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E-Commerce to Protect the Network Relationships: The Case of Taiwan's PC Industry

Tain-Jy Chen

Department of Economics, National Taiwan University, Taipei, Taiwan

Although Taiwan is one of the world's leading producers of information products, it lags behind advanced countries in the application of information technologies. The strength of Taiwan's industry lies in its low-cost manufacturing capabilities, which in recent years have been undermined by rising wages. Faced with a massive relocation of production activities to China, the Taiwanese government is trying to prevent the hollowing out of domestic industry by encouraging local firms to embrace new information technologies to strengthen their ties to multinational firms. The initiative aims at enhancing the flexibility of production and speeding up responses to the market through concerted actions by brand marketers, parts suppliers, and assemblers. New technologies underscore new working methods that erect entry barriers to protect existing network relationships.

Keywords digital information system, e-commerce, information technology (IT), network, supply chain

Taiwan ranks fourth in the world in terms of the production of information hardware, but lags behind most advanced countries in the application of information technologies (IT); both personal computer ownership and spending on IT products (including software) remain at low levels. This contrast between production and usage reflects Taiwan's industrial focus on manufacturing and its downplaying of services. Moreover, in terms of manufacturing, the emphasis has been placed on the buildup of physical capital and on mobilization of the labor force rather than technology. Precipitated by rising wages, Taiwan's industry entered an unprecedented stage of restructuring in the 1990s whereby manufacturing activities were relocated, en masse, to China. Working mainly as subcontractors for international brands, Taiwanese firms are faced with the immense challenge of preserving their position in the international production network whilst relocating their major manufacturing activities to China.

Taiwanese firms found that the solution lies in the application of information technologies with the aid of IT hardware, which they have been good at producing. By establishing a digital information network, which connects them to international buyers at one end, and their upstream suppliers of parts and components at the other, they are able to create a competitive edge in offering products in a timely and flexible fashion. This competitive edge is underscored by a group of parts and components suppliers who are willing to work in a concerted way to share the risks of demand uncertainties within the industry. Each network of suppliers is unique in terms of membership, work routine, and the way in which production is organized; hence, they constitute a barrier to entry that protects the position of the Taiwanese producer in the international subcontracting market. Information technologies strengthen the network ties by providing instant data and allowing members to react promptly to the data. They also broaden the capabilities of subnetwork leaders like Taiwanese firms through improved coordination of their own subnetworks across the national border. Under the digital information system, the production chain becomes a continuous flow of value whereby each participant in the activity has to estimate precisely both the volume and timing of its work input. There is little room for errors since buffer stocks (inventories) become an excessive luxury, which may affect the viability of the producer in the system. Information sharing is essential to the working of the network. Nonmembers first

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Address correspondence to Tain-Jy Chen, Department of Economics, National Taiwan University, 21 Hsu-Chow Road, Taipei, Taiwan 100. E-mail: tainjy@ms.cc.ntu.edu.tw

have to invest in building up trust in order to gain access to the network and then have to invest in hardware facilities to become part of the Information Web. Finally, they have to invest in software and internal work routines in order to fully adjust to the system. New technologies thus give extra protection to the existing relationships between Taiwanese subcontractors and their international buyers, allowing the former to relocate production to China without losing export orders. The purpose of this article is to discuss the background of this development and to demonstrate how the strategy works.

BACKGROUND

Economic Trends

In recent years, Taiwan's economic growth has slowed from its previous rapid pace of the 1980s, but has nevertheless remained robust. The average annual GDP growth rate for 1990–2000 was 6.42%, and as a result of this robust growth, per capita income rose from US$8,111 in 1990 to US$14,216 in 2000 (see Table 1).

However, there was a dramatic reorganization of the structure of the economy in the 1990s; in particular, the mainstay of economic activities has shifted from the manufacturing sector to the services sector. Manufacturing accounted for 33.31% of GDP in 1990, but this share declined steadily in the 1990s, settling at 26.33% in 2000 (see Table 2). In its place, the GDP share accounted for by service output increased from 41.76% in 1990 to 49.86% in 2000. Among the various service sectors, retail trade and finance have contributed most to this growth. With the growing importance of the service sector, demand for computer-related information services has also increased, particularly in insurance, transport, and finance industries.

