Technology and Organizational Factors in the Notebook Industry Supply Chain

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CAPS: Center for Strategic Supply Research
and
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[1]The comment is from Anne Stephenson of the U.S. Information Technology Office (USITO). Personal conversation July 2004.
[2]Contacts for authors: William Foster at wfoster8560@yahoo.com or 520-440-0807; Zhang Cheng at zhangche@fudan.edu.cn; Jason Dedrick at jdedrick@uci.edu; Kenneth Kraemer at kkraemer@uci.edu.

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Executive Summary

The notebook PC industry coordinates a complex, high-speed supply chain that spans the world and supports a production base largely concentrated in a small area in the Shanghai, China region. The industry is able to fill orders from around the world (sometimes configuring orders for individual customers in as little as five days, including shipping).

What is remarkable is that most of these notebooks are being made for the flagship (Global Brand) companies by Original Design Manufacturers (ODMs) that are Taiwanese owned and managed. Both the flagship companies and the leading ODMs have invested heavily in internal information technology systems, including Enterprise Resource Planning (ERP), order management, and shop-floor automation systems. They also use inter-organizational systems such as Electronic Document Interchange (EDI), RosettaNet, and various web technologies to communicate with each other and with suppliers, customers, and logistics specialists.

Though the flagship companies often procure the key components of laptops, the ODMs procure parts from a network of third-tier suppliers. These suppliers are also Taiwanese owned and operated. These companies focus on only one or two product lines and are managed by a strong CEO who often has close ties to the CEOs of his ODM customers. These relationships incorporate information technology (IT) in a more limited way, relying more on person-to-person communication to coordinate activities. Moreover, the ODMs generally rely on third-tier suppliers to communicate with firms farther back in the supply chain and do not have direct linkages with such firms.

Formal bidding and contracts are the basis of doing business between flagship companies and ODMs, but contracts mean very little between ODMs and their suppliers. The third-tier suppliers will go to great lengths to meet the needs of an ODM. They will work longer hours and outsource work to the companies of trusted colleagues in order to meet a deadline. The ODMs and the third-tier suppliers build long-term relationships, whereby third-tier suppliers can count on orders and agree upon win–win pricing solutions. ODMs keep only two or three suppliers of each component and divide their orders between these suppliers.

Most third-tier suppliers have invested little in information technology. Many receive forecasts and orders from ODMs using a web interface. But they in turn do not use the web to communicate with their fourth-tier suppliers. The third-tier suppliers are content to use face-to-face (F2F) meetings, phone calls, and faxes to supply forecasts and orders to their fourth-tier suppliers. Third-tier suppliers are beginning to invest in limited ERP systems, which are little more than financial management systems. These systems are needed to manage production at multiple sites in Taiwan and China.

Despite the limited use of IT, the Greater China supply chain works fairly well. A major reason is its organization and interpersonal relationships. The notebook industry is a dense network of mainly small- and medium-sized firms headquartered in Taipei with manufacturing and supply clustered in the Shanghai area of China. The CEOs of these firms are plugged into a network of personal relationships (*guanxi*). Through constant communication with its ODM customers and fellow suppliers, the Taiwanese business network begins to resemble a human neural network that matches supply and demand without keeping a lot of inventory in the system.

While the system works, there are current and potential problems facing the industry, such as: problems meeting promised delivery dates, quality issues leading to customer dissatisfaction and high warranty costs, lack of profitability throughout the supply chain leading to

inadequate investment to support future growth, risk of supply interruption due to financial instability of some ODMs and suppliers, disruption of the supply chain due to natural disasters and the lack of inventory, and risk of excessive concentration of the supply chain in China.

The economies of scale needed to meet price points in the market mean that ODMs and their suppliers have to achieve a larger physical scale of operations. This is illustrated by the efforts of some ODMs to vertically integrate (e.g., producing their own motherboards) and to use fewer suppliers. But some CEOs of ODMs are reluctant to take more manufacturing in-house, because it could put their friends' third-tier companies out of business.

The movement towards direct sales and Build to Order (BTO) production by many of the flagship companies increases the complexity of fulfillment and supply chain operations, and places new demands on the ODMs to automate their operations. As scale and complexity increase, there is greater need for formalization and IT systems to deal with these changes. As the computers of ODMs begin to talk to the computers of their suppliers, there is concern that this will undermine the personal relationships that support the Taiwanese business networks.

The flagship companies, in an effort to squeeze margins out of the supply chain, are currently procuring expensive components, such as displays, processors, and batteries from the manufacturers and providing them to the ODMs to integrate. There is pressure on the flagship companies to purchase lower price components directly from the third-tier manufacturers, driving down third-tier margins. This would also undermine the Taiwanese business networks that have been critical to the success of the industry.

The ODMs recognize the need to invest in IT and have been doing so, although thin operating margins limit their investments to systems that are strategic necessities (e.g., manufacturing automation) and those required by their customers. Larger third-tier suppliers have similar capabilities, but smaller third-tier and fourth-tier suppliers have very limited IT capabilities, in part due to their preference for personal relationships (*guanxi*). Even when offered financial support by the Taiwanese government, few have implemented RosettaNet systems to automate supply chain transactions. So, while the flagship PC makers are now digitally linked to their immediate suppliers, the digitization of the supply chain does not reach much farther back to the next tiers. In designing their supply chains, notebook flagship companies must keep in mind the impact of their actions on the Taiwanese business networks on which the industry depends.

Implications for Western Companies

This study is relevant to U.S. purchasing managers inside and outside the notebook industry because it provides insights into the relationship between digital supply chains and Chinese business networks. It also raises the issue of the business risk associated with dependence on the Greater China supply chain.

The most important implication is that companies cannot expect to easily extend their digital networks beyond the second tier of the supply chain. Taiwanese companies have shown a great ability to participate in Western companies' digital supply chains while substituting personal relationships (*guanxi*) for information technology with their third- and fourth-tier suppliers. Chinese business networks are based on interdependence, trust, and personal communication rather than formal contracts and computer-based information systems. While the second tier of the supply chain (CMs and ODMs) adopts information systems in response to its Western customers' requirements, it does not require third- and fourth-tier suppliers to adopt such systems. Phone, fax, and e-mail tend to suffice. More formal information systems are considered unnecessary and a large business expense which limits its flexibility and responsiveness. Therefore, Western managers should be wary about driving the digital supply chain down to the third and fourth tiers of the supply chain, as that may add cost and dampen responsiveness. The full digitalization of the supply chain is most likely neither possible, nor desirable.

The second implication is that, given continuing tension in the China-Taiwan relationship, Western companies are opening themselves up to business risk by relying heavily on Taiwanese suppliers that manufacture only (or mainly) in the People's Republic of China (PRC). While their financial risk is low because Taiwanese companies are making the investments, Western companies still risk potential disruption to their business operations and those of their key customers. PC makers tend to discount this risk because they all are in the same situation given that the supply chain is now concentrated in China. If one company is affected, they all are affected because not only is the second tier of the supply chain concentrated in China, the third and fourth tiers are located there as well. This is somewhat true of the electronics industry more broadly, and probably of other industries as well. Companies need to consider the business risk and develop contingency plans in case their supply network is disrupted. In fact, this is probably an industry-wide issue given the extreme concentration that may exist in some industries.

Introduction: Technical and Organizational Solutions to Supply Chain Problems

The personal computer industry is led by U.S. firms such as Dell, HP, Apple, and Gateway, with competition from Japanese and Asian firms, notably Toshiba, Fujitsu-Siemens, Acer, and Lenovo. Most of the industry's production is located in Asia, which is also where a large share of its parts and components production is done in a multi-tiered system (Figure 1). PC production is increasingly shifting to China, especially for notebook PCs, which are mostly made by Taiwanese Original Design Manufacturers (ODMs)[3] who supply global PC makers from production bases in the Yangtze River delta near Shanghai.

Global PC makers are sourcing notebooks from Greater China because of cost advantages and the efficiency and effectiveness of the tightly clustered supply chain. That performance is a function of technical and organizational features of the system. Although the system has worked well in the past, it has a number of broad problems, particularly quality control and reliability of delivery times. There is also a question of whether the system will work well as scale increases and the major flagship[4] PC makers shift toward more complex direct sales and build-to-order production.

One way to improve supply chain performance in the face of increasing complexity is through the use of information technology. The "ideal" technical supply chain solution is the digitally enabled supply chain, in which the flagship carrier (the global brand) has 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 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 down the supply chain.

With perfect information available, demand and supply can be balanced and efficiency can be maximized. Inventory in the supply chain can be kept to a minimum. More importantly, the bullwhip-effects phenomenon, whereby imperfect information about shortages results in excess inventory in the supply chain, could be a thing of the past. In short, the ideal technology solution would enable supply chains to be more effective, delivering the right products, at the right price, at the right time, and with the right quality.

Implementing such a digitally-enabled supply chain requires the use of technologies such as order management systems, enterprise resource planning (ERP) and supply chain management (SCM) applications by PC makers and suppliers. It also requires interorganizational systems such as EDI and Internet-based e-business systems to link them together. Yet only a few ODMs have these capabilities and even fewer of their suppliers have them, so digital integration of the supply chain is only partial, limited mostly to the PC makers and some ODMs.

[3]Throughout this report we use the term ODM extensively. Technically ODMs provide some of the design work on their notebooks. This makes them different from Contract Manufacturers (CMs). For the purposes of this study, the term ODM is used for manufacturers of notebooks regardless of the amount of design the company has put into the notebook.

[4]Flagship is a term used by Dieter Ernst to describe the lead organization in a global production network. Global Brands are flagships. See http://www.eastwestcenter.org/stored/misc/ewcwebpub.pdf.

What is *Guanxi*?
Almost every westerner who has done business in China will mention the importance of *guanxi* in getting things done. The Chinese will tell you that *guanxi* means personal relationships. (The best introduction to *guanxi* is Mayfair Yang (1994) though she focuses on the development of *guanxi* to navigate the bureaucracy of the Chinese government.) *Guanxi* has its roots in ancient gift-giving rituals for building the village collective. According to *guanxiliu*, the art of *guanxi* is built along the lines of existing relationships. The relationships on which *guanxi* can be built are dependant on time and place. In the 1800s, as Chinese migrated to Malaysia, newcomers could count on clan relationships to help them even if the proximity of the clan member was distant. Extended family relationships have always been the basis for establishing a *guanxi* relationship. In this generation of businessmen in Taiwan, college ties mean a great deal. Currently in Shanghai, if two people are from Taiwan, there is a basis for the development of *guanxi* between them. *Guanxi* can be developed by providing information or by the process of ordering and fulfilling.

In the art of *guanxi* it is more important to give and embellish the relationship and create a good feeling between parties than it is to receive a favor. What is given is important. (It has more impact to give someone a rare medicine that their father needs and that their friend has not asked for than it is to give cash.) *Guanxi* is transferable: I can ask a favor of someone you know who has *guanxi* with you if you will allow it. It must be remembered that the Chinese live in collective culture and things operate very differently than in our individualistic one. (*Guanxi* is a powerful force whose impact is partially unconscious and plays a powerful role in building the collective.)

This does not mean that there is no coordination of supply and demand in the supply chain, however. Over the years, the ODMs and their suppliers have developed so-called Taiwan business networks based on *guanxi*, the Chinese word for personal relationships. The Taiwan business networks are a "human neural network" that transfers information via person-to-person contacts among CEOs and managers. ODMs use *guanxi* to glean information they need to deliver on time and manage the ups and downs of their supply chain. There is a level of trust and coordination among Taiwanese ODMs and third- and fourth-tier companies that allows ODMs to make promises to flagship customers, even when demand is unpredictable.

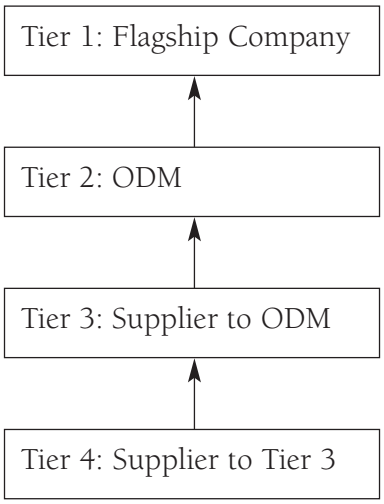
The ability of ODMs to trust their third-tier (see Figure 1) suppliers to such a great degree depends much less on technology and more on organizational factors such as industry clustering, executive networks, business practices, and interpersonal relationships. Third-tier suppliers use even less technology to communicate with fourth-tier suppliers, but there is still a strong organizational commitment and connections that guarantees that there will be few shortages.

While product designs and orders flow downward, information flows upward in the supply chain. For instance, third-tier suppliers are specialists in their product and provide information, and even research and development (R&D), on that small component to the ODMs. The ODMs, in turn, work with the flagship company to design next generation notebooks.

In spite of the capabilities of this human neural network, we have discovered general problems facing the industry, which raise issues for the industry's future:

- Are there benefits to be gained by having a fully automated supply chain between the flagship companies, through the ODM, to the third- and fourth-tier suppliers?
- Will ODMs vertically integrate to survive, and in the process undermine the third- and fourth-tier companies owned by their partners?
- In an effort to preserve margins and stay in the game, third- and fourth-tier suppliers are meeting product specifications, but are building components that will last for only three years, creating serious quality problems. For example, a reported 25 percent of notebook PCs are returned for warranty repairs in the first year. Can quality be improved through the use of IT for monitoring?
- Will flagship companies buy components directly from third-tier companies and provide them to ODMs to integrate as a way of squeezing out margins from the third-tier companies? The flagship companies already do this with screens, processors, and batteries. In an effort to drive out cost, are the flagship companies undermining the Taiwanese business networks that have been so critical to the industries' success?
- In order to increase the speed and efficiency of the supply chain, flagship companies, ODMs, and even third-tier companies are investing in IT. The supply chain is becoming automated. What impact does this automation have on the personal relationships that are so important to both Taiwanese business

Figure 1
Naming Convention for Companies in the Notebook Supply Chain



networks and the relationships between ODMs and the flagship companies?

