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Summary

Taiwan is a leading producer of computer hardware, but lags behind advanced countries in the application of information technologies. The strength of Taiwan's industry lies in its low-cost manufacturing capabilities, which have been undermined by rising wages in recent years. Facing with a massive relocation of production activities to China, the Taiwan government is trying to prevent the domestic industry from hollowing-out by encouraging local firms to embrace new information technologies to strengthen their ties to multinational firms. The initiative is aiming at enhancing the flexibility of production and speeding-up responses to the market through concerted actions by brand-marketers, assemblers, and parts suppliers. New technologies underscore a new work method that erects entry barriers to protect the existing network members.

Introduction

Taiwan ranks in fourth place in the world in terms of the production of IT hardware, but lags behind most advanced countries in terms of the application of IT. Both personal computer ownership and the spending on IT products (including software) remain at low levels. The 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 build-up of physical capital and on the mobilization of labor force. Starting in the 1990s, Taiwan's industry entered an unprecedented stage of restructuring in which manufacturing activities are relocated to China en masse. Working mainly as subcontractors for international brands, Taiwanese firms are faced with an immense challenge of preserving their position in the international production network while relocating their major manufacturing activities to China.

Taiwanese firms found that the solution lies in the application of IT with the aid of IT hardware that they are so good at producing. By establishing an information network connecting themselves to the international buyers on the one end, and their upstream suppliers of components and parts on the other, they are able to create a competitive edge in offering products in a timely and flexible fashion. The competitive edge is underscored by a group of components and parts suppliers who are willing to work in a concerted way and to share the risks of demand and price uncertainties in the industry. Each network of suppliers is unique on its own in terms of membership, work routines, and the way production is organized, and hence constitutes an entry barrier that protects the position of the Taiwanese producer in the international subcontracting market. Information technology strengthens the network ties by providing instant data and allowing members to promptly react to the data. The chain of production becomes a continuous flow whereby each participant in the activity has to precisely estimate its volume of work and the timing of the work. There is little room for errors because buffer stocks become a luxury, which may cost the viability of the producer in the new system. Information sharing is essential to the working of the network. Non-members have to invest in trust building first to gain access to the network, and then to invest in hardware facilities to become a part of the information web, and then to invest in software and internal work routines to fully adjust to the system. New technologies thus give extra protection to the existing subcontracting relationship between Taiwanese subcontractors and their international buyers, allowing the former to relocate production to China without undermining their ability to win export orders.

History of E-Commerce

The concept of electronic commerce (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 was to transmit information on work orders, shipments, invoices, etc., for the purpose of crosschecking, and the flow of information was 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 in Taiwan and encouraged the automotive industry 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 (including some modifications to address the local peculiarities), with the main aim of the pilot project being to develop a model framework for the local industry. The government later applied the pilot version of the EDI framework to other manufacturing industries with several variations of models to suit the industry characteristics. By 1998, the government estimated that a total of 452 manufacturing firms had adopted EDI (IDB (1999)). At the same time, local computer software firms were encouraged to develop EDI management information systems (MIS) and application software, to provide added value to the new technology. The government also took initiatives to introduce EDI into official customs-clearing procedures, inter-bank 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, the government decided to promote its use by launching a program entitled 'Industrial Automation and Electronic Business Program' (iAeB). 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. The Internet also differs from EDI in that it has an immense role to play amongst local consumers and the general population, although they may have no interest in Internet-based transactions, *per se*.

In June 1996, there were 440,000 Internet subscribers in Taiwan; by December 2000, that number had risen to 6.26 million, a 14-fold increase in four years. Internet subscribers now represent 28 percent of the entire population, making Taiwan one of the most Internet-penetrated countries in Asia, second only to Singapore (DGT, 2001).

Although Taiwanese firms were slow to adopt EDI, they seemed to react to Internet-based transactions quite enthusiastically. A survey conducted by the government indicated that as many as 46 percent of trade-related businesses had adopted some form of business-to-business (B-to-B) e-commerce, and about 80 percent of their current transactions were Internet-based, whilst the

rest were either EDI-based or a mixture of the two (MOEA (2000), pp.32-33). The same survey conducted amongst manufacturing firms put the B-to-B participation rate at 57 percent, with around 60 percent of them being purely Internet-based, whilst the rest were continuing to use some form of EDI.

Compared to B-to-B, business-to-consumer (B-to-C) e-commerce was rather slow to develop. Although the Internet penetration rate was substantial, only an estimated 36 percent of Internet users had any experience of shopping on the net. The average consumption of each Internet shopper was a meager US\$19.10 in 2000, well below the US shoppers' average spending of US\$272.60 (MOEA (2000), p.42). It seems that Taiwanese consumers have become spoiled with a dense network of actual shops in their neighborhood and the Internet-enabled distance-shopping seems to present little attraction to them; however, tourist-bound services seem to enjoy some popularity amongst Internet users. With the wide diffusion of cellular phones and personal digital devices, wireless-based Internet shopping has also recently gained something of a foothold.