TABLE 1
GDP growth and per capita income

	GDP growth rate (%)	Per capita income (US$)
1990	5.39	8111
1991	7.55	8982
1992	7.49	10,502
1993	7.01	10,964
1994	7.11	11,806
1995	6.42	12,686
1996	6.10	13,260
1997	6.68	13,592
1998	4.57	12,360
1999	5.42	13,235
2000	5.98	14,216

Note. From Monthly Bulletin of Labor Statistics, Council of Labor Affairs.

IT Infrastructure

Taiwan has been a major producer of computer hardware, but not a major consumer of computer-related services; nevertheless, the structural change in the 1990s has pushed Taiwan's economy toward greater consumption of such services. Taiwan produced US$22,157 million worth of IT hardware in 2000, ranking it fourth in the world in terms of IT output, just behind the United States, Japan, and Singapore. In contrast, the number of PCs owned in Taiwan is relatively small, estimated at 224 per thousand people. The number is dwarfed in comparison by the 585 per thousand in the United States or 483 per thousand in Singapore. Likewise, IT spending also accounts for only a small fraction in Taiwan's GDP. In 2000, only 1.47% of GDP was spent on IT hardware, software, and related services, much smaller than the proportions in the major IT-producing countries of the United States, Singapore, and Japan.

Low levels of PC ownership and IT spending indicate that Taiwanese society was not ready to take advantage of the new information technologies despite its ability to produce IT hardware for export. The island's hardware production ability has, however, been undermined by rising wages, and in the second half of the 1990s, hardware producers started shifting their production to China while attempting to continue to serve as subcontractors for international brands. These producers found that investment in information technologies in order to reorganize global production was a good way of preserving their position in the international production network. Thus, it is the linkage to international buyers that drives the diffusion of information technologies in Taiwan. The reasons are as follows.

First of all, as a subcontractor, there is a need to coordinate with international buyers in terms of production and shipping. The revolution in IT hardware production in the mid-1990s has forced Taiwanese manufacturers to restructure their production methods to meet the market trends. Key brand marketers, such as Dell and Compaq, have adopted the build-to-order (BTO) method to replace the traditional way of building to stock. This system entails subcontractors being required to produce products according to orders that are collected instantly on the Internet and then ship the products promptly to the designated places. The BTO method reduces the use of warehouses in the supply chain and puts components, parts, and subassemblies in a state of continuous flux. Subcontractors have to reorganize internal production in such a way that they can effectively coordinate their work with the actors in the other segments of the supply chain. For example, Compaq

TABLE 2
Distribution of GDP by industry, percent (%)

				Services		
	Agriculture	Manufacture	Construction and utilities	Retail	Finance	Others
1990	4.18	33.31	7.53	14.21	16.71	24.06
1991	3.79	33.34	7.36	14.61	16.25	24.65
1992	3.60	31.70	7.69	14.98	16.96	25.07
1993	3.64	30.56	8.02	15.30	17.56	24.92
1994	3.51	28.99	8.21	15.61	18.96	24.72
1995	3.48	27.92	7.98	16.35	19.26	25.01
1996	3.19	27.92	7.39	16.80	19.50	25.20
1997	2.55	27.80	7.05	17.23	20.56	24.81
1998	2.47	27.39	6.65	17.77	20.36	25.36
1999	2.56	26.59	6.10	18.49	20.35	25.91
2000	2.06	26.33	5.62	19.16	20.50	26.33

Note. From Monthly Statistics of the Republic of China, Taiwan.

requires that within 3 days of the placement of an order, its main subcontractors put together 96% of the components and parts in preparation for production and may often call for the shipment to be made within a week. The so-called "963" operating target can only be achieved with the help of a digital information network that coordinates work between Compaq, the subcontractor and a large number of upstream suppliers.

