 2005). A supplier might need a dozen or more such linkages.
- 10 At the conference, Masaru Yoshitomi questioned how trust is generated among suppliers given that *guanxi* is sometimes considered identical to corruption in China and that the modular character and volatile market demand of the PC industry require open transaction relationships which make it difficult to establish relationship-based trust over time. We consider *guanxi* a feature of Chinese business culture whether in China, in Taiwan or elsewhere in East Asia. It is not necessarily identical to corruption, although we recognise that the media often use it that way. The key point, however, is that trust exists in the local supply chain because the firms have longstanding relationships with one another that they carried with them from Taiwan to China when the industry moved en masse around 2001. There are no domestic Chinese suppliers to the notebook industry; they are all Taiwanese firms that moved to mainland China and do business with one another as they did in Taiwan. The supply chain is more or less a closed system.
- 11 A similar pattern exists within the desktop PC industry, which is located mainly in the Pearl River Delta region of China, including the cities of Dongguan and Shenzhen near Hong Kong. In contrast to notebooks, which are lightweight and can be shipped to the end customer by air, final assembly of desktops is regionalised due to bulk, weight, and logistics considerations.
- 12 Foreign suppliers of batteries, optical drives and other components have also moved some production there. Thus, nearly all the industry's physical production network is in China. Although high-value components such as microprocessors, storage, memory and flat-panel displays are still imported, it may be only a matter of time before they too are produced locally. Although one observer at the conference suggested that extensive digital networks were also in place, we have not found this to be an accurate description of digital networks in the industry. Leng (2004) states: 'The innovative supply chain system allows major producers like Quanta to trade materials flow on a real-time basis and finish the products within 48 hours. Quanta has linked its database with the databases of more than 1,000 suppliers so they can easily coordinate with Quanta's order schedule'.

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