National Environment

Population and Demographics

The population of Taiwan was estimated at 22.3 million at the end of 2000, and as a result of the declining fertility rate and increasing life expectancy, the population has been aging rapidly in recent years. In December 2000, people aged 65 and over accounted for 8.6 percent of the entire population (See Table 1).

The senior cohort, together with those aged between 50 and 64, tend to be the most resistant to adapting to Internet life since they were brought up in the pre-computer era. This Internet-resistant group currently accounts for 18.6 percent of the population. Conversely, the younger population aged between 15 and 29, accounting for 25.4 percent of the population; tend to be the most Internet-receptive. Between these two groups, those aged 30 to 49 have had a varying degree of exposure to computers and can be retooled to accommodate Internet life.

TABLE 1
Age Distribution of Taiwan's Population, 2000 (December)

Age	Percentage (%)
0 - 14	21.1
15 - 19	8.4
20 - 29	17.0
30 - 39	17.2
40 - 49	15.6
50 - 64	12.0
65 and over	8.6

Source: DGBAS, 2000b, *Monthly Bulletin of Statistics of the Republic of China, Taiwan.*

In 1968, the government in Taiwan extended the mandatory period of education from six to nine years (from primary school to junior high school) and since then, it has introduced a requirement for a three-year period of English education in the junior high school curriculum, thus exposing the majority of the population to the English language. Although Chinese language-based computers have been available since the late 1970s, knowledge of English is essential in the ability to use computers.

Along with the country's rapid economic growth, educational attainment levels have also been improved. By December 2000, the literacy rate amongst the population aged 15 years and above was 95.6 percent (See Table 2). Amongst this group, 30.9 percent had received secondary education and 20.6 percent had received post-secondary education (education beyond junior college). Altogether, 51.5 percent of the country's potential labor force has received secondary education or higher.

Taiwan's educational system produces a large number of junior-college graduates who are mainly trained as technical personnel in trade, engineering or office management. Starting from the late 1990s, the junior colleges were gradually upgraded to regular colleges, which are now expected to produce even more college graduates for the future. This upgrading in educational attainment is also conducive to the diffusion of Internet use.

TABLE 2

Educational Attainment of Taiwan's Population, Age 15 and Over, 2000 (December)

	Population (thousand)	Percentage (%)
Total	17,574	100.0
Literate	16,792	95.6
Graduate School	219	1.2
College	1,517	8.6
Junior College	1,935	11.0
Senior High	5,426	30.9
Junior High	3,820	21.7
Primary School	3,875	22.0
Illiterate	781	4.3

Source: Ministry of Interior, 2000 Taiwan-Fukien Demographic Fact Book, Republic of China.

Taiwan is a small island with a high population density and most of the island's population lives in either cities or towns. In 2000, a total of 16.3 million people were living in cities and towns, representing 73.4 percent of the population, whilst only 5.8 million, or 26.6 percent were living in villages (Ministry of Interior 2000). The most popular city and township habitat is condominium dwellings, which makes cable TV networks prevalent in Taiwan's urban households.

Economic Trends

In recent years, Taiwan's economic growth has slowed down from its previous rapid pace of the 1980s, but it has, nevertheless, remained robust. The average annual GDP growth rate for 1990-2000 was 6.42 percent, 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 3).

However, there was a dramatic reorganization of the structure of the economy in the 1990s; in particular, the mainstay of economic activities shifted from the manufacturing sector to the

services sector. Manufacturing accounted for 33.31 percent of GDP in 1990, but the share declined steadily in the 1990s, settling at 26.33 percent in 2000 (See Table 4). In its place, the GDP share accounted for by service output has increased to 49.86 percent from the 41.76 percent share in 1990. Amongst the various service sectors, retail trade and finance have contributed most to this growth.

TABLE 3
GDP Growth and Per Capita Income

	GDP growth rate (%)	Per capita income (US\$)
1990	5.39	8,111
1991	7.55	8,982
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

Source: Monthly Bulletin of Labor Statistics, Council of Labor Affairs.

TABLE 4
Distribution of GDP by Industry, Percent (%)

	Agriculture	Manufacture	Construction and Utilities	Services		
				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

Source: DGBAS,2000b, Monthly Bulletin of Statistics of the Republic of China, Taiwan.

With the growing importance of the service sector, demand for computer-related information services has also increased. Table 5 provides details of the consumption of information services by the major service sectors, where information service refers to computer software, Internet services, data exchange, e-commerce, and so on.