Second, growth in foreign direct investment (FDI) since the mid-1980s has further encouraged the use of computer-based communications for interunit coordination within companies. Intranets were adopted by many subcontractors as a means of coordinating work among their operational units in Southeast Asia, China, and Taiwan. China has become a very popular investment area since the Taiwanese government decided to allow Taiwanese enterprises to invest there in 1991 (Kraemer & Dedrick, 2002). The investment boom in China has resulted in a major shift of production lines from Taiwan to China, undermining the close ties between Taiwanese manufacturers and their international buyers. Taiwanese manufacturers have continued to negotiate and process orders in Taiwan, but the orders are increasingly being serviced by production lines located in China. In 1999, for example, 33.2% of the export orders for information products were serviced by factories in China, 9.3% were undertaken in Southeast Asia, 4.8% in other areas (such as Mexico), and only 52.7% were actually manufactured in Taiwan (Chen, 2001a). Massive relocation of production to China threatens to turn Taiwanese manufacturers into middlemen whose role will eventually diminish, hence rendering them expendable (Gerefi, 1995).

The government in Taiwan is also seriously concerned that the imminent "hollowing out" of the domestic manufacturing sector will loosen its ties to international buyers and hence jeopardize Taiwan's ability to win major export orders. Several measures have been conceived by the government as a means of reinforcing the foundation of Taiwan's export-order winning capabilities, one of which was to strengthen the "business-to-business" (B2B) networks linking Taiwanese companies to the major multinational buyers. This is the background of the iAeB program.

Industry Structure

One distinctive characteristic of Taiwan's industrial structure is the dominance of small and medium enterprises (SME). Enterprises with 100 employees or more account for less than 1% of the total number of business firms in Taiwan. The dominance of SMEs presents a major obstacle to the adoption of e-commerce in Taiwan's industry. SMEs lack the financial resources to invest in computer hardware and software to enable their computer-based transactions, and even if computer-based trading systems are installed free of charge, they still lack the human resources with the capability of maintaining them. Furthermore, in most cases, rather than the use of a standard package, e-commerce enabling software needs to be adapted to particular environments in which SMEs are trading, thus making them unaffordable to SMEs.

In order to overcome these obstacles, rather than searching for individual solutions, the Taiwanese government has advocated a group approach to the adoption of digital information infrastructures. The government encourages SMEs to adopt the new technology in consortium with large firms, which will often act as their buyers, and has initiated programs to subsidize such a group approach to the e-commerce solution. The government also offers

TABLE 3
Output value of manufacturing sectors, 2000

Sector	Output value (NT$ million)	Share (%)
Food	448,326	5.3
Textiles and apparel	434,248	5.1
Chemicals	913,878	10.8
Petroleum and coal	396,404	4.7
Rubber and plastics	366,846	4.3
Basic metal	795,631	9.4
Metal products	410,113	5.0
Machinery	406,149	4.8
Electrical and electronics	3,119,021	36.7
Transport equipment	481,140	5.7
Others	717,449	8.5
Total	8,489,205	100.0

Note. From Industrial Development Bureau, Ministry of Economic Affairs (2001).

various training programs through government-sponsored technology institutes to help SMEs to gain an understanding of digital information technologies.

Taiwan's manufacturing sector is more receptive to e-commerce than the service sector because of its close linkage to the American firms that are leading the drive toward total electronics-based trading. The manufacturing sector has evolved from a well-diversified structure to a very concentrated one; the output of the manufacturing sector in 2000 is listed at Table 3.

It can be seen from the table that due to the rapid expansion in the 1990s, the electrical and electronics sector now accounts for 36.7% of total manufacturing output; in contrast, traditional industries have shown a rapid decline in their output shares. For example, the textiles and apparel sector accounts for 5.1% of manufacturing output, rubber and plastic products account for 4.3%, and metal products account for 5.0%.

Within the electrical and electronics sector, IT-related production plays a central role; in fact, computers and computer peripherals alone had an output value of NT$959,971 million in 2000, accounting for 11.3% of total manufacturing output, exceeding all of the other manufacturing sectors listed in Table 3. The output value of semiconductors was NT$807,511 million, accounting for an additional 9.5%, and for telecommunications equipment it was NT$154,373 million, accounting for a further 1.8%. These three IT subsectors together accounted for 22.6% of total manufacturing output in 2000.

The growing importance of the IT industry creates an environment conducive to the diffusion of e-commerce. Although Taiwan has not been a major user of IT products, despite its major role in producing them, the situation has recently started to change. The IT industry itself has been active in IT investment to update itself in the new ways of international trading. Most IT firms are contract manufacturers for multinational firms, wherein the ability to receive, process, and respond to new information is essential to their competitiveness. They also have to integrate themselves into the global production and market-servicing networks of international buyers and digitization is indispensable in that endeavor.