Our analysis is presented in six parts. Part I describes the notebook industry and key changes occurring therein. Part II describes the conceptual framework of the study. Part III looks at the organizational components of the supply chain. Part IV looks at the technical components of the notebook supply chain. Part V looks at the implications for U.S. flagship companies. Part VI is the conclusion.

I. The Notebook PC Industry

The Notebook Industry Value Network

Although China leads the world in notebook production, most of that production is not owned or managed by domestic Chinese firms. Rather, most production is by foreign multinationals and by Taiwanese owned and managed firms. Taiwanese firms have been moving production capabilities from Taiwan to China since the 1990s. Nowhere is this more apparent than in the notebook PC industry, which is located in the Yangtze River Delta, particularly around Shanghai and Suzhou. A similar pattern exists within the desktop PC industry, which is located mainly in the Pearl River Delta region, including Dongguan and Shenzhen.

The scale and scope of these supply chains raise several important questions, such as: How do these supply chains work? How are they coordinated? How automated are they? How robust are they and what explains their robustness? And, what are their limitations?

A supply chain is usually defined as a "network of facilities and distribution options that performs the functions of procurement of materials, transformation of these materials into intermediate and finished products, and the distribution of these finished products to customers" (Ganeshan & Harrison, 1995). Such a definition applies to a single firm and its customers. The concept of network is especially important because the notebook industry is part of a large, highly disaggregated and globally distributed PC industry value network (Figure 2).

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. Depending upon the industry segment, these firms specialize in different activities, from R&D to design, manufacturing, assembly, logistics, distribution, sales, marketing, service, and support. Figure 2 groups the activities in the PC industry value chain under these categories of activities:

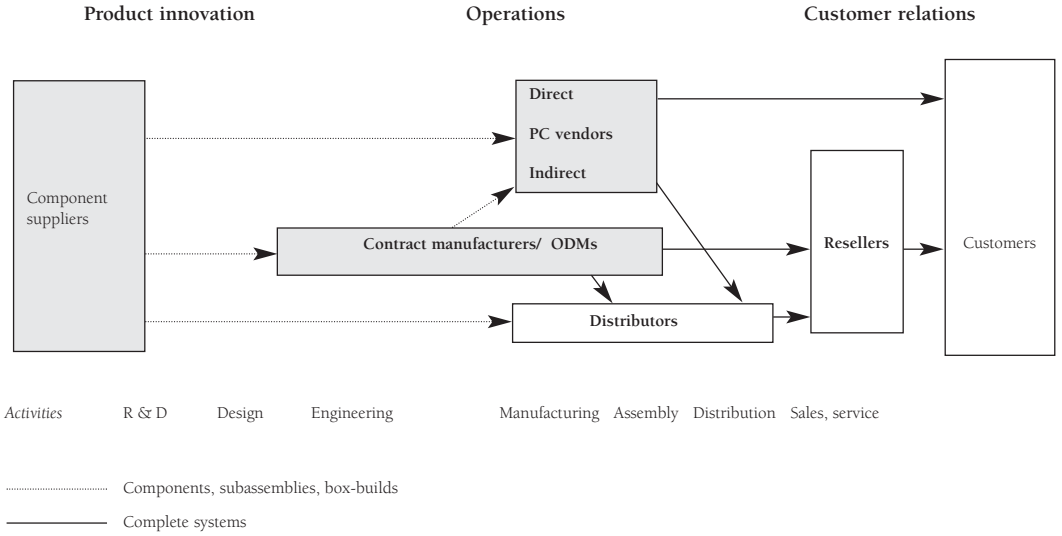
- *Product innovation* includes R&D, design, market research, and new product introduction.
- *Operations* include process engineering, manufacturing, logistics, IT, finance and human resources. In this analysis we focus on manufacturing and logistics, as we are concerned with the location of production activities.
- *Customer relations* includes marketing, sales, advertising, distribution, customer service, and technical support.

Figure 2 shows groups of companies in different industry segments and how they focus on specific activities in the value chain, while the arrows show the flow of components, subassemblies, systems, software and services from suppliers to the end customer. As the figure illustrates, the branded PC companies are only a small part of the overall value system. However, they are the focal point of the value system, making the production decisions that drive the whole system and coordinating the activities of other players.

The Greater China notebook PC industry and its interaction with flagships on the one hand and with suppliers on the other is shown in the shaded area of Figure 2, and is the focus of this report. The notebook segment is important because it represents an important shift in form factor, is the fastest growing part of the industry, and is concentrated mainly in the United States, Japan, Taiwan, and China.

Historically, vertically integrated computer companies such as IBM, HP, Fujitsu, Toshiba, and Siemens

Figure 2
The PC Industry Value Network



Source: Adapted from Curry and Kenney, 1999.

operated in all industry segments and carried out the major functions of product innovation, operations, and customer relations internally. However, with the advent of the PC, the industry's structure shifted to a horizontal network in which most companies specialize in one industry segment (e.g., PCs, motherboards, hard drives) and concentrate most of their resources on one or two of the major activities—product innovation, operations or customer relationships. Most flagship PC companies focus on customer relationships and the design aspect of product innovation, while outsourcing many other activities.

This strategic focus has occurred because the PC is a modular product assembled from standard parts which can be produced almost anywhere by anyone. Only limited value is added by PC assembly, and there is little product innovation on the part of PC assemblers. Architectural standards are mostly determined by Intel and Microsoft. PC components and peripheral makers can design products that meet those interface standards, with little need to interact directly with the PC assembler.

For the most part, PC makers add value through customer relationships, either directly via direct sales and service relationships (help desk, repair, inventory management, replacement planning, and disposition), or indirectly through design branding, marketing, and quality assurance. They also add value by coordinating the logistics of the global production networks that turn components into finished products and deliver them to customers, even if they add little value through actual physical transformation of the product (Curry & Kenney, 1999).

Thus, the branded PC companies largely outsource assembly to contract manufacturers (CMs) or Taiwanese original design manufacturers (ODMs). Although the proportion of outsourcing differs from firm to firm, it is increasing in all firms, as shown in Table 1. Increasingly, the flagship companies are also outsourcing much of the new product development process to the Taiwanese ODMs (Dedrick & Kraemer, 2005). These CMs and ODMs are now the key operational part of the industry's supply chain, linking component and peripheral suppliers to meet the product requirements of the branded companies.

The Notebook Industry Is Growing

Although desktop computers still dominate production, there has been a gradual shift in the PC form factor towards notebook computers as their capabilities have increased and their costs have declined. For example, notebooks accounted for 21.3 percent of total PC production in 2001; that percentage increased to 26.4 by 2003, and is expected to reach one-third of the market by the end of 2005 (IDC, 2004; IDC, 2005). The fact that notebook sales are growing around 25 percent annually, whereas desktop sales are growing

Table 1
Flagship PC Makers Outsourcing to Taiwanese Firms

Flagship companies	Subsidiaries in China	Estimated percent outsourcing, Jan. 2005 [b]	Percent of Taiwan shipments, April 2005 [c]	Taiwanese ODM suppliers [a]
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*	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

Sources:
[a]You-Ren Yang & Chu-Joe Hsia, 2004. They quote this table from a report of the Ministry of Economic Affairs, Taiwan. Cited in Yung-Kai Yang, 2005.
[b]Digitimes, 2005a.
[c]Digitimes, 2005c.

around 7 percent annually, suggests that the notebook market will continue to overtake the desktop market.

Taiwanese Firms Dominate the Industry

The extent to which notebook production is dominated by Taiwanese companies is illustrated in Table 2, which shows that the Taiwanese notebook industry went from a 40 percent share of the global market in 1998 to 72 percent in 2004.

Although the Taiwanese notebook industry has grown in volume each year, the average sales price of notebooks has been decreasing, which means that there is even greater pressure on profit margins in the industry. This price decline largely has been due to falling component prices, especially for memory and displays; but at lower prices the margins for the ODMs also get squeezed.

Production Network Is Concentrated in China

All of the Taiwanese notebook firms have their headquarters and R&D facilities in Taipei, Taiwan. Moreover, the larger firms are expanding their R&D facilities in Taipei as a means of protecting their intellectual capital and competitive advantage. In contrast, nearly all production facilities are located in China.

The major reason that Taiwanese firms have migrated to China is to take advantage of China's great pool of relatively educated and talented young people who are

Table 2
Taiwanese Notebook Computer Industry from 1998-2004

	1998	1999	2000	2001	2002	2003	2004	2005 (f)
Shipments volume [a]	6,088	9,703	12,708	14,161	18,380	25,238	33,340	39,035
Shipments value [b]	$8,423	$11,073	$13,549	$12,239	$13,847	$16,809	$21,830	$25,177
Average Sales Prices	$1,384	$1,141	$1,066	$864	$753	$666	$655	$645
Global market by volume [a]	15,610	19,816	24,437	25,747	30,033	37,857	46,110	
Taiwan's share of global market volume	40%	49%	52%	55%	61%	66%	72%	73%

Source: MIC, 2005.
Notes: [a]Units in thousands; [b]U.S. dollars in millions.

willing to work on assembly lines for labor rates that are significantly lower than in Taiwan. The generally accepted figure is that it costs $25 dollars less to build a notebook in China than in Taiwan (Yang, 2005). The costs savings are due to the difference in labor rates.

The production facilities are clustered in a triangle of cities in the Yangtze River Delta near Shanghai.

Suzhou – Asus, Uniwill
Shanghai – Quanta (located in Songjiang), Inventec
Wuhan - Compal
Kunshan – Compal, Wistron, Elite (ECS), Twinhead, Mitac, Clevo
Wujiang – Arima, FIC

There are no Chinese ODMs and there are no significant Chinese suppliers to the Taiwanese ODMs, or to their suppliers in this region.

Some Taiwanese firms, such as Quanta and Arima, have built very large campuses complete with worker housing and require their suppliers to locate within the campus or nearby. Most ODMs, especially those that arrived in China earlier, are more dispersed, but still within one or two hours of their key suppliers.

The supply base is also Taiwanese. Some suppliers had moved to the Shenzen area with the desktop industry. These and other firms moved to or opened operations in the Shanghai/Suzhou area as the ODMs moved in. Though no one knows exactly how many suppliers there are, several of the third-tier manufacturers we interviewed reported having between 1,200 and 3,000 suppliers. One large ODM reported having 700 suppliers. Officials in Suzhou and Kunshan reported that there are 1,500 Taiwanese electronic companies in Suzhou with $12 billion invested, and another 1,500 in Kunshan. They are joined by major multinationals such as Samsung, Siemens, Panasonic, Hitachi, and Epson, which produce notebook PC components and other products.

This clustering of production by the notebook makers and their suppliers is an important aspect of coordination in the Chinese production network, as it relies heavily on informal and non-IT communication. Relatively close clustering facilitates the sharing of information, speeds logistics, minimizes plant inventory, and ensures a ready supply of locally produced parts and components. It also has enormous capacity to respond to upward changes in demand since most suppliers operate one to two shifts during a five-day work week, and can increase hours or work days when needed. One company we interviewed gave an example of receiving an order that was 1.5 times its capacity. To meet this challenge, its employees worked overtime from 8 a.m. to 1 a.m. for three months to fulfill the order.

Industry Has Low Profit Margins

The PC industry in general, and the notebook industry in particular, is not highly profitable. Exceptions are Intel and Microsoft, whose market dominance in microprocessors and operating systems enables them to earn net profits of 22 percent and 31 percent, respectively. By contrast, Dell leads the PC makers with net profits of 6.6 percent, while HP, IBM, and Gateway have consistently lost money in PCs for several years.[5]

In our company interviews, ODM executives often asked for advice on how to make money in their highly competitive, low-margin industry, which faces continual requests for lower prices from the flagship PC brands. Both gross and net margins for the ODMs have been falling since 1998. Gross margins for most ODMs were around 5 percent to 7 percent in 2004. Net margins for larger ODMs ranged from -0.9 percent to 3.7 percent (Table 3), and the smaller ODMs reported losses. Asustek's margins were substantially higher (17.5 percent) because of its highly profitable motherboard business, but its margins have also been declining since 1998.[6] Because margins are low, the loss of major contracts, or financial loss on those contracts, have huge effects on a company. This is illustrated by the case of Arima (Table 3), which had major losses on a contract. On the other hand, the ODMs on average are doing as well as the flagship PC makers, so the problems may be more symptomatic of an industry whose products are seen as commodities, and whose standard-setting intellectual property is controlled by two companies.

In contrast to the ODMs, the profit margins of most suppliers to the ODMs are relatively stable and healthy, with gross margins around 10 percent to 20 percent (Table 4). In particular, keyboards, cases, motherboards, batteries, power supplies, and optical storage firms show large profits margins, whereas memory and LCD firms show declining profits and/or losses.

[5]Financial data from Excite Money & Investing. http://money.excite.com.
[6]Asustek's net profit margins are higher than its gross profit margins because of non-operating income from investments.

Table 3
Profit Margins (Percent) for Taiwanese ODMs

	1998		2000		2002		2004	
Company	**GPM[a]**	**NPM[b]**	**GPM**	**NPM**	**GPM**	**NPM**	**GPM**	**NPM**
Quanta	18.8	17.8	11.5	10.3	8.8	7.6	5.2	3.7
Compal	15.3	13.2	9.2	8	8.7	6.8	6.2	3.1
Wistron	0	0	0	0	7.4	2.2	5.2	-0.7
Asustek	31.5	32.9	23.3	22.1	16	12.1	17.5	19.3
Mitac	9.5	4.9	7.3	3.8	8.2	3.4	8.1	4.2
Inventec	13.1	7.4	6.6	4.1	8.4	4.9	5.4	1.8
Arima	11.5	8.6	7.9	6.3	3.5	0.8	1.3	-10.6
ECS	-2.8	-13.8	12.5	7.2	9.3	4.5	5.8	-3.7
First International	7.3	0.4	9.7	0.3	7.3	-5.3	3.3	-12.3
Clevo	8.2	1.6	5.6	-4.6	9.7	1.9	8.1	3.7
Twinhead	9.4	5.6	1.5	-16.7	3.5	-11.9	5.2	-2.6
Uniwill	0	0	0	0	7.6	-3	6	-0.8
Lite-on							7.0	2.9

Source: Taiwan Stock Exchange Corp. (http://www.tse.com.tw/en/),
Notes:
[a]GPM (Gross Profit Margin)=(Revenue-COGS)/Revenue.
[b]NPM (Net Profit Margin)=Total Net Income/Revenue=[(Revenue-COGS-SGA+Non Operation Income)/Revenue].