It can be seen that insurance, transport and finance are amongst the highest information-intensive sectors in Taiwan's service industry. Taiwan has become 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 towards greater consumption of such services.

TABLE 5
Information Content of Service Industries, Selected 3-Digit Industries

Industry	Consumed Information Service (NT\$ million)	Value-added (NT\$ million)	Information Content (%)
	(1)	(2)	(3) = (1) / (2)
Academic research	642	22,566	2.85
Insurance	3,591	170,756	2.10
Transport	1,979	118,591	1.67
Printing and publication	1,033	67,949	1.52
Finance	5,658	485,361	1.17
Hotel	441	42,027	1.05
Public service	7,866	852,936	0.92
Leasing	305	42,342	0.72
Food service	1,209	173,141	0.70
Real estate	1,411	217,122	0.65
Foreign trade	2,162	417,221	0.52
Retailing	3,550	709,163	0.50
Wholesale trade	2,052	434,634	0.47
Medical service	1,048	246,376	0.43
Entertainment	163	76,706	0.21
Legal and accounting	52	25,421	0.21
Advertisement	194	133,163	0.15
Storage	20	23,896	0.08

Source: Calculated from 1996 Input-Output Tables (Taiwan).

As shown in Table 6, Taiwan produced US \$20,903 million worth of IT hardware in 1999, ranking it in fourth place in the world in terms of IT output, just behind the US, Japan and Singapore. The production ability, however, was undermined by rising wages, and in the second half of the 1990s, hardware producers started shifting their production to China while continuing to serve as subcontractors for international brands. These producers found that investment in IT to reorganize production globally is a good way to preserve their position in the international production network. In essence, it is the linkage to international buyers that drives the diffusion of IT in Taiwan.

However, the number of PCs owned in Taiwan is relatively small, and estimated at 197.04 per thousand people. The number is dwarfed by 517.07 per thousand in the US or 436.61 per thousand in Singapore. Likewise, IT spending also accounts for only a small fraction in Taiwan's GDP. In 1999, only 1.34 percent of GDP were spent on IT hardware, software, and related services, much smaller than the proportions in major IT-producing countries of the US, Singapore, and Japan. Low levels of PC ownership and IT spending indicate that the Taiwan society was not ready to take advantage of new technologies despite its ability to produce IT hardware for export.

TABLE 6
IT Infrastructure and Production in Asia-Pacific Economies

	IT as % of GDP, 1999 ^a	PCs per 1,000 population 1999 ^b	IT Hardware Production, (US\$M) 1999 ^c
Australia	3.33	469.97	915.72
China	1.13	12.24	17,750.00
Hong Kong	1.32	297.59	1,703.45
India	0.53	3.31	730.27
Indonesia	0.35	9.08	980.00
Japan	2.06	286.94	53,727.73
Korea	1.61	181.80	6,982.50
Malaysia	1.70	68.71	8,864.80
New Zealand	3.81	328.02	123.66
Philippines	0.78	16.92	2,070.00
Singapore	3.22	436.61	24,568.86
Taiwan	1.34	197.04	20,903.10
Thailand	0.63	22.71	7,937.20
United States	4.14	517.07	85,085.21
Asia Pacific ^d	1.81	30.72	147,257.30
OECD ^e	3.09	285.55	221,159.20

Note: ^aSource: International Data Corporation. IT is defined as “the revenue paid to vendors (including channel mark-ups) for systems, software, and/or services.

^bSource: International Telecommunication Union, World Telecommunication Indicators. Geneva: International Telecommunication Union, March 2000.

^cSource: Reed Electronics Research, The Yearbook of World Electronics Data, 2000. Surrey, UK: Reed Electronics Research, 2000.

^dAsia-Pacific consists of the following countries: Australia, China, Hong Kong, India, Indonesia, Japan, Korea, Malaysia, New Zealand, Philippines, Singapore, Taiwan, Thailand.

^eOECD consists of the following countries: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States.

First, there is a need to coordinate with international buyers in terms of production and shipping. The revolution of IT hardware production in the mid-1990s has forced Taiwanese manufacturers to restructure its production method to meet the market needs. 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, whereby the subcontractors are required to make products according to orders that are collected instantly on the Internet and ship the products promptly to the designated places. The BTO method eliminates warehouses in the supply chain and puts components, parts and sub-assemblies in a continuous flux. Subcontractors have to reorganize internal production in such a way that they can effectively coordinate work with the actors in the other segments of the supply chain. For example, Compaq requires its main subcontractors to put together 96 percent of the components and parts in preparation for production within 3 days of the placement of an order, and the shipment is often to be made within a week. The so-called “963” operation target can only be achieved with the help of an information network that coordinates work between Compaq, the subcontractor, and a large number of upstream suppliers.