The pressure to adapt to the digital information network was felt by independent producers as well as subcontractors. Acer, one of the few Taiwanese firms marketing its own brand, for example, suffered a major defeat in the desktop PC market in the late 1990s because of a belated transition to the new information technology. This defeat occurred despite its flexible production network, which is based on informal and social peer group linkages, and which had worked so well in the past (Ernst, 2000b). Taking advantage of new information technologies, Acer's rivals such as Compaq were able to achieve the same level of flexibility and product breadth as Acer did, with a higher speed. The defeat forced Acer to reformulate its organizational structure to accommodate the IT-based initiatives.

The History of E-Commerce in Taiwan

For our purpose, e-commerce refers to the use of digital information systems in managing production. By this definition, the concept of e-commerce was first embraced in Taiwan in the 1980s by the automotive industry, an industry operating within several production networks known as core-satellite systems. Within each system, an assembler performs as a core firm in consortium with several key components and parts suppliers, which, in turn, work in connection with their own suppliers. Several of these core-satellite systems started to wire themselves together with computer terminals, linking with each other through public telephone lines. The main function of the system is to transmit information on work orders, shipments, invoices, etc. for the purpose of cross-checking, with the flow of information being primarily unidirectional from the core firm to the satellite suppliers.

When the technology for electronic data interchange (EDI) was developed and standardized, the Taiwanese government wasted no time in promoting it, encouraging the automotive industry in Taiwan to experiment with this new technology. In 1993, the government began providing subsidies to the three local automotive assemblers in order to establish EDI systems within their core-satellite networks. A total of 143 automotive-related firms participated in the project, which adopted international standards with some modifications to address local peculiarities. The main aim of the pilot project was to develop a model framework for the local industry. The government later applied the

pilot version of the EDI framework to other manufacturing industries whereby several variations of models were created to suit specific industry characteristics. By 1998, the government estimated that a total of 452 manufacturing firms had adopted EDI (Hsu, 1999). At the same time, local computer software firms were encouraged to develop EDI-based management information systems (MIS) and application software, to provide added value to the new technology. The government also took similar initiatives to introduce EDI into official customs-clearing procedures, interbank transactions, grocery chains, and the construction industry, with varying degrees of success.

When it became obvious that the Internet would be the new-generation technology for e-commerce, the government decided to promote its use by launching a program entitled the "Industrial Automation and Electronic Business" (iAeB) program. Again, the manufacturing sector was chosen to experiment with the new technology, but this time, it was the personal computer industry that was chosen to run the pilot project. Unlike the EDI project, which was essentially built as a "domestic" network, the iAeB was intended to be international, and in fact, three multinational firms, IBM, Compaq, and Hewlett Packard (HP), were selected to be the leading firms to establish the Internet-based procurement networks.

iAeB Program

The Taiwanese government launched the Industrial Automation and Electronic Business (iAeB) program in 1999, whereby tax incentives would be provided for private enterprises investing in computerization and related technology development, in conjunction with personnel training to accommodate such computerization. Just as in the case of R&D expenditure, under the auspices of the Statute for Industrial Upgrading, a certain proportion of this expenditure can be taken as a tax credit. By December 2000, tax credits had been granted in 36,293 cases of e-commerce-related investment.

In addition to tax incentives, the Industrial Development Bureau (IDB) of the Ministry of Economic Affairs also took initiatives to construct "model" electronics-based exchange systems in the PC industry, where supply-chain management is emphasized. The aim was to link PC system producers to their suppliers for the coordination of ordering, production, warehousing, transportation, delivery, and sales. The model program is divided into A and B projects. The A project takes an international system producer as the core firm around which the exchanges are to be clustered, while the B project takes an indigenous producer as the core firm. The model systems are subsidized by the government, at up to 50% of the costs, but technologies accumulated in the process of developing such systems are to be made available for other firms to emulate them. While the government will subsidize the hardware and software needed for B2B systems that connect firms together, intranets within a firm do not qualify for such a subsidy. After reviewing the tenders submitted by the industry, the IDB chose IBM, Compaq, and Hewlett Packard to run the A project, and 15 indigenous PC makers, including Acer, Mitac, and Asustek, to run the B project.