Strategies of Taiwanese ODMs

In the face of low margins, pricing pressures from flagship firms, and intensive internal competition, the Taiwanese notebook makers have followed a variety of different strategies. They have sought to increase the scale of their operations, develop their own branded notebook businesses, vertically integrate by making some components themselves, and shift from building barebones units to complete systems.

Regarding scale, only a few Taiwanese notebook makers have been successful in achieving large volume production (Table 5). Quanta and Compal have consistently been the top two firms, followed by Wistron, Inventec, and Asustek. However, there is considerable fluctuation from quarter to quarter, with firms moving up and down based on their fortunes in securing production contracts (Table 6). The most dramatic change was Arima's fall from 9 million units to 0.7 million units (Table 5), primarily due to major losses under an HP contract. Also notable was Asus' climb from eighth place to fourth place, primarily due to vertical integration which has allowed it to reduce costs and gain more production contracts (Table 6).

A second strategy followed by some firms is to develop their Own-Brand Manufacturer (OBM) business in addition to the Original Equipment Manufacturer (OEM)/ODM business. Most of the Taiwanese notebook manufacturers (*Quanta, Compal, Wistron, Mitac, Inventec, Uniwill, FIC*) are pure OEM/ODM businesses, which means that they produce notebooks for flagships such as HP, Dell, Toshiba, Apple, or Gateway. The difference between an OEM and ODM business is that in the ODM business, the company contributes a part of the design for the product rather than just manufactures the product. In contrast, many of the smaller notebook ODMs also have OBM businesses, though mainly in Taiwan or other regional markets to avoid conflict with their customers. *Arima, Asus, Clevo, Elite,* and *Twinhead* fall into this category. They keep both OBM and OEM/ODM businesses within their organization, and not only do they sell their own brand products, they also produce products for the flagships.

A third strategy is vertical integration. *Asus* (for a brand name of Asustek) does both OBM and OEM/ODM business and is further integrating parts of the supply chain into the business. Rather than place them all in the same business unit, *Asus* places them in subsidiaries. Therefore, its OBM and OEM/ODM business have some independence compared to other companies. However, *Asus's* branded subsidiary is 100 percent owned by *Asus* and does not plan to become an independent and public company traded in the stock market. Unlike other ODMs, *Asus* has integrated forward from motherboard production, where it is the world leader, into system assembly, while also moving into production of other components. It has higher margins than other ODMs, although this may be a result of higher margins in its motherboard business. A similar strategy has been followed successfully in the desktop business by Foxconn, which moved downstream from making cables, connectors, and enclosures into motherboard and system assembly. It is

Table 4
Profit Margins (Percent) for Taiwanese Suppliers to ODMs

Components	Company Name	1998		2000		2002		2004	
		GPM	NPM	GPM	NPM	GPM	NPM	GPM	NPM
Memory	Nanya Tech (NTC)	-47.2	-45.5	15.6	10.1	22.7	7.8	34.4	17.4
	Winbond	22.9	-2.5	39.6	21	19.3	-13.1	30.9	10.9
	Mosel	0.3	-16.1	11	7.8	-31.3	-132.7	2.7	13.1
	PSC	-20	-50.2	35.9	22.4	9.8	-11.7	44.1	37.1
LCDs	AUO			19.9	11.9	16.9	8	23.6	17
	ChiMei					21	11.1	21.8	16.8
	ChungHwa (CPT)	5.8	0.2	17.7	19.3	10.5	-8.5	13.7	13.2
	Quanta Display					8.5	-1.1	15.2	9.9
	HannStar			-8	0.8	11.9	2.9	15.5	6.5
Motherboard	Compeq	31.9	20.4	20.8	15.5	-2.4	-8.1	-1	-23.5
	Unimicron	14.7	6.5	19	10.7	17.1	8.3	20.2	13.3
	Gold Circuit Electronics (GEC)	26	11.7	22.9	8.6	2.4	-45.1	20.4	9.6
	HannStar Borad			13.8	6.2	18.4	5.8	18	22.4
	Vertex	18.1	16.6	9.1	0.2	13.4	2.3	-4.4	1.1
	Career Technology			25.6	13.6	22.6	9.2	24.6	14.7
	Tripod	9.1	1.3	18.2	8.4	19.7	9.9	15.7	12.4
Connectors	Foxconn	17.4	14.4	12	11.2	6.7	6.9	6.5	7.1
	SpeedTech	44.5	3.7	41	10.1	32.7	8	18.3	-2.5
Battery	E-One Moli Energy					-27.7	-74	-1.7	-10.3
	Simplo			11	6.8	14.8	7	12.4	7.9
	Solomon	10.6	-6.7	5.8	9.3	7.5	-24.1	7.4	-7.1
	Gallopwire (GLW)					11.2	0.5	7.5	0.7
Power Supply	Delta Electronics	19.4	17.9	13.8	18.9	11	13.3	8.8	14.4
	Com2B	2.7	-6.5	9.7	11.8	8.5	10.5	8	4.9
	Li Shin (LSE)	23.7	11.1	22.3	15.1	20.8	20.1	23.6	8.6
	Potrans	23.7	12.3	14.9	-10.9	17.7	-14.6	14.7	-32.4
Optical Storage	Quanta Storage			15.1	-1.2	31.3	14.8	10.5	6.1
	Lite-On			10.4	8.7	15.1	14.3	10.6	8.8
	Pan International	-0.4	-15.5	11.3	2.2	8.4	4.6	11.7	9.3
	BTC	-1.6	-13	14.2	4.9	7.9	-7.8	2.4	-23.6
	Ultima	9	1	1	0.3	8	-0.4	-5.8	-41.3
Keyboards	Sunrex	13.5	5	14	4.8	20.4	16.5	21.7	24.6
	Darfon					5.8	-14.8	17.8	0.2
	Chicony	14.8	5.2	17.7	0.8	14.2	15.8	8.1	8.4
	Lite-On			10.4	8.7	15.1	14.3	10.6	8.8
Cases	Catcher	39.2	24.7	43.6	21.2	36.8	17.8	38.8	116.4
	Waffer					35.2	16	36.9	24.7
	Uneec (Chenming)					10.7	4.7	10.6	2.4
	Loyalty Founder Enterprise (LFE)	21.1	8.7	8.9	4.4	20.1	7.3	7.8	5.5

Source: Taiwan Stock Exchange Corp. (http://www.tse.com.tw/en/).

less clear whether moving upstream from ODM production into components (other than motherboards for internal use) is a viable strategy. For instance, Quanta's display business is losing money and is not able to keep up with larger competitors such as Samsung in the highly capital-intensive LCD business.

A fourth strategy employed by some Taiwanese ODMs to increase their value-added is to increase the proportion of full systems produced versus barebone units. Full systems are complete notebooks with all parts and components, whereas barebone units usually include a motherboard, enclosure, cables, and connectors, but not the display, microprocessor,

Table 5
Notebook Shipments by Taiwan Vendors (million units)

Company	2003	2004	Global Market Share (2004)	2004 Growth
Quanta	9.3	11.1	24%	19%
Compal	5.53	7.7	17%	39%
Inventec	3	2.8	6%	-6%
Wistron	2	3.2	7%	60%
Asustek	1.9	2.7	6%	42%
FIC	1.3	0.6	1%	-46%
Arima	9	0.7	2%	-22%
Uniwill	1.16	1.4	3%	21%
ECS	8.78	0.5	1%	-42%
Clevo	5	0.5	1%	10%
MTC		1.4	3%	-
Twinhead		0.4	1%	-
Global	37.8	46.1	-	22%

Source: DigiTimes, 2005b.

Table 6
Taiwanese Notebook PC Manufacturer Rankings, 4Q 2002-4Q 2004

	4Q02	1Q03	2Q03	3Q03	4Q03	1Q04	2Q04	3Q04	4Q04
1	Quanta	Quanta	Quanta	Quanta	Quanta	Quanta	Quanta	Quanta	Quanta
2	Compal	Compal	Compal	Compal	Compal	Compal	Compal	Compal	Compal
3	Arima	Wistron	Wistron	Wistron	Asus	Wistron	Asus	Wistron	Wistron
4	Wistron	Inventec	Inventec	Asus	Wistron	Asus	Wistron	Inventec	Asus
5	FIC	Arima	FIC	Inventec	Inventec	Inventec	Inventec	Asus	Inventec
6	ECS	FIC	Arima	FIC	Uniwill	FIC	Mitac	Mitac	Mitac
7	Inventec	Asus	Asus	Mitac	FIC	Mitac	Uniwill	Uniwill	Uniwill
8	Asus	ECS	ECS	Uniwill	Mitac	Uniwill	FIC	Arima	Arima
9	Mitac	Mitac	Mitac	Arima	Arima	Arima	Arima	FIC	FIC

Source: MIC, 2005.

memory, battery, keyboard, hard drive, or optical drive, which are inserted in the final assembly process. Full systems can be shipped direct to the customer or retailer, whereas barebone units are shipped to branded PC makers or distributors for final assembly. Vendors such as HP, Toshiba, Sony, Apple, and Gateway are shifting towards greater procurement of full systems from ODMs. In contrast, Dell procures barebone units, which are then sent to a Dell plant in Malaysia for final assembly and shipment to global markets. Approximately two-thirds of the notebooks produced by Taiwanese ODMs are full systems compared to barebone units, and the trend is towards more full systems production (Table 7).

This then is the industry context in which we examined the current use of IT and the extent to which it approaches the ideal technical supply chain solution. Although not part of our original protocol, we discovered that organizational features of the supply chain were important factors in its current relative success, despite limited IT use. The framework for our research is described next.

Table 7
Full Systems versus Barebone Units

Notebook type	2003	2004
Full System	15,438	22,022
Barebone unit	9,800	11,384
Total	25,238	33,406
Full System Share	61.2%	65.9%
Barebone Unit Share	38.8%	34.1%
Total	100%	100%

Source: MIC, 2005.

II. Conceptual Framework and Methodology

Conceptual Framework

In order to assess the extent to which the current use of IT in the industry approaches the technical ideal of a supply chain solution, we developed a conceptual framework with which to compare current IT with the theoretical ideal. Firms look to improve the efficiency of their supply chains by improving the physical flows of material forward from suppliers to customers and the information flows backward from customers to suppliers. 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 in the system.

An ideally integrated supply chain would integrate information flows related to: products and their descriptions and prices; purchase orders with quantities and required dates; planned and actual production schedule, shipments and deliveries, and status against such schedules; technical and engineering data on products and their components; accounting information, such as prices and discounts; and product quality data, including tests and warranties.

In the past, companies have managed these information flows through phone, mail, fax, and EDI. During the 1990s, firms made major investments by upgrading their internal IT with enterprise systems (SAP, Oracle, Peoplesoft) and making enhancements to key legacy systems, such as those for order management and shop-floor management. These systems were especially important to integration in multidivisional firms or firms with activities in multiple locations. They also created a new platform for inter-firm integration. With the advent of the Internet, firms have begun to shift from EDI to more flexible web-based XML protocols for interdivisional and inter-firm flows. Most firms have multiple systems in place simultaneously, with more automated ones for routine, high-volume exchanges and manual systems for non-routine exchanges, such as schedule changes, quality problems, and expedited orders.

We cannot assess supply chain integration directly, but we can do so indirectly by assessing whether certain information technologies are in place that would provide the capabilities for integration. Based on the IT and SCM literature, and our fieldwork, we have developed a framework and identified a set of IT and Internet modules that would be expected to be in place to support the ideal of supply chain integration (SCI) (Figure 3).

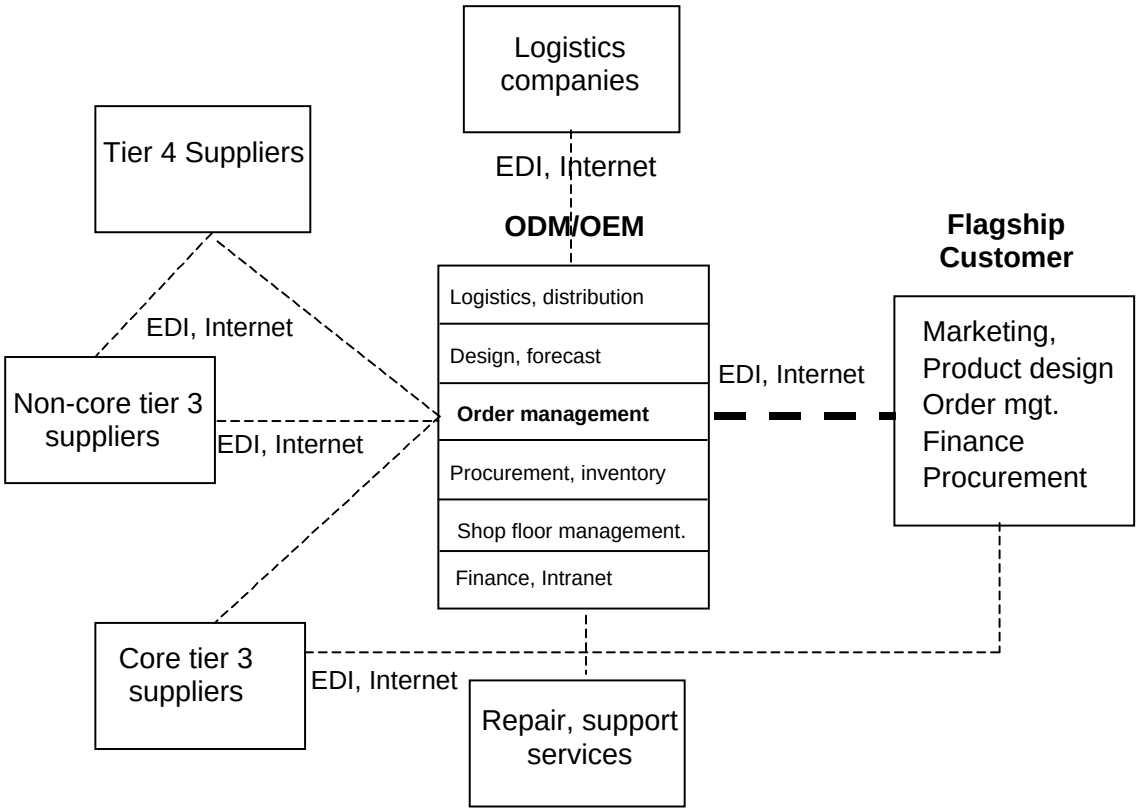
These indicators are clearly a rough approximation of SCI, but they represent a beginning benchmark for comparison across companies, and possibly over time. In addition, this formal accounting can be complemented by informal assessments of weaknesses, such as the lack of standards, the use of manual methods, and the re-keying of data, which suggest suboptimal integration.