Second, advancement of foreign direct investment (FDI) since the mid-1980s has further encouraged the use of computer-based communications for inter-unit coordination within companies. Many major investors adopted intranets as a means of coordinating work amongst their operational units throughout 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, and the boom in China investment 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 percent of the export orders for information products were serviced by factories in China, 9.3 percent were undertaken in Southeast Asia, 4.8 percent in other areas (such as Mexico) and only 52.7 percent were actually manufactured in Taiwan (Chen 2001).

The government in Taiwan is 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. The government has conceived several measures as a means of reinforcing the foundation of Taiwan's export order-winning capabilities; one of which was to strengthen the B-to-B networks linking Taiwanese companies to the major multinational buyers. This explains why the government has chosen IBM, Compaq and HP as the showcase companies in establishing supply-chain management networks to tie them to their major suppliers in Taiwan.

In March 2000, Taiwan elected a new president from the opposition party and unseated the KMT government, which had ruled Taiwan for over 50 years. The transition of power has not been smooth, as the new ruling party does not have a majority in the parliament. Having been unable to implement the programs that the party has conceived in its efforts to reform the economy, and burdened by the simultaneous international recession, the performance of Taiwan's economy since the new government took office has been miserable. The manufacturing sector has gone into a tailspin with both high-tech and traditional industries being forced to lay off workers, but whilst the recession has hampered the willingness and ability of enterprises to invest in Internet-related facilities, consumer demand for Internet services seems to have been unaffected. In addition to the increase in household connections to the Internet, Internet shops (Internet cafés) have also mushroomed throughout the streets of Taiwan in 2001.

Industry Structure

One distinctive characteristic of Taiwan's industrial structure is the dominance of small and medium enterprises (SMEs). Table 7, which lists the size distribution of business firms from the 1996 census, shows that firms with 100 employees or more account for less than 1 percent of the total number of business enterprises in Taiwan. The average size of manufacturing firms is slightly larger, but manufacturing firms with 100 employees or more still account for only 2 percent of the entire sector, whilst the size of service firms is even smaller. 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 also 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.

To overcome these obstacles, rather than searching for individual solutions, the Taiwanese government has advocated a group approach to the adoption of e-commerce. 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 various training programs through government-sponsored technology institutes to help SMEs to gain an understanding of e-commerce related technologies.

Taiwan's manufacturing sector is expected to be more receptive to e-commerce than the service sector because of its close linkage to the American firms that are leading the drive towards total electronic-based trading. The manufacturing sector has evolved from a well-diversified structure to a very concentrated one; the output of manufacturing sectors in 2000 is listed at Table 8. It can be seen from Table 8 that due to the rapid expansion in the 1990s, the electrical and electronics sector now accounts for 36.7 percent of the total manufacturing output; in contrast, traditional industries have shown a rapid decline in their output shares. For example, the textile and apparel sectors account for 4.4 percent of manufacturing output, rubber and plastic products account for 4.3 percent and metal products account for a mere 0.5 percent. Within the electrical and electronics sector, ICT-related production plays a central role; in fact, computers and computer peripherals had an output value of NT \$959,971 million in 2000, accounting for 11.3 percent of total manufacturing output, exceeding all of the other manufacturing sectors listed in Table 8. The output value of semiconductors was NT \$807,511 million, accounting for 9.5 percent, and for telecommunications equipment it was NT \$154,373 million, accounting for a further 1.8 percent. These three ICT sub-sectors together accounted for 22.6 percent of total manufacturing output in 2000.

TABLE 7
Distribution of Business Firms by Size, 1996

Size by Employment	All Sectors		Manufacturing Sector		Service Sector	
	No.	%	No.	%	No.	%
Below 5	618,434	(71.4%)	71,105	(45.9%)	523,552	(79.0%)
5 - 9	138,272	(16.0%)	36,631	(23.7%)	88,037	(13.3%)
10 - 29	82,212	(9.5%)	32,890	(21.3%)	40,386	(6.1%)
30 - 49	13,608	(1.6%)	6,544	(4.2%)	5,561	(0.8%)
50 - 99	8,631	(1.0%)	4,593	(3.0%)	3,056	(0.5%)
100 - 499	4,590	(0.5%)	2,587	(1.7%)	1,509	(0.2%)
500 and more	821	(0.1%)	403	(0.3%)	361	(0.1%)
Total	866,573	(100.0%)	154,753	(100.0%)	662,462	(100.0%)

Note: The numbers of firms in the manufacturing and service sectors do not add up to the sum total because mining, utilities and construction sectors are left out.

Source: DGBAS, 2000a, Industrial and Commercial Census, 1996.