According to the project proposals, 20 Taiwanese subcontractors were to be connected to IBM's e-procurement system, 10 were to be connected to Compaq, and 12 to HP. The main purpose behind the design of the A project was to improve the speed of data exchanges in order to coordinate purchasing orders. These subcontractors, most of which are also participating in the B project, were subsequently connected to their components and parts suppliers. In total, 1800 components and parts suppliers are expected to be incorporated into the B project, the main aim of which is supply-chain management (Wu, 2001).

THEORETICAL ARGUMENTS FOR SUPPLY CHAIN STABILITY

According to the management literature, there are two fundamental sets of factors that determine the extent of international sourcing: location-specific factors and relational factors (Bartlett & Ghoshal, 1989; Kotabe, 1992). Location-specific factors refer to labor, human, and technological resources that enable competitive production across borders, as well as political and economic conditions that ensure a stable flow of goods from an offshore location to the market. Relational factors refer to working relationships, trust, and linkages that ensure offshore activities can be effectively coordinated with other activities in the value chain to provide a competitive product. A country can invest in location-specific factors, such as human resources development or technology upgrading, to make itself more attractive in international sourcing activities; it can also invest in relational factors to strengthen its ties to multinational firms that dominate the international commodity chains. Taiwan's iAeB program is aimed at the latter.

Meanwhile, the risk of international sourcing arises from two sources: one from the demand side and the other from the supply side. The literature has shown that demand-side disruptions often create more damage than supply-side disruptions, as the damage takes the form of unexpected costs in expedited shipping, high level of inventories, and low demand fulfillment (Levy, 1995). Supply-side disruptions are also potentially damaging, but they are manageable by conventional means such as diversification of supply sources. Moreover, production-related disruptions tend to decline over time because of learning effects, whereas demand-side disruptions, which are a part

of market nature, do not. This implies that a competitive production network must find a way to minimize the demand-side risks.

The new digital technologies make the demand-side disruptions more manageable because information on demand fluctuation can be collected and shared between the parties involved in the supply chain within a shorter time span. Traditionally, a producer has to forecast the demand for its product and produce or source accordingly. When demand disruptions arise, the producer adjusts production or sourcing orders, but the reaction is often piecemeal and ad hoc (Borthayre, 1998). Given the new digital technologies, a producer can now produce according to actual demand rather than to forecast, or at least it can systematically modify the forecast by taking the most recent data on actual demand into account. This leads to so-called "built-to-order" (BTO) production. The essence of BTO is that a producer continuously updates its projection about market demand by taking new information into account and adjusting the volume, composition, and timing of production accordingly. In its perfect form, the BTO method completely eliminates inventories and stocks of finished goods, while instantaneously adjusting the flow of the value chain. The key to the success of this method lies in the ability of the production flow to be calibrated precisely and modified instantaneously, with the burden often lying with upstream suppliers.

Minding the new trend of production, many of Taiwan's PC manufacturers have introduced enterprise resource planning (ERP) schemes to enhance their capabilities in supply chain management, with the aim of improving production efficiency, controlling the flow of materials and components, cutting down inventory levels, and avoiding the risk of price fluctuations in major components and parts. The ultimate purpose is to accommodate the need of final producers who stand on the front line of the market and often dictate the chain of production. For example, Compal, a Taiwanese subcontractor working for Dell, switched its production method to BTO in 1995 at the request of Dell (who pioneered direct marketing of PCs). Within the BTO scheme, Compal distributes parts from the main system and ships them separately to the designated assembly factories where Dell then assembles them into final products according to specific customer orders. This method increases the variety of products by adjusting the parts attached to the main system and reduces the risk of price fluctuations that are often associated with key components such as central processing units (CPUs) and random access memory (RAM) cards, which can be inserted at the final stage of assembly instead of being shipped from Taiwan as a part of the system.

In order to accommodate the new production method, Compal established a virtual hub at its company headquarters to coordinate the shipping and delivery of its upstream suppliers. Compal's ERP system provides data on its demand for parts and components for the next 3 months, according to hourly updated information from Dell, and the suppliers are responsible for stocking 7-day inventories at their own factory sites in line with this demand projection. Delivery is to be made once or twice a day to Compal's production line in Pin-Cheng, about 50 miles south of Taipei, with the quantity and specification instructed by the computer. Transfer of ownership is made upon delivery; before that point, the suppliers bear the entire costs of inventory, storage space, and the risk of price changes. The effect of the BTO method is astonishing. Under the traditional production method, it took 45 days to ship a computer after receiving the order; the new method has shortened this time to several days. The average inventory turnover for Compal was 54.6 days in 1995; this was reduced to 30.9 days in 1999 (Chen, 2001b).