Methodology

Data Collection

This research is based on more than 10 years of research on the personal computing industry by the Personal Computing Industry Center at UC Irvine, monitoring of the business press related to the industry, and recent field interviews. The field interviews were conducted in 2004 and 2005 on site in Taiwan and China. Many of the interviews were with MIS executives, although interviews were also conducted with senior executives, product development managers, procurement managers, and sales managers.

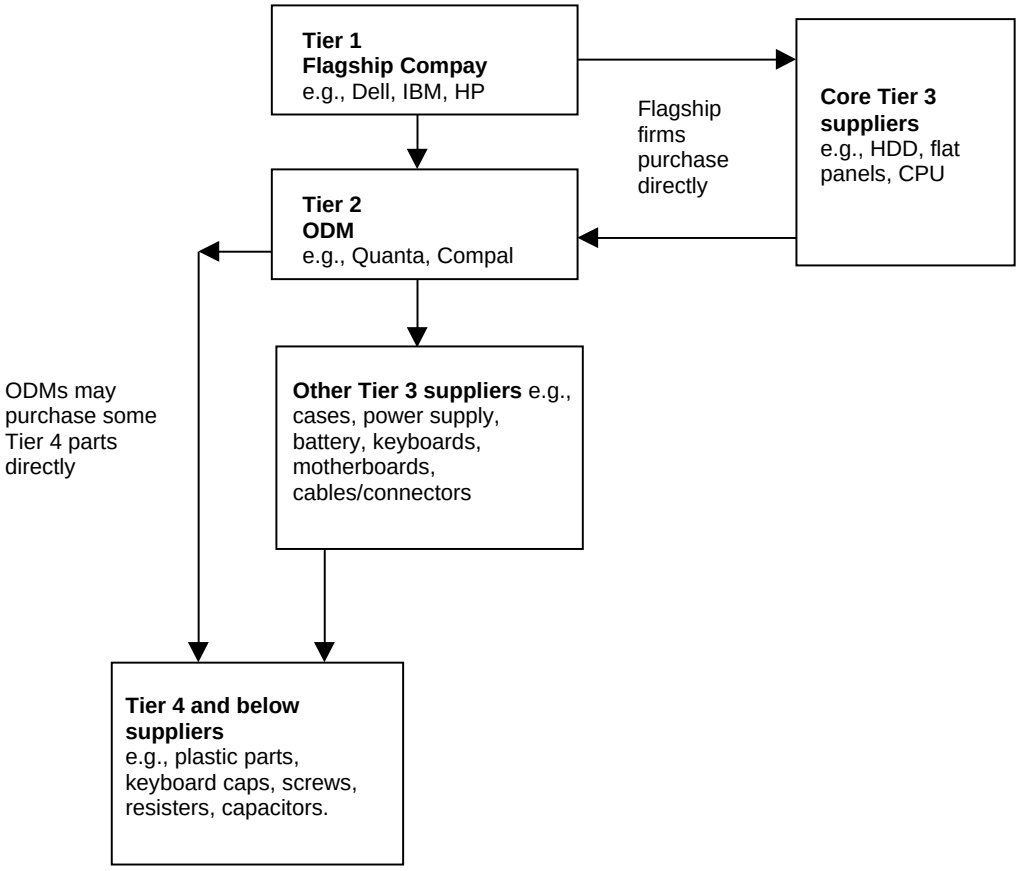
Figure 3
IT and Internet Modules for the "Ideal" of Supply Chain Integration



There were two teams, each consisting of two researchers each. The PCIC team first interviewed about 15 people in five ODMs in China. They had earlier established relationships with some ODMs in Taiwan which helped arrange interviews with their subsidiaries in China. They were also accompanied by a translator who had special connections that helped to get other interviews. Both researchers and the translator participated in the interviews. Immediately after the semi-structured interviews, one researcher would write up one interview and another would write up the other. Then each would check the write-up with his or her own notes, seek clarifications, and make additions or changes where appropriate.

Based on the responses of the first set of interviews, a second instrument was designed for the Arizona-Fudan team. (See Appendix 2 for the instrument.) This team conducted interviews in both Taiwan and China, but focused more on third-tier and fourth-tier suppliers. The interviews were conducted in English. Most of the interviews were hosted by graduates of the Executive MBA program at National Central University and Fudan University. This team interviewed 10 third-tier suppliers and two fourth-tier suppliers. The second team also wrote up its notes, put them into a common spreadsheet form (Appendix 3), and had the recorded interviews transcribed. As part of the interview, interviewees were shown a copy of Figure 4, which delineates the difference between a PC Company, ODM, and third-tier and fourth-tier supplier, in order to establish a common framework for the interview and discussion.

Figure 4
Supply Chain Model for Interviews



III. Organizational Factors and the Notebook Industry Supply Chain

Procurement Strategies of Flagship Firms

A significant portion of the world's PCs and PC components are manufactured by Taiwanese manufacturers (ODMs) headquartered in Taiwan, but who manufacture in China.

The flagship carriers and the ODMs are becoming highly automated. This automation extends to how the flagship carriers and the ODMs communicate. The major ODMs now use EDI, along with RosettaNet to process orders from their flagship customers. The RosettaNet system is an Internet-based and more user friendly system for exchanging messages for different business interface processes, such as requesting prices and product availability. Messages are sent in XML format using RosettaNet standards. Once set up, the system is able to compose and interpret messages automatically without any human involvement (Malakooty, 2005) to process orders from their Multinational Corporation (MNC) customers.

As illustrated in Table 1, the flagship PC companies usually have two or three ODMs in their supplier list. The flagship companies usually divide their product line among these multiple suppliers. The major advantage of the flagships' use of multiple suppliers is to get the suppliers to compete against each other so that the flagship carrier gets the minimum price for the product it sources. Branded PC makers may have as many as 25 individual notebook products, of which about one-half are put out to bid each year, each of which is bid separately. The result is great volatility for notebook makers as the flagships tend to routinely switch between vendors for individual products.

Because they buy in volume, large flagships are able to get better prices for core components such as screens and monitors, than the ODM. In some cases, the flagship gives the ODM the product to integrate. Other flagships, such as Dell, integrate these products directly in their own factories. The way that third-party core components are purchased and integrated can have a significant impact on the cost of production and can be a source of competitive advantage.

As the name implies, ODMs play a role in the design of the notebooks they manufacture. Again, this role differs from one flagship to another and between each particular bid that is going out. Many of the flagships, such as Dell, invest very little in R&D and count on their ODMs and the component suppliers to innovate and to design the next generation of notebooks. Most flagships are involved in the design process and are involved in developing metrics for performance and quality. They also have their own design personnel and product managers, who monitor the ODMs during the development process.

Procurement Strategies of ODMs and Their Suppliers

The ODMs source connectors, wires, batteries, and electronic parts, such as resistors and capacitors, from a wide range of third-tier suppliers. Some make their own motherboards and casings. Other ODMs source these from third-tier suppliers.

Third-tier suppliers must manage inventory in a manner that reduces costs but ensures that they can meet the needs of their ODM customers. Most third-tier suppliers do not keep a great deal of inventory on hand and they are more likely to keep raw materials rather than finished products in stock. The third-tier suppliers also rely heavily on their fourth-tier suppliers to supply them with products on an as-needed basis.

The third-tier suppliers operate on a hybrid of build-to-stock and build-to-order. According to one third-tier provider, "For cable assembly we build to order as we follow different designs according to the customer's request; for standardized connectors we can build to stock to adjust production loading. But mainly we build to order for better production and financial control." In general, the third-tier 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 12 hour days. Also, third-tier suppliers are not hesitant to outsource work to a trusted friend or relative's company in order to meet a ODM's requirement.

Both ODMs and third-tier suppliers prefer to keep two suppliers of each part or component. By getting quotes from two of them, the costs of production become much more transparent and competition keeps the price down. The customer divides the order between the two suppliers. Each supplier knows what percentage of the total "buy" is being given to it. This provides an important feedback loop that lets the third-tier provider know whether it is being competitive in terms of price and quality.

While there is market-based competition in the supply chain, relationships are also very important between ODMs and their third-tier suppliers. Contracts between ODMs and their third-tier suppliers are flexible and subject to renegotiation after the contract starts, if conditions change.

Generally, suppliers do not disclose the amount of inventory they are carrying to their customers. It is assumed that whatever the customer orders, the supplier will deliver. To not do so means that they will no longer receive orders and will lose face. On the other hand, third-tier companies generally do not switch suppliers often, or auction off orders to a host of suppliers.

The third-tier suppliers are generally small and centrally managed by an owner who relies on his own *guanxi* network of personal relationships to navigate and carve out his company's position in the supply chain. These hundreds of third- and fourth-tier suppliers interact in a way similar to a neural network, which matches demand with supply and makes sure that there are no shortages in the supply chain. Because of the efficiency and effectiveness of this system, the ODMs are able to be very responsive, in turn, to their flagship customers.

Organizational factors such as personal relationships are much more important than technological solutions between the ODMs and third- and fourth-tier suppliers. As one fourth-tier 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 with their suppliers to find cheaper alternate methods to meet the specs of flagship customers. Though the ODMs are being squeezed to 6 percent gross margins, some of their suppliers we interviewed said that they were making between 10 percent and 20 percent gross margins. The Taiwanese companies are bound together by common organizational bonds that make the Taiwanese supply chain both efficient and effective.

Clustering of Activities

In Taiwan, many of the presidents of the ODMs lived in the same neighborhoods and it was relatively easy for them to meet to do business. The ODM suppliers were also close by and many dealings could be done face to face. Logistics was not much of a problem, as suppliers were near ODMs and technology was not needed to overcome logistical hurdles.

Because of the Taiwanese government's restrictions on notebook production in Taiwan until 2001, it was often the third- and fourth-tier suppliers who first went to China to take advantage of low labor costs. Those associated with desktop PC production ended up around Shenzhen in the Guangdong province. Those associated with notebook production chose to locate around Shanghai in the Yangtze delta. When the notebook producers were given permission in 2001 by the Taiwan government to move manufacturing to China, these notebook manufacturers chose to locate in the Yangtze delta as well.

The organizational network from Taiwan was moved to the Shanghai area. Long-term relationships remained in place and Taiwanese management was able to continue to negotiate face to face.

Logistics is a real problem in China, but by locating close to their customers, third- and fourth-tier suppliers minimize transportation risks. As one fourth-tier provider said, "For every customer I will make sure to have a plant within two hours of his plants."

IV. Information Technology in the Notebook Supply Chain

At different tiers of the supply chain there are levels of automation (Table 8, Table 10). There are also levels of automation between firms, partly based on different business models.

Information Technology in the Flagship Firms and the ODMs

As shown in Table 8, IT plays a central role in the operation of both the flagship companies and the ODM suppliers.

Flagship IT

A highly important IT module for flagship firms is their order management systems, which can be custom-built, such as Dell's Dell Order Management System (DOMS), or a commercial application, such as SAP-F (fulfillment). These systems are a major source of competitive advantage for the flagship company and are continually being upgraded. Order management systems are integrated with Enterprise Resource Planning (ERP) systems for internal operations, and supply chain systems such as i2 for estimating demand, forwarding information, and ordering up and down stream. The order management systems use EDI, RosettaNet, or web interfaces. A number of the flagship companies have implemented Collaborative Planning and Forecast Replenishment (CPFR) with their ODM and CM suppliers. CPFR is Rosetta-based and allows ODMs to confirm that they are able to meet scheduling commitments.

Table 8
IT Modules in Flagship, ODM, and Core Third-Tier Companies[7]

	Tier 1				Tier 2				Core Tier 3
IT Modules	**1(a)**	**1(b)**	**1(c)**	**1(d)**	**2(a)**	**2(b)**	**2(c)**	**2(d)**	**C3(a)**
Product Data Management	Y		Y	Y	Y	Y			Y
Sales / Order Management		Y	Y	Y	Y				Y
Material Inventory Management	Y		Y	Y	Y		Y		Y
Production / Shop Floor Management	Y		Y	Y	Y	Y	Y	Y	Y
Human Resources									
		Y	Y						
Fianance / Accounting	Y		Y	Y	Y				Y
E-Retailing		Y	Y	Y	Y	Y	Y	Y	Y
E-Supplier Integraton			Y	Y	Y	Y	Y	Y	
Distribution / Logistics SCM			Y	Y	Y				Y

Source: Field data collection by authors, 2004, 2005.

[7]In this chart, a blank means either "no such IT-module" or "the researchers did not ask about this technology in the interview." The names of the companies are coded with one representing flagship companies, two representing ODMs, and C3 representing core tier-three suppliers.

The ODMs IT

The IT used by ODMs is shaped very much by the requirements of flagship customers. In general, the ODMs have to have the capability to interoperate with multiple IT systems, as each flagship company and core supplier has a different IT system. The ODMs must be able to communicate with each of these systems. Large ODMs also have to have sophisticated internal systems. However, our interviews indicate that the IT capabilities of ODMs generally do not match those of the leading flagship companies.