TABLE 8
Output Value of Manufacturing Sectors, 2000

Sector	Output value (NT\$ million)	Share (%)
Food	448,326	5.3
Tobacco and beverages	24,713	0.3
Textiles	348,222	4.1
Apparel	86,026	1.0
Leather products	41,937	0.5
Bamboo and wood	16,543	0.2
Furniture	52,318	0.6
Paper	153,845	1.8
Printing	65,540	0.8
Chemical products	717,619	8.5
Chemical materials	196,259	2.3
Petroleum and coal	396,404	4.7
Rubber	62,153	0.7
Plastics	304,693	3.6
Non-metal minerals	194,348	2.3
Basic metal	795,631	9.4
Metal products	410,113	0.5
Machinery	406,149	4.8
Electrical and Electronics	3,119,021	36.7
Transport equipment	481,140	5.7
Precision instruments	58,584	0.7
Miscellaneous	109,621	1.3
Total	8,489,205	100.0

Source: Industrial Development Bureau, Ministry of Economic Affairs, and *Monthly Statistics of Industrial Output*, May 2001.

The growing importance of the ICT industry creates an environment conducive to the diffusion of e-commerce. Although Taiwan has not been a major user of ICT products, despite its major role in producing them, the situation has recently started to change. The ICT industry itself has been active in ICT investment to update itself in the new ways of international trading. Most ICT 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 production and market-servicing networks of international buyers, and digitisation is indispensable in that endeavor.

Infrastructure

In December 2000, there were 12.6 million subscribers to fixed-line telephones in Taiwan, representing 56.8 percent of the population. In comparison, there were 17.9 million subscribers to cellular phones, which were not available until the late 1980s, and this subscription rate has in fact continued to rise in 2001 despite the ongoing recession. According to the statistics released by the Directorate General of Telecommunications, total subscriptions to cellular phones had reached 19.6 million by the end of April 2000, representing a phenomenal 88.3 percent of the entire population. The boom in cellular-phone use was precipitated by the liberalization of the telecommunications market, which began in 1996. Liberalization removed the monopoly power of the government-owned telephone operator and opened the market to private competition. This participation by private operators in the cellular phone industry has led to a rapid decline in service charges, along with enhancements to the service quality and choice, which in turn, has

induced the ballooning demand amongst the younger population, those who would not normally have a fixed-line telephone for personal use at home.

As a result of this demand for cellular phones, mobile phone services in Taiwan now account for the majority of the telecommunications industry. In 2000, the total revenue from Taiwan's telecommunications industry was just under NT \$300 billion (about \$9 billion), of which 51.9 percent was revenue from mobile phone services. In comparison, fixed-line services accounted for 43.9 percent of total revenue, whilst the rest was derived from data communications, radio paging services, and so on. (Data provided by the Directorate General of Telecommunication, <http://www.dgt.gov.tw>, 2001). More importantly, private cellular-phone operators had a 35.99 percent share of the overall industry sales, exceeding the share of the mobile phone services provided by the state-owned operator, now known as Chunghwa Telecom, although the latter still dominates fixed-line services. Private competition also drove down the ultra-high tariffs previously charged by the state-owned monopoly. In 1999, the average cellular phone service fee in Taiwan was estimated at US\$29 per month based on 90-minute peak-time service and 50-minute off-peak service (ITU 1999), which was very close to the worldwide average of US\$33.40.

In December 2000, about 40 percent of all households were connected to the Internet, a dramatic increase from only 7.9 percent in 1997. Like most other countries, Internet penetration in Taiwan started with the younger generation, and schools are generally the place where students first experience Internet connection. A 1999 survey by the Institute for Information Industry (III) indicated that around 70 percent of Taiwan's Internet users were below 30 years of age, and 69.3 percent of them were college students or college graduates. About a half of all Internet users live in metropolitan Taipei and the number of male users exceeded the number of female users; however, a similar survey conducted in 2000 shows that the gender-gap has been reversed as female users took the edge over males. Most new entrants to 'cyberspace' come from the population cohort aged between 16 and 35 with post-secondary education. Because of the active participation by college students and graduates, 78 percent of Internet users now have an educational attainment beyond the secondary degree level, and the average age of Internet users is moving downwards whilst the average level of educational attainment is moving upwards.

The most common activities conducted on the Internet by Taiwanese users are, respectively, sending and reading e-mail, transmitting files, searching for information, downloading online voices and images, playing games, chatting and reading news. On average, Taiwanese Internet users spend 9.1 hours browsing web sites each month, and stay online for 24.4 minutes during each visit (*Commercial Times*, 3 March 2001, quoting data from Netvalue).