The end result of the new production method has in fact been to reduce inventory levels and to pass the burden of holding inventory onto upstream suppliers. The entire supply chain becomes more efficient when the inventory burden is shifted backward because the value of finished goods is higher than that of semifinished goods, whose value is in turn higher than that of raw materials. Holding final goods in inventory is so expensive that many PC manufacturers prefer their products to be shipped by air cargo rather than sea lines. Levy (1995), for example, documented that air freight of personal computers from Singapore to the United States costs 10% of the product value compared to the sea freight cost of just 1%, but the cost of holding inventories in transit during the sea transportation phase completely outweighs the advantages of transportation costs.

Under the BTO production scheme, a long supply chain holds the edge over a short supply chain; the long chain is advantageous not only because it can shift the burden further backwards to upstream suppliers, thus reducing the value of inventories, but also because it can spread the risks among suppliers at different stages. Moreover, a longer supply chain provides more room for adjustment in terms of the flow of production should demand disruptions suddenly arise. Taiwan's production network, comprised of many specialized small producers, is a typical example of a long supply chain in which small fixed capital allows for great flexibility in output adjustments. However, there is also an inherent weakness in a long supply chain, namely, the difficulty of coordinating production activities in a short time span. The purpose of Taiwan's iAeB program is to ensure that small upstream firms in the supply chain are integrated into the new production system despite their inability or unwillingness to adopt electronics-based logistics.

The new production method, driven by information technologies, also provides a chance for Taiwanese

subcontractors to increase their power in the global production networks. As Ernst (2000a) argues, the power of international brand marketers, which he refers to as the "flagship" in the global production network, lies in their control over the knowledge that is essential to innovation, and their capability to coordinate and manage the global supply chain. As the supply chain is lengthened and extended across many national borders, it becomes increasingly difficult for the flagship to coordinate all of the work in the value chain. The difficulty is exacerbated by the increasing pressure of speed-to-market as a result of shortening product life cycles, where "market" refers to all major markets across the globe rather than a single national market. Under these circumstances, subcontractors who are capable of providing integrated services to the flagship will become valuable partners of the latter and power in the global production network will therefore be enhanced. Information technologies enable an integration of a subset of the global production network in which Taiwanese subcontractors play a dominant role. This subset is characterized by multiple, flexible, and short-term links, which can be connected and disconnected with ease to accommodate demand fluctuations with a minimum cost resulting from idled or strained capacity and manpower.

It is in fact the existence of these small upstream suppliers that provides the foundation of competitiveness for Taiwanese PC subcontractors serving brand marketers such as IBM, Compaq, and the like. Therefore the success of the B project is the key to sealing the bond between Taiwanese subcontractors and their brand marketers. Procurements by leading American PC firms sourcing in Taiwan, namely, Compaq, IBM, HP, Dell, and Apple, totaled NT$25 billion in 2000, a 48.8% increase from the $16.8 billion worth of procurements in 1999 (IDB, 2001). The A and B projects were aimed at preserving the subcontracting relationship after some segments of production are relocated to China. In order to do so, the supply-chain management (SCM) of Taiwanese subcontractors will have to encompass the production lines and parts suppliers in China. In fact, in implementing the A project, Compaq has encouraged its subcontractors to include Kunshan, a major cluster of Taiwanese PC assembly lines in China, in their SCM networks.