Most of the ODMs implemented ERP in the late 1990s, many with financial support from the Taiwanese government. These ERP systems required the ODMs to define and refine their processes in order to automate them. The ODMs saw substantial benefits from these systems, which dramatically reduced the time it took to process an order—from a couple days to a couple of hours. More importantly, these ERP systems helped the ODMs integrate their new manufacturing operations in China with headquarters in Taiwan.

IT is essential to manage the sheer volume of notebooks that the largest ODMs are manufacturing. In addition, most ODMs are manufacturing many different configurations for multiple customers, each configuration requiring multiple parts. The ODMs see IT as essential to their operation, as well as a strategic necessity.

Most of the ODMs are receiving forecasts and orders from the flagship companies via EDI, web applications, or CPFR. Most are using the RosettaNet system and standards for at least one web application (Table 9). Most of the ODMs have supplemented their SAP ERP system with their own systems for shop-floor management. These systems are seen as a core competence for them and a source of strategic advantage. In one specific company, the system takes an order via EDI and automatically checks if the configuration exists. If there is a Bill of Materials (BOM), then the system checks for duplicate orders. If it is a new configuration, then the system creates a new BOM. The SAP system then takes over and checks material availability, creates a work order, and triggers an order to the commodity hub with a few hours lead time to get the material to production. The custom shop-floor system compares material usage status and the SAP BOM. It sets input sequence/queuing, material readiness, and picking systems. The SAP system handles order fulfillment.

The ODMs realize 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 for each supplier. The ODM's ERP system then sends forecasts and orders via the web system to its third-tier suppliers.

Under its "ABC" program, the Taiwanese government provided financial inducement for the ODMs to implement RosettaNet with their key Taiwanese suppliers. The Taiwanese government's avowed interest was to increase the ability of the Taiwanese ODMs and their Taiwanese suppliers to compete in the global marketplace. The RosettaNet system is used by the ODMs to communicate with their third-tier suppliers, but the use is limited.

Information Technology in the Third- and Fourth-Tier Suppliers

There is a major difference between second-tier ODMs and their third-tier suppliers in terms of the use of IT (Table 10). Though the ODMs meet regularly with procurement officials of the flagship companies, the ODMs and third-tier suppliers depend on face-to-face meetings and the *guanxi* ties that they have developed over many years.[8]

Most of the ODMs send forecast data and orders to the third-tier suppliers through websites or even e-mail. Generally, third-tier suppliers are not set up to implement EDI or RosettaNet. Most third-tier suppliers also have websites for showing available product information. Some of the companies find the web invaluable for searching for suppliers.

All of the third-tier suppliers we interviewed either had ERP systems or were in the process of implementing them (Table 11). The fact that many Taiwanese third-tier suppliers are now operating multiple manufacturing facilities puts a big strain on the hands-on management style of most small-business CEOs. The ERP systems are used as financial management systems to help the CEO manage multiple product lines being produced at multiple manufacturing sites. Companies 3(a), 3(c), and 3(i) are also using ERP systems for Material Inventory Management and Production (Shop-Floor) Management. Only 3(i) is using its ERP system for logistics. It is important to note that third-tier and fourth-tier companies are using IT for internal operational management systems, not for inter-organizational systems. This is very different from second-tier (ODM) companies that have invested heavily in systems linking

[8]It must be acknowledged that there are many Taiwanese in the flagship procurement offices who have *guanxi* relationships with friends in the ODMs. Personal relationships were used extensively by flagship companies in getting DRAM chips during the DRAM shortage induced by the earthquake in Taiwan.

Table 9
Companies using RosettaNet Standards

Companies	Using RosettaNet Standards	Member of Taiwan's Plan B
Flagship notebook firms		
Compaq	x	
Dell	x	
Fujitsu Siemens	x	
Gateway	x	
HP	x	
IBM	x	
Sony	x	
Toshiba	x	
Toshiba		
Taiwanese ODMs		
Arima Computer		x
Asus Computer		x
Compal Electronics		x
First International Computer		x
Inventec Corporation		x
MicroStar (MSI)		x
Mitac International		x
Quanta		No[a]
Twinhead International		x
Wistron		n.a.
Tier 3 suppliers		
Compeq Manufacturing Company		x
Delta Electronics		x
Foxconn		x
Primax Electronics		x
Sampo Technology Corporation		x
Tatung		x

Source: Malakooty, 2005.
Notes: [a]Personal interview with Quanta.

Table 10
Information Technology in Third-Tier and Fourth-Tier Firms[9]

	Tier 3									Tier 4	
Companies	**3(a)**	**3(b)**	**3(c)**	**3(d)**	**3(e)**	**3(f)**	**3(g)**	**3(h)**	**3(i)**	**4(a)**	**4(b)**
Product Data Mgmt									Y		
Sales / Order Mgmt	Y								Y	Y	
Material Inventory Mgmt.	Y		Y						Y	Y	
Production / Shop Floor Mgmt.	Y		Y						Y		
Human Resources											
Finance / Accounting	Y		Y						Y	Y	
E-Retailing			Y		Y	Y		Y			
E-Supplier Integration					Y	Y	Y	Y	Y		
Distribution / Logistics SCM									Y		
E-Mail / FTP	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y

[9]In Table 10 a blank means "no such IT-module," as the researchers asked about each technology. In Table 9 of flagship and ODM companies, a blank either meant "no such IT-method" or the "interviewer did not ask about the technology." For confidentiality reasons the names of the companies are hidden behind numbers. The number three represents third-tier companies and the number four represents fourth-tier companies.

Table 11
ERP Systems of Third-Tier and Fourth-Tier Companies

	Company	ERP System
Tier 3	3(a)	Taiwanese ERP (Dingxin)
	3(b)	Taiwanese ERP (Dingxin)
	3(c)	SAP ERP
	3(d)	Taiwanese ERP (DSC)
	3(e)	Taiwanese ERP (DSC)
	3(f)	BPCS with a lot of customizing
	3(g)	Taiwanese ERP
	3(h)	Oracle ERP
	3(i)	SAP ERP
Tier 4	4(a)	PRC ERP
	4(b)	No ERP

to flagship customers, and to a lesser degree linking to the third-tier suppliers.

Most of these new "ERP" systems have limited functionality, mostly as financial reporting systems. Also, most of these firms do not have shop-floor automation, MRP, customer relationship management, or supply chain management applications in place (Table 10). Most of the third-tier suppliers we interviewed did not see their information systems as providing a strategic advantage. They also did not believe their information systems allowed them to manage either more suppliers or customers.

The third-tier suppliers made it clear that they would accept forecast information from ODMs in a web-based format, by fax, e-mail, and phone. Two companies, 3(f) and 3(h) communicated with a select group of international customers using the XML standard RosettaNet.

The third-tier suppliers all used e-mail and generally saw e-mail as fine for communicating on a daily basis, but distrusted it for orders. They wanted a signature, so they tended to use a fax machine. One third-tier supplier that we interviewed was dependent on e-mail to negotiate prices and receive orders because he sold into the international market. In this case, the power of e-mail to transcend time and distance limitations outweighed its disadvantages. When dealing with international suppliers, the third-tier companies generally ordered through websites.

There is a striking difference between the ODMs and the third-tier suppliers in terms of the perceived benefit of IT use. Most third-tier suppliers that we interviewed did not see IT as a source of strategic advantage. They did see it as supporting the management of the company, but did not consider IT to be essential. One exception was a very large third-tier supplier, whose IT capabilities were similar to those of the ODMs. The combination of scale and the fact that this supplier sold directly to many flagship customers gave it the resources and need to develop sophisticated IT systems.

We only interviewed two fourth-tier suppliers, but the IT in these firms was even less advanced than in third tier. Third-tier suppliers negotiated prices in person with their fourth-tier suppliers. As one CEO told us, "I like to look in the eye of my suppliers when negotiating price." Third-tier suppliers mainly placed orders via fax to their fourth-tier suppliers.

One fourth-tier provider we interviewed had a number of PCs, but no ERP system. He was content to run his business using spreadsheets. For e-mail, he used a Chinese portal. Another fourth-tier supplier explained that though he was investing in an ERP system, its "shop-floor system" did not meet his needs. His company preferred to use its old paper based "shop-floor system."

Summary of Findings

In the highly competitive notebook industry, the efficiency and effectiveness of its supply chain can make the difference between whether a flagship company survives or thrives. Small differences in product quality, product costs, inventory costs, and availability can be worth millions of dollars to flagship carriers. In order to maximize the effectiveness and efficiency of the supply chain, flagship companies and their ODMs are using information technology to minimize inventory while ensuring that customers get the product they want at a competitive price. These companies use IT to support order management, logistics and distribution, procurement and inventory control, shop-floor management, and finance (Table 8).

Though the flagship carriers often directly purchase core third-tier products, such as processors and monitors, the ODMs procure products such as fans, heat sinks, connectors, and cables from non-core third-tier companies. Most ODMs are heavy users of IT (Table 8). They use websites to provide the third-tier companies with forecast information and some push out orders. There is a dramatic difference between the use of IT in the ODMs and in their third-tier suppliers. These third-tier customers primarily use IT as financial controls to help manage multiple production sites in China (from their headquarters in Taiwan).

The third-tier suppliers buy supplies from their fourth-tier suppliers. Very few of the third-tier suppliers use

web systems to communicate with their fourth-tier suppliers. Much of the communication takes place through face-to-face contact, phone, and fax methods.

The third-tier suppliers generally are not chosen on the basis of their IT capabilities, but rather on their ability to fulfill orders and on long-standing relationships. Most third- and fourth-tier suppliers do not feel pressured by the ODMs to invest in substantial IT.

The structure of IT in the notebook supply chain is asymmetric. The digital supply chain that runs from the flagship companies to the ODM suppliers becomes a one-way stream between the ODMs and the third-tier suppliers and is non-existent between the third- and fourth-tier companies.

The coordination of production between the ODMs, third-tier, and fourth-tier suppliers is not highly automated and relies on relationships. Many of these relationships go back 10 to 30 years and are based on a common identity. The notebook industry is a classic example of a Chinese business network, only in this case the network is based on a shared Taiwanese identity. Even though most production is now done in the People's Republic of China (PRC), one finds very few companies that are not Taiwanese-owned and operated participating in this network. It may seem incongruous, but companies that are indigenous to the PRC are not part of the notebook manufacturing network. As Francis Fukuyama points out in his book *Trust: Social Virtues and the Creation of Prosperity,* Chinese society is characterized by a high level of mistrust, compared to other societies, such as the United States. There is, however, 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, provides 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.

IT can increase the speed, efficiency, and precision of inter-organizational communications. However, by taking people out of the loop and replacing them with computers, IT can dampen the responsiveness of a production network. Hundreds of manufacturers communicating continually via cell phones with their suppliers, customers, and each other, create a very sensitive system.

In conclusion, the notebook industry relies on a production network consisting largely of Taiwanese companies whose activities are concentrated in Taiwan (management, R&D, IT, product development) and the Shanghai/Suzhou area (manufacturing, process engineering). This network is connected to the flagship branded PC makers through Western-style business transactions, including formal contracts and heavy use of IT. 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.

V. Implications for U.S. Flagship Companies

The U.S. flagship companies excel at developing global brands, providing service, implementing IT, and providing leadership for the industry. There will be a future for companies like Dell and Apple, each of which has a strong foundation for sustaining competitive advantage (Dell's cost advantages and Apple's product innovation). The other major U.S. PC makers, HP and Gateway, have struggled to achieve profitability in the face of ongoing price competition from Dell. Among the Taiwanese companies, only Acer has shown the ability to compete with them in global markets. China's Lenovo hopes to do the same through its acquisition of IBM's PC business.

As competition in the notebook industry intensifies, it is essential that the flagship companies understand one of the sources of the ODMs' ability, namely the Taiwanese business networks that support them.

This network generally functions quite well, but it presents problems to foreign PC makers who lack visibility into product availability, capacity, or quality processes of upstream suppliers.

Due to continuous price pressure, some flagship companies and ODMs have pursued strategies to cut costs that may result in worsening product quality. Currently, the flagship carriers are developing computers that on average will only last three years and the ODMs and third-tier networks are fulfilling these expectations. Price pressures in the supply chain are resulting in corners being cut in the manufacturing process that impact the life of a computer.

For instance, some third-tier companies that make connectors as part of the production process must apply gold to the connectors. The ability of the third-tier company to meet the specification and not exceed it can make the difference between 10 percent profitability for the third-tier company, and bankruptcy. Third-tier companies are also preserving margins by substituting materials that meet the flagships' specifications, but which cost less than those used in the original design. Flagship strategies are also undermining ODM relationships with suppliers. Taiwanese ODMs have traditionally looked out for the economic health of their suppliers, and vice versa, by being responsive on pricing and demand. However, some flagship companies are bypassing the ODMs to negotiate prices directly with key suppliers. In doing so, the flagship companies are undermining the relationships of the Taiwanese business networks that play such an important role in the success of the industry. On the other hand, the flagships are gaining direct visibility into supplier cost and quality.

VI. Conclusion

The notebook PC industry coordinates a complex, high-speed supply chain largely concentrated in the Shanghai, China region. Most notebook production is now done by about a dozen Taiwanese ODMs who have taken over development, manufacturing, and in some cases, after-sales support for branded flagship PC makers such as Dell, HP, Apple, and Gateway.

ODMs are electronically integrated with the flagship networks. Some have the capability of supporting BTO production and direct shipment. However, the digital supply network stops at the third-tier suppliers. Efforts, driven by the Taiwan government, to connect third-tier suppliers to ODMs through RosettaNet were a partial failure. Many third-tier suppliers do not have the ERP systems to support a digital supply chain. What many third-tier suppliers are installing under the name of ERP systems are really glorified financial systems that have no supply chain management, MRP, or order management functionality. Many third-tier suppliers do not want to sacrifice their margins by investing in extensive IT. In addition, they are only managing a few products so their IT needs are minimal. As they see it, the only need for IT is to coordinate manufacturing among a number of plants and to provide information to their own top management to support decision making. Yet, in spite of their inability or unwillingness to bi-directionally integrate digitally with their customers, these suppliers are experts in their product lines and are generally highly responsive to the needs of their customers. So, ODMs rely on their networks of personal relationships combined with limited IT, such as web interfaces, to integrate these suppliers.