Most Internet users used some form of modem, whilst the rest were using other online access methods. For 2000 as a whole, Taiwan's Internet service providers (ISPs) collected a total of NT \$4.52 billion (about US \$137 million) in access fees, representing 47 percent growth from the previous year. In addition to ISPs, Taiwanese Internet users also use cable TV and direct PCs (which are provided by satellite TV operators, with direct broadcasting system (DBS) technology) for Internet access. Cable TV has enormous potential for providing Internet services in Taiwan as 80.6 percent of all Taiwanese households are connected to cable TV networks, and the government has been allowing cable operators to engage in data communication services since 1997.

Broadband coverage remains narrow, however, as most computer modems are connected to traditional phone lines that dial up to an ISP; the speed of data transmission is limited to 56Kbps. The state-owned Chunghwa Telecom is the largest ISP operator, with international access bandwidth of 1,074 Mbps. The remainder are private operators which either lease lines from Chunghwa Telecom or use their own small bandwidth capacity amounting to a mere fraction of Chunghwa Telecom's. At the end of 2000, the combined bandwidth capacity of Taiwan's ISP operators was 2,136 Mbps, which, when divided by the Internet population of 6.26 million, provides 34.9 Kbps for each user. By January 2001, only 5.2 percent of Internet users were connected to broadband, and mostly through cable TV modems, but the Taiwanese government has an aggressive plan to increase the broadband coverage ratio to 50 percent by 2006. This is to be achieved through further liberalization of the telecommunications industry whereby private fixed line operators will be encouraged to intensify market competition and accelerate the diffusion of broadband coverage.

In March 2000, the government issued three new licenses to private fixed-line operators, all of which commenced operations in 2001. Not only will these private operators participate in domestic competition for voice and data communications, but they will also be allowed to invest in intercontinental access cables. Up until now, these access cables had been monopolized by the state-owned Chunghwa Telecom, which is accused of charging excessive rental fees for international connections in order to put its competitors in the ISP business in a disadvantageous position. As a result, Chunghwa Telecom has continued to dominate Taiwan's ISP market with a market share of around 38 percent (through its subsidiary Hinet.com) but has been slow in establishing its broadband-enabling asymmetric digital subscriber line (ADSL) network as a result of bureaucratic procedures that have hampered the procurement and construction of the necessary infrastructure. With the ensuing entry of private fixed-line operators, the construction of ADSL and optical fiber networks has accelerated, leading to increased broadband penetration, which in turn has driven down Internet access fees. The intense competition has increased the number of ADSL subscribers from a mere 2,000 in 1999 to 125,000 in 2000, whilst the number of cable modem subscribers has risen from 25,000 to 95,000 during the same period. Chunghwa Telecom currently charges NT\$799 for 32-hour access, and the government's ultimate aim is to bring the access fees down to the same level as in the US.

Cable TV operators, which provide Internet access through cable modems, are important broadband carriers in Taiwan. There are two major cable TV operators, Giga Media and EHome, and through their widespread household cable TV connections, these cable operators provide a host of value-added services to Internet users. Taking note of the extensive coverage of cable TVs in Taiwan, some ISPs are also teaming up with cable TV operators to provide Internet services. The advantage of a cable modem is that it can provide a host of access services to condominium dwellings, hence leading to significant savings on fixed investment and maintenance costs. Modems also provide two-way multimedia services, encompassing voice, data and images, particularly attractive to entertainment-bound Internet users; for example, EHome's offer of entertainment programs called ET Community Service has been very well received in the Taipei and Hsinchu areas where high-tech-oriented people cluster.

Four of the newly licensed fixed-line operators, which amassed a tremendous amount of capital in the process of bidding for the license, have not lived up to expectations in terms of speeding up the construction of Taiwan's telecommunication infrastructure. These private operators were expected to build their own backbone networks across the country as well as 'last-mile' access

lines to the end users. Largely as a result of the slowdown in the economy in 2001, the private operators have in fact decelerated the pace of their investment, and have instead, spent most of their money on intercontinental sub-aquatic cables to compete directly with Chunghwa Telecom on international bandwidth capacity. If this strategy works, the network rental fees that Chunghwa Telecom currently charges the ISP operators will come down significantly in the future. The provision of bandwidth capacity for international access is apparently more lucrative than long-distance telephone operations at the present time, and although reluctant to enter into any competition with Chunghwa Telecom on local-call services, private fixed-line operators are still leasing the physical facilities from Chunghwa Telecom in order to provide long-distance telephone services. They also offer ADSL access to Internet users, but again, through the local phone lines owned by Chunghwa Telecom.

Financial Resources

One of the most important functions facilitating e-commerce is the Internet payment mechanism. Taiwanese consumers are well accustomed to payment by credit cards, which were introduced to Taiwan in the 1970s, but they are not so accustomed to using this payment method on the Internet. There were 18.3 million credit cards in circulation in 2000, with card-based transactions amounting to NT\$659 billion (approximately US\$20 billion) (Ministry of Finance 2001). Most credit cards were issued by international credit card agencies, such as Visa and American Express, thus enabling international transactions.