ASSESSMENT OF THE iAeB PROGRAM

The A project was completed by the end of 2001, while the B project will take a few more years. Although it is obviously too early to assess the effects of the iAeB program, some preliminary results are observable. First of all, by taking a group approach to the establishment of the supply-chain management system, the system so established encompasses some local advantages that serve to protect local vendors from foreign competition. It is possible that international brand marketers such as IBM, HP, and Compaq would have worked out their own B2B system even without any initiative from the Taiwan government; it is also quite likely that some Taiwanese vendors would have been included in that system. The difference that this initiative makes is that it persuades international brand marketers such as IBM to establish a Taiwan-specific B2B system with Taiwanese vendors. Although the portal adopted for the Taiwan system may not differ from other portals, for example, IBM's "e-Procurement" portal, which is used globally, it is adapted to local peculiarities in term of accounting practices, invoicing, quality control, and the financing of goods in process. The adaptations make sure that the subsystems to be established for the purpose of local accounting or the banking industry are compatible with the main system. Once these subsystems are established and annexed, the value of the B2B network established by companies like IBM becomes more valuable because of the auxiliary support. Considering this sunk investment, IBM is therefore unlikely to readily abandon this system. If some member has to be removed because of unsatisfactory performance, there is a high likelihood of it being replaced by another vendor from Taiwan.

Further value is added to the system by the long-established working relationships between the procurement engineers of IBM, HP, Compaq, and their vendors in Taiwan. For example, the vendors can provide their product roadmaps to the buyers and the buyers can factor this information into their product design. Local procurement managers possessing information on both sides can provide good advice to Taiwanese vendors by interpreting the raw information provided by the buyers to enable a better match up of the product orientation. If some of the vendor's products in the market go wrong, the procurement engineers can often detect the likely source of the problem and offer prescriptions to eradicate the problems based on the accumulated knowledge of their vendors. Because the procurement office in Taipei was the architect of the digital procurement system, the possible roles and contributions of the office itself was taken into account and embedded in the system.

The A project was initially designed for procurement purposes only, but other functions may be added as participants consider them desirable. For example, design collaboration was added to one of the A projects because the buyer believed that collaboration at the design stage can improve the compatibility of the product orientation between the buyer and the vendors. When a new PC is to be designed by the buyer, one of the vendors may be asked to design a motherboard or a power supply system for the new product. This cooperative design process, which is to be carried out at the supplier's own expense, will trickle down to production orders and can be easily modified in

the process of production should the market reaction differ from initial expectations. The design collaboration is undertaken on an exclusive one-to-one basis, but the partners involved can be switched from one product area to another. This constitutes a natural entry barrier for new members.

Compared with the A project, the B project is more difficult to accomplish because it involves a large number of small firms. While the A project was successfully concluded at the end of 2001, the B project is still struggling along with only lukewarm acceptance from the small suppliers. The key problems are a lack of technological capability to handle the digital transaction system and a lack of awareness of the urgent need for restructuring (Clendenin, 2001). However, for small firms that have already signed up, the benefits of digital-based logistics are apparent. Although lead times allowed for delivery may be shortened by the new system, orders become more stable; more importantly, linking up with large subcontractors, such as Compal and Mitac, gives them the leverage they need in terms of material procurement and financing. A more stable supply relationship with these major subcontractors gives small suppliers greater purchasing power against material producers, which are often larger than themselves. If these material suppliers are also signed up to the system, the bargaining power of the small components and parts suppliers is smoothed out because of their common linkages to main subcontractors.

The banking sector is now displaying strong incentives to rely upon the supply chain management systems derived from the B project. With the visibility of the production flow from materials to final products, banks can finance production with a mortgage on the goods in process, which was previously difficult to monitor. In a sense, financial services, which facilitate production rather than directly participating in production, can also be integrated into the digital information system to make the whole supply chain more efficient. Likewise, transportation service providers directly participating in production can also be integrated into the system to enhance productivity. A manager at Compaq, for example, explained that local trucks delivering products to Compaq's warehouse in Taipei often left the warehouse with no load. A better-informed system may take advantage of this unutilized capacity (interview, April 30, 2001).

An electronics-based logistical network may also impact the business organization of Taiwan's PC industry. Small components and parts producers in Taiwan's supply chain receive little financial and technological transfers from major subcontractors (Ernst, 2000a). Arm's-length transactions prevail and cooperative links established for a particular job are often short-lived. The establishment of an Information Web that provides instantaneous production data to coordinate works along the supply chain may even require a knowledge transfer from the components and parts producer to the subcontractor. This is because a subcontractor gains power in the global network by providing integrated services, the capability of which often comes from a large size. The data shows that a four-firm concentration ratio of Taiwan's PC and PC peripherals has increased almost across the board in the 1990s (Chen et al., 2001). Small components and parts suppliers have to build their competitive edge on technological capabilities just to remain in business, and knowledge transfer to the subcontractor may be necessary to collectively build a competitive product. As the suppliers are also likely to bear the burden of holding inventories to accommodate the just-in-time production system, a strong commitment from the subcontractor becomes necessary. The short-lived links between the subcontractor and the suppliers will likely be replaced by a longer term relationship. Technological requirements and the willingness to invest in information technologies, such as the B project, will also weed out less competent and less willing suppliers from the network.