With fierce competition between notebook manufacturers, prices are dropping rapidly. Since the majority of the cost of a notebook PC is in the Microsoft software, the Intel chip, and the flat screen panel, there is very little room for margins on motherboards, connectors, cables, etc.[10]

The ODMs, under immense price pressure, must decide what components they should develop in-house and what they should outsource to third-tier suppliers. Currently, the third-tier suppliers, by supporting multiple customers, have enjoyed economies of scale and specialization that keep them competitive, even with the pressure for lower priced notebooks. However, such a system may not be sustainable. The pressure for lower prices and direct negotiation by flagship companies with third-tier suppliers seems to be undermining the business networks that have been an integral part of the ODMs' success. One option for ODMs is to bring more component production in-house, but this requires developing new technical competencies and has not been highly successful thus far. More importantly, bringing the manufacturing of a component in-house could force out of business a supplier with whom the CEO of the ODM has a long-term relationship.

For flagship PC makers, the brutal competition in the supply chain means lower costs, but also may be leading to lower quality products. If customers are willing to see a notebook PC as a throwaway product that is replaced every three years, and perhaps accept shorter warranties, then a model of "planned

[10]The current effort to develop a Chinese processor to rival Intel's product line could drastically change the pricing structure of notebooks and significantly alter the relationships on which their production is based. WinCE and Linux are being ported to the Chinese Godson (Dragon Chip) processor and a 1 Ghz. processor will soon be available. However, Intel has used a variety of means to fend off competitors in the past (e.g., IBM, NEC, Motorola, Via, Transmeta), with only AMD having any consistent success.

obsolescence" might be acceptable. But for many, the failure of a notebook means an expensive loss of data and lost productivity, and it is not clear that the rush to the bottom in pricing is really the best strategy. It might be better to nurture long-term suppliers, allowing them to focus on quality and innovation, and to invest in IT to complement the existing relational networks, rather than to play one against the other and use IT to circumvent these social networks, which offer capabilities that no digital solution can provide.

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1 APPENDIX

Acronyms

ATP	Ability to Promise
BOM	Bill of Materials
BTO	Build to Order
BTS	Build to Stock
CEO	Chief Executive Officer
CPFR	Collaborative Planning and Forecast Replenishment
CIO	Chief Information Officer
CM	Contract Manufacturer
EDI	Electronic Document Interchange
ERP	Enterprise Resource Planning
FTP	File Transfer Protocol
F2F	Face to Face
IT	Information Technology
JIT	Just in Time
LCD	Liquid Crystal Display
MRP	Manufacturing Resource Planning
ODM	Original Design Manufacturer
OEM	Original Equipment Manufacturer
PC	Personal Computer
PLM	Product Lifecycle Management
PRC	People's Republic of China
Q&A	Quality Assurance
R&D	Research and Development
SCI	Supply Chain Integration
SCM	Supply Chain Management
VMI	Vendor Managed Inventory
VPN	Virtual Private Network
XML	eXtensible Markup Language

Instrument

INTERVIEW PROTOCOL FOR SUPPLIERS TO ODMs AND CMs

For the study of the use and value of IT in the notebook PC industry supply chain in Greater China

This interview protocol is to be administered to the CIO or CEO (where there is no CIO) of companies that are suppliers of key commodity components (cases, power supply, battery, keyboards, motherboards, cables/connectors) to notebook PC ODMs such as Quanta, Compal, Wistron, Asus and Arima or CMs such as HonHai/Foxconn in China. We refer to these companies as third- and fourth-tier suppliers because they are third and fourth in line behind branded PC companies, after the second-tier CMs or ODMs, which actually produce the notebooks. (See figure on next page.)

The protocol consists of open-ended questions. It is critical therefore that you take detailed notes and/or record (and later transcribe) the interview so that you have a complete and accurate record. It is also important that you "probe" the answers to each question. By probe, we mean that you seek further detail, examples, or explanations for the initial answers, especially when they are short responses, or responses that you are not sure you understand.

Although there are some lists related to some questions, they mainly are for illustration. You do not need to ask every person about every item on the lists. They are mainly a prompt and guide for you, the interviewer. We want their answers to the questions. They might say things not even on our lists. If they don't say much of anything in response to the general questions, you can use the list to probe for possible answers.

Introduction to the study for the CIO (or CEO)

We are doing a study of inter-firm relationships in the notebook PC industry supply chain in Greater China. We would like to talk to you about your relationships with your customers and your suppliers. We particularly want to focus on the use and value of information technology in supporting these relationships. First we want to ask you questions about the use of IT internally in your company, then in your company's relationship with your major customers, and finally in your relationships with your suppliers. We would like to know how your company uses IT in these relationships and the value of IT to your company.

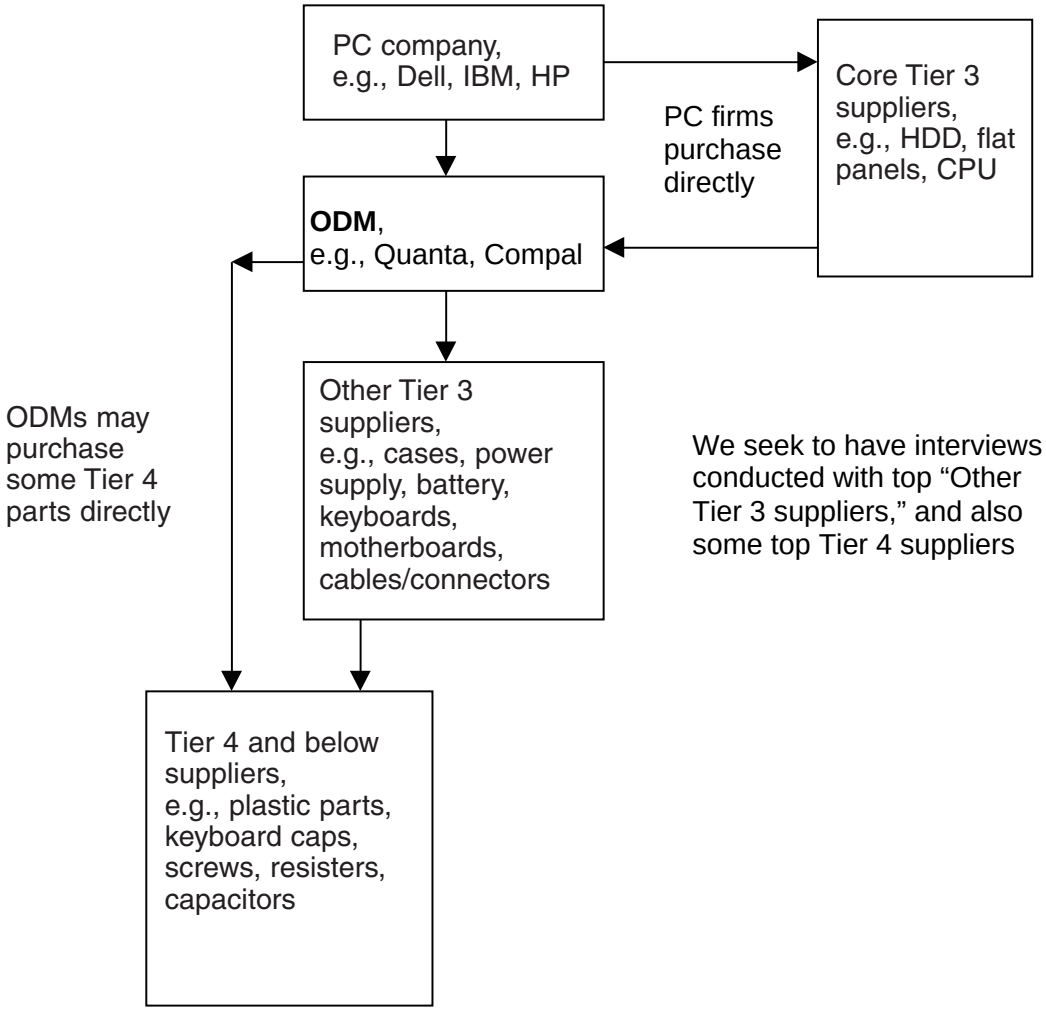
The project is sponsored by the National Science Foundations of the United States and China, and the International Institute for Supply Chain Management.

Your responses to our questions will be completely confidential. No information will be specifically attributed to your company. [Your responses will only be shared among researchers in the project. They will not be shared with funders or anyone else outside of the project.]

Only summary information from across the interviews will be presented in papers and reports. These will be shared with you before going to publication.

2 APPENDIX

Notebook PC Industry Supply Chain for Interviews



Company name _____

Interviewee _____**[Request business card]**

Title _____

E-mail address _____

Regarding your company.

What is your company size (# of employees)? Where is your headquarters?

- What are the key activities in your company? (Probe for a list such as: R&D, product design, sales and marketing, product development, supply chain coordination, production/manufacturing, product distribution, post-production support.)
- Where are your facilities for manufacturing, R&D and other activities?
- How are your products distributed? Directly to other manufacturers, to distributors, or both?
- Customers: How many major customers? Are they in China, Taiwan, or elsewhere?
- Suppliers: How many major suppliers? How much of your supply base is in China?

Regarding <u>your own internal IT</u>

- How do you use computers or other IT in your company? What are your key applications? Probe for a list such as: ERP, MRP (material requirements planning), SCM, CRM, order management, inventory management, shop-floor management, etc.

- What non-IT working methods do you use in your relationships with other companies? Phone, fax, face-to-face meetings?
    - For what types of interactions do you use IT versus non-IT communications?
- Does your company consider IT strategic to the business or mainly as a tool to cut costs? If strategic, in what way is it strategic? Probe…

Regarding the use of IT with your customers

What is the influence of your customers on your own IT?

- Have your customers pressured you to adopt particular applications such as ERP or MRP, particular platforms such as EDI or the Internet, or particular standards such as RosettaNet?
- What are the key technologies that interface with your customers? (Let them answer or suggest a list that they can respond to.)
    - Phone
    - Fax
    - E-mail
    - FTP
    - Shared repository for documents such as engineering files
    - EDI
    - Extranet or XML-based tools for transactions with partners
- Are you electronically connected to your customers to:
    - Get requests for bids?
    - Exchange engineering and technical information?
    - Get orders for products?
    - Get production plans and forecasts?
    - Provide them with information on your inventory?
    - Monitor quality problems?
- Does the use of IT lead you to work with more or fewer customers? Why or why not?
- Do your customers consider your IT capabilities an important factor when selecting suppliers? Please explain or illustrate how or why.
- Do any of your customers employ vendor-managed inventory or just-in-time systems?
- What is the value of your use of IT with your customers?
    - Keeps us in business; without it we could not get the business
    - Reduces cost
    - Reduces errors
    - Gives us a competitive advantage over other suppliers
    - Improves our forecasting accuracy
    - Increases the speed with which we can respond to customer demand
    - Helps to coordinate better with customers, integrate more tightly
    - Enables us to increase the number of customers
    - Enables us to concentrate on a small number of large customers

Regarding the use of IT with your suppliers

- What are the key technologies that interface with your suppliers? (Get a list, or suggest a list that they can respond to.)
    - Phone
    - Fax
    - E-mail
    - FTP
    - Shared repository for documents such as engineering files
    - EDI
    - Extranet or XML-based tools for transactions with partners
- Are you electronically connected to your suppliers to:
    - Send requests for bids?
    - Share product spec's and engineering information?
    - Order products?
    - Provide them with demand forecasts and production plans?

  - Provide them with information on your inventory for replenishment?
  - Inform them of quality problems and warranty performance?
- Do you pressure your suppliers to adopt any particular IT applications or standards?
- Does the use of IT lead you to work with more or fewer suppliers? Why or why not?
- Does your company consider a potential supplier's IT capabilities an important factor when selecting suppliers?
- What is the value of your use of IT with your suppliers?
  - Keeps us in business; without it, we could not manage so many suppliers
  - Reduces cost
  - Reduces errors
  - Increases the speed with which we can communicate changes in demand to our suppliers
  - Enables us to better understand our suppliers inventory
  - Helps to coordinate better with suppliers; integrate more tightly
  - Has enabled us to reduce the number of suppliers
  - Has enabled us to increase the number of suppliers
  - Other
- Could you please provide us with a list of your key suppliers and the CIO's contact information? [This tends to be a sensitive question which they often do not want to reveal and so it should be asked last.]