Taiwan's Banking Law was amended in 2000, incorporating a provision allowing banks to issue 'electronic money' in order to facilitate electronic-based trade. Under the law, banks issuing 'cash-storage cards', which carry cash in an electronic form to enable real-time transactions, must hold reserves against the value embodied in the cards. Treating banks as the designated issuers, the law implicitly disallows non-bank financial institutions to issue such cards.

Financial resources that enable the establishment and the operation of e-commerce businesses are also important to the development of e-commerce. The lack of physical assets and tangible products often makes it difficult to finance such businesses using traditional financial instruments. A few 'dot.com' companies have tried, and failed, to list on the Taiwan stock exchange and eventually moved to the US for listing on the NASDAQ. Although criticized by the industry, the government in Taiwan instructed the Bureau of Industry Development to establish criteria that would enable the Bureau to recommend that premier dot.com companies could be listed on the Taiwan Stock Exchange under the heading of 'technology shares'. The targets are Internet content providers (ICPs) and application service providers (ASPs); however, with the bursting of the dot.com bubble in 2000, the program has not yet produced any recommendations from the Bureau.

Taiwan has nurtured a sizable and vibrant venture capital industry that provides critical support to Taiwan's high-tech ventures; however, the industry tends to lean towards hardware manufacturers in which concrete 'new products' are pivotal in winning the endorsement of fund managers. The industry is decidedly lukewarm towards cyberspace start-ups, and instead, it is the established big business groups that are taking the initiative and chipping in funds to jump-start e-commerce operations, the purpose of which is often to facilitate trade within the groups or with the group's external customers and suppliers. For them, e-commerce is more of a new format of 'production' than a new product to be offered to the market.

Business Environment and Electronic Commerce Adoption

Electronic commerce is virtually negligible in Taiwan at the present time although the government has plans to bolster this up to 9 percent of GDP by 2004 (*APROC* 2000). According to a survey conducted by the Institute for Information Industry (III) on Taiwan's Top-1000 enterprises, less than 40 percent of these enterprises had plans to introduce any form of e-commerce, and less than 30 percent of them had plans to introduce any online trading in terms of bookings, price quotations, invoicing, etc. (MOEA 1999). According to the survey, the top-ranking firms which did have plans to engage in e-commerce, were mainly interested in broadening their marketing channels (54 percent), followed by coordinating activities among suppliers and subcontractors (27 percent), improving internal management efficiency (12 percent), and others (8 percent). However, most of Taiwan's enterprises engaging in international trade do so as contract manufacturers without their own brand names, therefore, it is unclear to what extent e-commerce can broaden their marketing opportunities. If e-commerce is to be limited to domestic trade, its effectiveness would seem questionable, whereas, the use of e-commerce as a means of coordinating supply-chain activities in order to speed up production, to reduce inventories and to provide prompt market services, may be more meaningful for Taiwanese manufacturers. A survey by the III on the same sample approximately one year later indicated that just under 30 percent of respondents had acquired the necessary hardware facilities for e-commerce (*DigiTimes* 26 October 2000). Most of them were optimistic over the future of B-to-B e-commerce, but less so in respect to B-to-C e-commerce.

It is obvious that the introduction of e-commerce may well interfere with the existing company routine and practices in terms of parts procurement, production scheduling or product delivery, and most of the Taiwanese companies introducing e-commerce did so in an experimental manner. Thus, the prevalence of e-commerce at the present time is limited to customer services and catalogue viewing. Most enterprises are skeptical about the security of online trading, which suffers from limited legal protection, as well as the inherent inability of potential consumers to judge a vendor's product quality through online information. The skepticism is particularly keen in the financial industry where online transactions may reveal sensitive personal data. In fact, 42.5 percent of the respondents to the III survey indicated that security was the most serious bottleneck impairing the introduction of e-commerce in Taiwan. Many traditional industries, particularly those dominated by SMEs, such as the paper products and apparel industries, are most resistant to the idea of Internet transactions. They consider the adjustment costs to the new trade regime to be too high. Some existing commercial practices in the industry also impede the adoption of e-commerce; for example, in the pharmaceutical industry, commission is a common practice in wholesale trading between drug manufacturers on the one hand, and physicians and hospitals on the other, who totally reject the introduction of online trading since it eliminates the scope for negotiation of commission.

Technological barriers also impede the introduction of e-commerce in Taiwan. Although most large enterprises are interested in establishing a web site, and can afford to do so, they may lack the necessary technical personnel to maintain it. In fact, without the adjustment of a company's internal operational routine, a web site is nothing more than a cosmetic arrangement, which can have no real effect on efficiency.