In the end, electronic commerce may be unable to prevent Taiwanese producers from relocating to China as the division of labor tends to be governed by locational factors that cannot be altered by e-logistics; nevertheless, a digital information system may help Taiwanese producers to minimize the financial risks while maximizing the benefits from global production. It turns out that although China is a labor haven, it is not a perfect site for offshore sourcing because of real-time logistical difficulties. Studies on offshore sourcing have shown that some of the most important components of a country's logistical friendliness are compatible customs and documentation requirements (Murphy & Daley, 1994). By this standard, China is by no means a logistically friendly country. For example, security check procedures in China require that a commodity bound for export sit in the airport for at least 24 hours before it clears customs. Inefficient and unreliable freight carriers, both on land and air, often cause logistical snags. The absence of direct cargo flights between China and Taiwan also hampers any shipments between the two sides of the Taiwan Strait.

Restrictive licensing practices in the Chinese markets further impede the flow of goods from one province to the other, disjointing the supply chain. Take Compaq's A project as an example. Despite the whole-hearted support from the city government of Kunshan in establishing an information highway between Taiwan and Kunshan, the lack of real-time logistical support limits the Chinese operations to the production of stand-alone subsystems that can be shipped directly to the final market, such as the United States. This limitation, on the one hand, prevents wholesale relocation of the entire production network to China, while on the other hand it encourages Chinese operations to develop self-sufficiency, which will enable them eventually to compete directly with Taiwan's headquarters.

CONCLUSION

The early development experiences of Taiwan's e-commerce indicate that the pace of the adoption of digital information system depends on IT infrastructure, finance, industry structure, and network relations. Network relations are particularly important in Taiwan where large firms are typically forced to adopt the new form of trading because they are contract manufacturers for multinational firms that are under pressure to deliver products more timely and more flexibly, while small firms are forced to adopt it because of the pressure from large subcontractors. The obvious benefit of this new trading practice is a reduction in inventory levels and time to market. Since the flow of information has become faster and more widespread through the diffusion of the Internet, the ability to react to new information quickly and effectively has become the key to competition. A monopoly on information becomes more difficult in the new age; therefore, competitive edge comes from the ability to digest information and to take advantage of the opportunities that information reveals.

The exchange of information is essential to the coordination of activities among members in B2B trade, but much of this information is proprietary knowledge, which its owner will be unwilling to share with anyone other than its long-term strategic partners. This implies that the members involved in recurring B2B trading tend to be engaged in long-term relationships, further implying that the buyer–supplier relationship in B2B trade is more stable than in traditional commerce. Since the flow of information is more rapid and the ability to process information is enhanced with new information technologies, producers can now respond more readily to consumer-related information. Therefore, the traditional way of planned production is replaced by BTO, which reduces the impacts of demand side disruptions.

The experience of Taiwan's promotion of B2B trading between major subcontractors and international buyers indicates that the establishment of a Web-based trading system can strengthen the buyer relationship if local advantages are built into the system. These advantages include linkages to local service industries that support and facilitate trade, engineering, and managerial capabilities that add value to the flow of information and, most of all, an efficient supply chain that underscores the strength of the subcontractors. A refined and stretched-out supply chain seems to be most competitive in a demand-driven production system because it can reduce inventory costs to the lowest possible levels and because it can best absorb demand shocks. A stretched-out supply chain also runs the highest risk of supply-side disruptions, however. Failure to communicate information properly, failure to coordinate activities precisely, or failure to absorb the shocks adequately at any segment of the value chain can result in serious supply disruptions. The system becomes even more vulnerable when suppliers themselves have to manage production across borders, in addition to servicing offshore buyers. This is the daunting task faced by Taiwanese producers in the PC industry.

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