Summaries of Interviews with Tier 3 and Tier 4 Companies

Company 3(a)		
Internal IT Usage	IT in company	◆ Implementing ERP System (SAP) to replace previous system (a Taiwan local brand: Dingxin): Implemented so far are Sales Order Management, Materials Inventory Management, Shop-Floor Management, and Finance). R&D, HR and logistics are being implemented in second stage. HP is providing the consulting services. ◆ E-mail/EDI.
	Non-IT methods with other companies	◆ Phone, fax, face-to-face.
	The role of IT	◆ ERP is in developing stage (errors cannot be eliminated by ERP).
IT Use with Customers	Customer pressure	◆ No.
	Communication interface	◆ E-mail, one or two customers use web-based system.
	Electronically connected with customers to	E-mail most ◆ Get request for bids—by e-mail. ◆ Exchange engineering and technical information—FTP. ◆ Get order for products—by e-mail, then key in to ERP. ◆ Get production plans and forecasts (receive forecast/sale/order on web)—few. ◆ Provide them with information on your inventory—few. ◆ Monitor quality problems—no.
	The use of IT on the numbers of customers	◆ No.
	IT capabilities as an important factor for customers to choose suppliers	◆ No, the customer only cares for the quality, ability to meet commitments, price.
	Customers employing vendor-managed inventory or just-in-time systems	◆ VMI (for some customers) and JIT. Two to four weeks for Acon to get materials. ◆ Both BTO and BTS ("For cable assembly, we build to order as it should follow different designs according to customer's request; for connector, which are common material, we can build to stock to adjust production loading. But mainly we build to order for better production and financial control.")
	The value of using IT with customers	◆ Keeps us in business; without it we could not get the business—no. ◆ Reduces cost (not clear now since the investment on ERP is very large). ◆ Reduces errors—some. ◆ Gives us a competitive advantage over other suppliers—no. ◆ Improves our forecasting accuracy—no. ◆ Increases the speed with which we can respond to customer demand—some yes. ◆ Helps to coordinate better with customers; integrate more tightly—maybe. ◆ Enables us to increase the number of customers—no. ◆ Enables us to concentrate on a small number of large customers—no.
IT Use with Suppliers	Key technologies with suppliers	◆ Face-to-face, phone to request price from at least two suppliers and sometimes e-mail.
	Electronically connected with suppliers	◆ Sometimes by e-mail with attachment.
	The pressure on suppliers to adopt the standards	◆ No.
	The use of IT leads to more/fewer suppliers	◆ No.
	IT capabilities is an important factor to choose suppliers	◆ No—price, availability and past history are more important.
	The value of IT usage with suppliers	E-Mail as IT: ◆ Keeps us in business; without it, we could not manage so many suppliers—no. ◆ Reduces cost—no. ◆ Reduces errors—no. ◆ Increases the speed with which we can communicate changes in demand to our suppliers (hard to say, depending on e-mail checking interval). ◆ Enables us to better understand our suppliers inventory—no. ◆ Helps to coordinate better with suppliers; integrate more tightly—no. ◆ Has enabled us to reduce the number of suppliers—no. ◆ Has enabled us to increase the number of suppliers—no.

Company 3(b)		
Internal IT Usage	IT in company	◆ Have successfully implemented ERP (a Taiwan local brand: Dingxin). ◆ E-mail (Lotus Notes), MSN, VPN are frequently used.
	Non-IT methods with other companies	◆ Phone, face-to-face.
	The role of IT	◆ ERP is mainly as a management tool. ◆ The ERP system doesn't integrated with outside partners.
IT Use with Customers	Customer pressure	◆ No.
	Communication interface	◆ E-mail, MSN, phone and fax.
	Electronically connected with customers to	◆ Get request for bids—no, have been pre-determined in contract. ◆ Exchange engineering and technical information—no. ◆ Get order for products—by paper. ◆ Get production plans and forecasts (two weeks). ◆ Provide them with information on your inventory—no. ◆ Monitor quality problems—no.
	The use of IT and the numbers of customers	◆ No.
	IT capabilities as an important factor for customers to choose suppliers	◆ No.
	Customers employing vendor-managed inventory or just-in-time systems	◆ VMI and BTO model.
	The value of using IT with customers	◆ Keeps us in business; without it we could not get the business—no. ◆ Reduces cost—no. ◆ Reduces errors—yes. ◆ Gives us a competitive advantage over other suppliers—maybe. ◆ Improves our forecasting accuracy—no. ◆ Increases the speed with which we can respond to customer demand—no. ◆ Helps to coordinate better with customers, integrate more tightly—no. ◆ Enables us to increase the number of customers—no. ◆ Enables us to concentrate on a small number of large customers—no.
IT Use with Suppliers	Key technologies with suppliers	◆ Mostly by phone and fax.
	Electronically connected with suppliers	◆ Sometimes e-mail.
	The pressure on suppliers to adopt the standards	◆ No.
	The use of IT leads to more/ fewer suppliers	◆ No.
	IT capabilities is an important factor to choose suppliers	◆ No. Raw materials and logistics of supply is main concern.
	The value of IT usage with suppliers	◆ No to all.

Company 3(c)		
Internal IT Usage	IT in company	◆ ERP (SAP, have been used for two to three years. Functions include finance, accounting, MRP, inventory). ◆ E-mail.
	Non-IT methods with other companies	◆ E-mail (mostly since more customers are worldwide), meeting, phone call, fax.
	The role of IT	◆ Strategic to compete in the market, also cost saving.
IT Use with Customers	Customer pressure	◆ Yes. (e.g. Motorola asks them to check web system to get the forecasting data. Their system now is integrated with forecasting database. Simens has similar requirement. Overall, there are about 10 percent of customers (big, overseas customers) who pressure them on their IT usage.) ◆ Customers require to smooth supply chain activities and information transparence. ◆ They choose SAP mainly because most customers have used SAP. SAP makes customers feel comfortable and may prepare for future integration.
	Communication interface	◆ E-mail, phone, and meeting.
	Electronically connected with customers to	◆ Get request for bids—no (price is negotiated annual and set down in contract). ◆ Exchange engineering and technical information—e-mail. ◆ Get order for products—web/fax (customers provide annual/quarterly forecasting data and monthly confirmation on demand). ◆ Get production plans and forecasts—partly (usually face-to-face to set down annual production plan based on customers' forecast, web-interface to get forecasting). ◆ Provide them with information on your inventory—e-mail (both raw materials and finished products). ◆ Monitor quality problems—use QA to monitor, usually exchange quality information by phone (since it is a emergency issue). ◆ Provide ATP (availability to promise)—yes.
	The use of IT on the numbers of customers	◆ Irrelevant.
	IT capabilities as an important factor for customers to choose suppliers	◆ Major one, since most customers are overseas (in the United States and Europe). Their concern is on IT capability.
	Customers employing vendor-managed inventory or just-in-time systems	◆ Only big customers ask for VMI. No JIT since they keep raw material and produce mainly based on production plan. However they are also BTO when monthly order is confirmed.
	The value of using IT with customers	◆ Keeps us in business—about 70 percent business. ◆ Reduces cost—yes (both management cost and production cost). ◆ Reduces errors—no. ◆ Gives us a competitive advantage over other suppliers—yes. ◆ Improves our forecasting accuracy—yes. ◆ Increases the speed with which we can respond to customer demand—yes. ◆ Helps to coordinate better with customers—yes. ◆ Enables us to increase the number of customers—not really, but helpful. ◆ Enables us to concentrate on a small number of large customers—yes. ◆ Other—optimize internal management activities.
IT Use with Suppliers	Key technologies with suppliers	◆ By phone (to negotiate price and lead time, which occurs quite often). ◆ E-mail is to exchange technical information. ◆ Phone and e-mail are efficient enough to communicate with suppliers.
	Electronically connected with suppliers	◆ Send request for bids—e-mail (usually three suppliers for each component). ◆ Exchange engineering and technical information—e-mail (require all suppliers to use e-mail so that they can exchange design drawing as attachments). ◆ Confirm order for products—by fax. ◆ Share production plans and forecasts—send forecast by fax/e-mail. ◆ Provide them with information on your inventory—no (3(c) does not care about suppliers' inventory information). ◆ Monitor quality problems—no. ◆ Required to provide ATP (availability to promise)—by e-mail/phone. They are concerned about supply lead-time. If supplier cannot promise, they will turn to another supplier with full order. Neither will they split order.
	The pressure on suppliers to adopt the standards	◆ Force suppliers to exchange design information by e-mail. ◆ Require major suppliers to implement ERP.
	The use of IT leads to more/ fewer suppliers	◆ Irrelevant.

Company 3(c) - Continued		
IT Use with Suppliers	IT capabilities is an important factor to choose suppliers	◆ No (fast, security, reliability are top three concerns. Price is O.K. Logistic advantage is preferred, but not important. However most suppliers are in Zhujiang delta.).
	The value of IT usage with suppliers	◆ Keeps us in business—yes. (They need to exchange much technical/production information fast, which requires IT supports.) ◆ Reduces cost—sometimes. ◆ Reduces errors—yes. ◆ Increase order response time—yes. ◆ Helps to coordinate better with suppliers —yes (however, face-to-face, phone and meeting are used to key suppliers). ◆ Help us to better understand suppliers' production/inventory—yes. E-mail/phone is helpful. However what we actually care about is lead-time (supply uncertainty, ATP etc.), not stock. ◆ Enables us to increase the number of suppliers—increase. ◆ Other?

Company 3(d)		
Internal IT Usage	IT in company	◆ ERP (Taiwanese ERP vendor DSC, a version with less features than SAP). ◆ A document center for internal use.
	Non-IT methods with other companies	◆ Face-to-face for giving pricing information and for promotion.
	The role of IT	◆ Don't use IT strategically, but would like to.
IT Use with Customers	Customer pressure	◆ Customers have not pressured them to adopt IT. Three or four years ago, a number of companies pushed them to use EDI, but they have discontinued using EDI.
	Communication interface	◆ Use a number of technologies with customers: Phone, fax, e-mail (of course with attachments of spreadsheets and pdf drawings).
	Electronically connected with customers to	◆ Get request for bids—no. ◆ Exchange engineering and technical information—yes. ◆ Get order for products—no (percentage of forecast are negotiated quarterly, they must meet a percentage of the forecast data). ◆ Get production plans and forecasts—yes (being negotiated quarterly). ◆ Provide them with information on your inventory—no. ◆ Monitor quality problems—no, by paper.
	The use of IT on the number of customers	◆ Allow to work with more customers.
	IT capabilities as an important factor for customers to choose suppliers	◆ IT is not much of a factor in choosing suppliers. Much more important is the ability of supplier to meet commitments in past.
	Customers employing vendor-managed inventory or just-in-time systems	◆ Doing vendor managed inventory and have supply centers near the manufacturers' plants. They are finding that they often stock more product than the customer takes delivery of. They are exploring information technology that will help them better predict inventory levels.
	The value of using IT with customers	◆ Keeps us in business; without it we could not get the business—yes. ◆ Reduces cost—think so. ◆ Reduces errors—no, DSC gives errors too. Also have to re-key forecast data from website into DSC ERP system. ◆ Gives us a competitive advantage over other suppliers—yes. ◆ Improves our forecasting accuracy—yes. They still have trouble doing an accurate forecast. Are looking for IT that will make forecasting more accurate. ◆ Increases the speed with which we can respond to customer demand—of course. ◆ Helps to coordinate better with customers, integrate more tightly—of course. ◆ Enables us to increase the number of customers—yes. ◆ Enables us to concentrate on a small number of large customers—not exactly. They would like their customers to fit a bell curve. Have a balance between big and small companies. ◆ Other
IT Use with Suppliers	Key technologies with suppliers	◆ No web system for its suppliers. Instead, they use phone, fax, and also e-mail. They use these methods to share forecasting data, but not in spreadsheet.
	Electronically connected with suppliers	◆ E-mail.
	The pressure on suppliers to adopt the standards	◆
	The use of IT leads to more/fewer suppliers	◆ Because they have to create special manufacturing model, they sometimes go with one trusted supplier.
	IT capabilities is an important factor to choose suppliers	◆
	The value of IT usage with suppliers	◆

Company 3(e)		
Internal IT Usage	IT in company	◆ ERP (developed by DSC, a Taiwanese company). ◆ They see their ERP systems as primarily saving time.
	Non-IT methods with other companies	◆
	The role of IT	◆ They did not understand the concept of strategic use of IS and its relation to ERP. This may be because most other manufacturers of heat sinks are using ERP too.
IT Use with Customers	Customer pressure	◆ Customers have not pressured them to adopt IT. Three or four years ago, a number of companies pushed them to use EDI, but they have discontinued using EDI.
	Communication interface	◆ The ERP system has a Electronic Commerce module (developed by DSC) that provides a web interface for customers. ◆ Their customers have developed web-based systems that it is supposed to check regularly to get forecast data that is provided weekly. They provide data on the web system on how much of the forecast they can fulfill, and at what price.
	Electronically connected with customers to	◆ Get request for bids—yes. ◆ Get order for products—yes. ◆ Get production plans and forecasts— yes. ◆ Provide them with information on 3(e)'s inventory. ◆ Monitor quality problems.
	The use of IT on the numbers of customers	◆
	IT capabilities as an important factor for customers to choose suppliers	◆ Customers consider IT capabilities when selecting suppliers. Generally, they work with three select vendors though they may provide request for quotes to more vendors.
	Customers employing vendor-managed inventory or just-in-time systems	◆ Some of their customers require that they have a hub next to the customer's manufacturing site and keep one week of inventory there.
	The value of using IT with customers	◆ Keeps us in business—very important. ◆ Reduces cost—in short term raise costs, in long term lower costs. ◆ Reduces errors—very important. ◆ Gives us a competitive advantage over other suppliers—equal. ◆ Improves our forecasting accuracy— very important. ◆ Increases the speed with which we can respond to customer demand—very important. ◆ Enables us to increase the number of customers—not very important. ◆ Enables us to concentrate on a small number of large customers—to focus on big customer.
IT Use with Suppliers	Key technologies with suppliers	◆ The EC (Electronic Commerce) system is used to communicate with suppliers they have about 50 suppliers for five products.
	Electronically connected with suppliers	◆ The primary way of communicating with suppliers is through the EC system. Forecasting information is sent and suppliers respond with price and availability numbers. Orders are placed over the web.
	The pressure on suppliers to adopt the standards	◆ Suppliers must work with their EC web-based system.
	The use of IT leads to more/fewer suppliers	◆
	IT capabilities is an important factor to choose suppliers	◆ Suppliers are evaluated based on quality and capacity as well as technical merit.
	The value of IT usage with suppliers	◆ Keeps us in business—not very important. ◆ Reduces cost—not as important as increasing efficiency. ◆ Reduces errors—very important. ◆ Increases the speed with which we can respond to customer demand—very important. ◆ Helps to coordinate better with customers—not important (suppliers do not report inventory). ◆ Enables us to increase the number of customers—not important (maybe can handle more suppliers).

Company 3(f)		
Internal IT Usage	IT in company	◆ ERP system by BPCS (but 3(f) has almost rewritten the system by themselves and have done a lot of customizing. ◆ Both Model A (RosettaNet) and Model C (web-based interface to their systems). Government gave them money to develop both. ◆ Considers Product Life-Cycle Management as 3(f)'s next priority for implementation.
	Non-IT methods with other companies	◆ Phone, fax, e-mail, and face-to-face meetings.
	The role of IT	◆ Originally they invested in IT to cut costs, but now pushing strategy through Product Live Management (PLM).
IT Use with Customers	Customer pressure	◆ Dell provides them with supply invoices from products that it sends to Dell's ODMs using B-Global (RosettaNet). Participation in B-Global is expensive ($1,500) a month. ◆ The customers' websites (e.g. the websites of Compal, ASUS, ECS, and ECS (Elite)) allow customers to provide forecasting data to them. ◆ Some customers allow them to give quotes and percentage of forecast they can respond to on the customers' websites. Their customers provide orders to them on customers' websites.
	Communication interface	◆ Phone, fax, and e-mail supplement their customers' web systems and RosettaNet (Some of its customers send forecast data in a spreadsheet that is attached to e-mails).
	Electronically connected with customers to	◆ Get order for products—yes (on customers' websites). ◆ Get production plans and forecasts— customers provide forecast on web. ◆ Monitor quality problems—they provides data on quality daily to customers. Quarterly, the customers audit their quality data.
	The use of IT on the numbers of customers	◆
	IT capabilities as an important factor for customers to choose suppliers	◆ Yes (because it leads to efficiencies).
	Customers employing vendor-_ managed inventory or just-in-time systems	There is often vendor managed inventory.
	The value of using IT with customers	◆ Keeps us in business—very important. ◆ Reduces cost—important. ◆ Reduces errors—important. ◆ Gives us a competitive advantage over other suppliers—important (B2B project). ◆ Improves our forecasting accuracy—not so important. (Customers can not provide forecasting data accurately.) ◆ Increases the speed with which we can respond to customer demand—very important. ◆ Helps to coordinate better with customers—not so important. ◆ Enables us to increase the number of customers—does not matter. ◆ Enables us to concentrate on a small number of large customers—very important.
IT Use with Suppliers	Key technologies with suppliers	◆ Website for suppliers will be finished by the end of the year.
	Electronically connected with suppliers	◆ B2B project is a pilot. If successful, then all suppliers (120) will have to join. The website allows for forecast negotiation, for Darfon to give a quote, VMI, and PO negotiation. ◆ They do not share product specs and engineering documents electronically with its suppliers. ◆ They currently send forecast data and request for bids via spreadsheets attached as e-mail.
	The pressure on suppliers to adopt the standards	◆ Yes. They hope to implement web interface for suppliers.
	The use of IT leads to more/fewer suppliers	◆ Irrelevant.
	IT capabilities is an important factor to choose suppliers	◆
	The value of IT usage with suppliers	◆ Keeps us in business—important ◆ Reduces cost—important. ◆ Reduces errors—very important. ◆ Increase order response time—very important. ◆ Helps to coordinate better with suppliers—maybe. ◆ Help us to better understand suppliers' production/inventory—important. ◆ Enables us to increase the number of suppliers—don't think so.

Company 3(g)		
Internal IT Usage	IT in company	◆ In Taiwan uses an ERP system by a Taiwanese software company for their IT. ◆ They use web-based interface to their systems.
	Non-IT methods with other companies	◆ Phone, fax, e-mail, and face-to-face meetings.
	The role of IT	◆ They invested in IT as a strategy for their business.
IT Use with Customers	Customer pressure	◆ No.
	Communication interface	◆ Customers' web system, phone, fax, and e-mails (sometimes with attachments).
	Electronically connected with customers to	◆ Get production plans and forecasts—some customers send forecast data in a spreadsheet attached to e-mails. 3(g) provides forecast for some projects on the web system.
	The use of IT on the numbers of customers	◆
	IT capabilities as an important factor for customers to choose suppliers	◆
	Customers employing vendor-managed inventory or just-in-time systems	◆ They often do vendor managed inventory.
	The value of using IT with customers	◆ Keeps us in business—not very important. ◆ Reduces cost—very important. ◆ Reduces errors—important. ◆ Gives us a competitive advantage over other suppliers—important (some projects). ◆ Improves our forecasting accuracy—important. ◆ Increases the speed with which we can respond to customer demand—very important. ◆ Helps to coordinate better with customers—important. ◆ Enables us to increase the number of customers—does not matter ◆ Enables us to concentrate on a smaller number of large customers—does not matter.
IT Use with Suppliers	Key technologies with suppliers	◆ E-mail (with attachment), phone, fax, web system.
	Electronically connected with suppliers	◆ Send request for bids—by e-mail (with spreadsheet), phone, fax, and web system. ◆ Share production plans and forecasts—share forecast data by e-mail/web system.
	The pressure on suppliers to adopt the standards	◆ No.
	The use of IT leads to more/fewer suppliers	◆
	IT capabilities is an important factor to choose suppliers	◆
	The value of IT usage with suppliers	◆ Keeps us in business—not important. ◆ Reduces cost—important. ◆ Reduces errors—very important. ◆ Increase order response time—very important. ◆ Helps to coordinate better with suppliers—maybe. ◆ Help us to better understand suppliers' production/inventory—important. ◆ Enables us to increase the number of suppliers—don't think so.

Company 3(h)		
Internal IT Usage	IT in company	◆ They have a thousand PCs and 30-40 servers. ◆ Oracle ERP system which they have customized. (The Oracle screens are in English, but they can put Chinese data in the system.) ◆ Thirty-two people in the IT department. Also a computer integrated manufacturing (CIM) department with 11 employees. ◆ Voice Over IP is reducing communication costs around 3(h). They are also using video conferencing.
	Non-IT methods with other companies	◆
	The role of IT	◆ Not of strategic needs (But they do see IT as supporting there business strategy. Even if cost of IT is high they will implement if it supports business goals). ◆ Implementation of IT does not minimize errors because data needs to be re-keyed into the ERP system.
IT Use with Customers	Customer pressure	◆ Two foreign and one domestic customer (Inventec) pressured them to implement RosettaNet. ◆ Customers push for IT, but will not pay for it.
	Communication interface	◆ Phone, fax, e-mail, FTP (They consider EDI out of date).
	Electronically connected with customers to	◆ In terms of RosettaNet, forecast, inventory, shipping, payment, and invoice PIPs are supported. ◆ Get production plans and forecasts—yes, by RosettaNet. ◆ Provide them with information on your inventory—yes, by RosettaNet. ◆ Monitor quality problems—by e-mail. ◆ Provide ATP (availability to promise)—yes, by RosettaNet.
	The use of IT on the numbers of customers	◆ Irrelevant.
	IT capabilities as an important factor for customers to choose suppliers	◆
	Customers employing vendor-managed inventory or just-in-time systems	◆ They have implemented VMI to a certain degree by having hubs in Europe and China to support cell phone and data communication products.
	The value of using IT with customers	◆ Reduces cost—no. ◆ Reduces errors—yes. ◆ Gives us a competitive advantage over other suppliers—no. ◆ Improves our forecasting accuracy—yes. ◆ Increases the speed with which we can respond to customer demand—yes. ◆ Helps us to coordinate better with customers—yes. ◆ Enables us to increase the number of customers—no. ◆ Enables us to concentrate on a small number of large customers—no.
IT Use with Suppliers	Key technologies with suppliers	◆ Phone, fax, and e-mail. They also have a couple suppliers who have their own web interface which they log on to in order to place orders.
	Electronically connected with suppliers	◆ They are generally not connected electronically to suppliers. ◆ They have a number of Japanese suppliers who have critical components and many customers. They know the inventory of the supplier, but can not depend on the quality of information from the supplier.
	The pressure on suppliers to adopt the standards:	◆ No.
	The use of IT leads to more/fewer suppliers	◆ Irrelevant.
	IT capabilities is an important factor to choose suppliers	◆ No.
	The value of IT usage with suppliers	◆ Because of no IT with suppliers, the answers to this section is empty.

Company 3(i)		
Internal IT Usage	IT in company	◆ Their internal IT is based on SAP (six modules: material planning, production planning, sales and distribution, financial accounting, quality management, and APO).
	Non-IT methods with other companies	◆
	The role of IT	◆
IT Use with Customers	Customer pressure	◆
	Communication interface	◆
	Electronically connected with customers to	◆ Get production plans and forecasts. Many of their customers provide forecast information.
	The use of IT on the numbers of customers	◆
	IT capabilities as an important factor for customers to choose suppliers	◆ Customers consider IT capabilities when making decisions about preferred customers.
	Customers employing vendor-managed inventory or just-in-time systems	◆
	The value of using IT with customers	◆ Keeps us in business—yes. ◆ Reduces cost—some areas. ◆ Reduces errors—sure. ◆ Gives us a competitive advantage over other suppliers—yes. ◆ Increases the speed with which we can respond to customer demand—sure. ◆ Enables us to concentrate on a small number of large customers—yes.
IT Use with Suppliers	Key technologies with suppliers	◆ Fifteen suppliers communicate via RosettaNet, 30 by FTP, and 600 by web-based system, the rest by phone, fax, and e-mail. ◆ 3(i) talked about an initiative between it and Taiwan's ODMs to develop a common web interface with the goal of locking Samsung out of the market. ◆ Dell also has someone on site to monitor indicators such as quality, capacity, and logistics.
	Electronically connected with suppliers	◆ Confirm order for products—by web interface. ◆ Share production plans and forecasts—provide forecast plan to suppliers by web interface. ◆ Provide them with information on your inventory—by web interface. ◆ Monitor quality problems—by on-site QA.
	The pressure on suppliers to adopt the standards	◆ Help their suppliers to provide techniques about IT systems and give them some important suggestions for their IT systems.
	The use of IT leads to more/fewer suppliers	◆
	IT capabilities is an important factor to choose suppliers	◆ Consider suppliers IT capabilities very seriously when selecting suppliers.
	The value of IT usage with suppliers	◆ Reduces cost—yes. ◆ Reduces errors—yes. ◆ Increase order response time—yes. ◆ Helps to coordinate better with suppliers—yes. ◆ Help us to better understand suppliers' production/inventory—yes. ◆ Enables us to increase the number of suppliers—decrease (a little).

Company 4(a)		
Internal IT Usage	IT in company	◆ Implementing ERP System (a local Taiwan brand: Tianxin), finance, sales, procurement, inventory management. MRP is problematic. ◆ Main use is for management.
	Non-IT methods with other companies	◆ E-mail, face-to-face, phone, fax.
	The role of IT	◆ ERP systems only a management tool.
IT Use with Customers	Customer pressure	◆ No, except for some pressure to use e-mail.
	Communication interface	◆ E-mail, web brochure for product codes. About five of their customers (out of 400) have web interfaces for providing forecasting information.
	Electronically connected with customers to	From a few customers with web interface: ◆ Get request for bids—yes. ◆ Exchange engineering and technical information—fax and FTP. ◆ Get order for products—yes. ◆ Get production plans and forecasts (receive forecast/sale/order on web)—yes. ◆ Provide them with information on your inventory—no. ◆ Monitor quality problems—no, by paper.
	The use of IT on the numbers of customers	◆ Not relevant, but might effect in future.
	IT capabilities as an important factor for customers to choose suppliers	◆ No.
	Customers employing vendor-managed inventory or just-in-time systems	◆ Mainly BTO model. They have a three-day time from receipt of order to delivery of product.
	The value of using IT with customers	Their goals for planned ERP system: ◆ It should be a management tool—yes. ◆ It should increase response speed—yes. ◆ It should provide accurate information—yes. ◆ IT keeps us in business—yes; without it we will not get the business. ◆ Reduces cost—some. ◆ Reduces errors—yes. ◆ Gives us a competitive advantage over other suppliers—maybe, but it is hard to say since ERP is quite common in companies. ◆ Improves our forecasting accuracy—yes. ◆ Increases the speed with which we can respond to customer demand—yes. ◆ Helps to coordinate better with customers, integrate more tightly—no. ◆ Enables us to increase the number of customers—no. ◆ Enables us to concentrate on a small number of large customers—no.
IT Use with Suppliers	Key technologies with suppliers	◆ Fax, phone, and e-mail (in descending order). ◆ Have a website for product information. ◆ Face-to-face communication is important. ◆ Use web to search for new suppliers, followed by traditional business means.
	Electronically connected with suppliers	◆ Some via e-mail, ftp/fax for design data exchange.
	The pressure on suppliers to adopt the standards	◆ No.
	The use of IT leads to more/fewer suppliers	◆ Not relevant.
	IT capabilities is an important factor to choose suppliers	◆ No. Never require them to use e-mail.
	The value of IT usage with suppliers	E-Mail: ◆ Keeps us in business—yes. Without it, we could not manage so many suppliers. ◆ Reduces cost—no. ◆ Reduces errors—no. ◆ Increases the speed with which we can communicate changes in demand to our suppliers—no. ◆ Enables us to better understand our suppliers inventory—no. ◆ Helps to coordinate better with suppliers, integrate more tightly—no. ◆ Has enabled us to reduce the number of suppliers—no. ◆ Has enabled us to increase the number of suppliers—not relevant.

Company 4(b)		
Internal IT Usage	IT in company	◆ Twenty-five PCs ◆ They have no IT between either its customers or suppliers.
	Non-IT methods with other companies	◆ Faxes are used for orders.
	The role of IT	◆ All computers are for internal operation and financial accounting.
IT Use with Customers	Customer pressure	◆
	Communication interface	◆
	Electronically connected with customers to	◆ Get order for products—by fax.
	The use of IT on the numbers of customers	◆
	IT capabilities as an important factor for customers to choose suppliers	◆
	Customers employing vendor-managed inventory or just-in-time systems	◆ Customers employ vendor managed inventory. They supply chemicals on an as-needed basis. They locate their plants within two hours of each customer and will make enough chemicals to keep their customers running (no outages).
	The value of using IT with customers	◆
IT Use with Suppliers		Key technologies with suppliers
		◆
	Electronically connected with suppliers	◆
	The pressure on suppliers to adopt the standards	◆
	The use of IT leads to more/fewer suppliers	◆
	IT capabilities is an important factor to choose suppliers	◆
	The value of IT usage with suppliers	◆

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CAPS: Center for Strategic Supply Research
2055 E. Centennial Circle
P.O. Box 22160
Tempe, AZ 85285-2160

Telephone (480) 752-2277
www.capsresearch.org

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