E-commerce is most pervasive in the PC, telecommunications and semiconductor industries, which are also the most globalized in terms of trade and production. In these industries, e-

commerce is used mainly for supply chain management and inventory control. Driven partially by the emergence of low-priced PCs, and the introduction of build-to-order (BTO) methods by major brand name manufacturers such as Compaq and Dell, Taiwan's PC manufacturers are actively participating in e-commerce, together with their suppliers and subcontractors, and their participation tends to strengthen the cooperative relationships in the global production networks. Faced with increased competition from Southeast Asia and China, Taiwan's PC industry has to develop the capability for integrating regional resources for the manufacture and distribution of products, and for servicing its customers, and e-commerce is an important component in building such a capability. Many of Taiwan's PC manufacturers have introduced enterprise resource planning (ERP) schemes to enhance their 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. Some have also gone beyond BTO to provide services such as configure-to-order (CTO), which is often undertaken at 'warehouse-cum-assembly' lines located close to the markets to be served.

For example, Compal, a subcontractor for Dell, switched its production method to BTO in 1995, at the request of Dell. Within the BTO scheme, Compal disassembles parts from the main system and ships them separately to the designated assembly factories where Dell will then assemble them into final products according to orders from the consumers. This method increases the variety of products by adjusting the parts attached to the main system, and reduces the risk of price fluctuation that is often associated with key components such as CPU and RAM, which can be inserted at the final stage of assembly instead of being shipped from Taiwan as a part of the system. To accommodate the new production method, Compal established a virtual hub at the 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 in the next three months, which is updated every hour, and the suppliers are responsible for stocking 7-day inventory 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 off 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, 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 shortened this time to several days. The average turnover of the inventory at Compal was 54.6 days in 1995; it was cut to 30.9 days in 1999 (Chen et al. 2001).

National Policies

Policy Institutions

In December 1997, the Taiwanese government established a task force under the Executive Yuan, known as the National Information Infrastructure (NII) Task Force, with its main task being to design and oversee policies promoting the development of e-commerce. Several major government agencies are involved with this task force (see Table 9); amongst them, the Council for Economic Planning and Development (CEPD) is responsible for the drafting and amendment of laws and regulations that will facilitate or accommodate the development of e-commerce. The Industrial Development Bureau (IDB) and the Department of Commerce, under the Ministry of Economic Affairs, are responsible for assisting in the respective digitization and automation efforts of manufacturing firms and trading firms, whilst the Ministry of Finance is responsible

for the promotion of electronic banking. In addition, two government-sponsored research institutes are responsible for the provision of technical support to private enterprises in their efforts toward digitization. The Institute for Information Industry (III) will provide support in computer software applications and portal-related technologies, whilst the Industrial Technology Research Institute (ITRI) is to develop the necessary hardware technologies for e-commerce applications.

TABLE 9
Government Institutions for E-commerce Development

Institutions	Responsibilities
Council for Economic Planning and Development (CEPD)	Laws and Regulations: Digital Signature Law, Law for the Protection of Private-data Processed by Computers, Law for the Revelation of Government-Held Information
Bureau of Industry Development, MOEA	Digitalization and Automation of the Manufacturing Industry
Department of Commerce, MOEA	Digitalisation and Automation of the Trade Sector
Ministry of Finance	Electronic Banking
Institute for Information Industry (III)	Technical support to private firms interested in digitalisation
Industrial Technology Research Institute (ITRI)	Technology development for e-commerce applications

Enabling Policies

The government first liberalized the telecommunications market in 1996 in order to induce more competition within an industry that had previously been monopolized by a state agency. The government agency that had been operating the sole telephone system in Taiwan was converted into a state-owned corporation, Chunghwa Telecom. Left without any business-operation responsibilities, the government agency then became the regulatory agency for the telecommunications market. Licenses for private cellular-phone service providers were issued in 1997, with a total of eight licenses being granted, but market consolidation has reduced the number of operators to four today. Competition has led to a lowering of the service provision charges, contributing to a boom in the cellular-phone subscription rate. Today, the combined share of the private cellular-phone operators exceeds that of Chunghwa Telecom by a significant margin.

Following the liberalization of the cellular-phone market, the government further allowed four private fixed-line operators to be established in 2000, so as to compete with Chunghwa Telecom in fixed-line services, including voice and data communications. The government plans to privatise Chunghwa Telecom by the end of 2001 although the pace of privatization has been slowed by the shrinking stock-market trading volume in recent months and the target date may become protracted.

The banking sector was liberalized in 1991 when fifteen new licenses for private banks were issued. Intensified competition has improved the quality of banking services, but the industry is suffering from an excess of banks whilst awaiting consolidation. New laws designed to facilitate mergers and acquisitions within the financial sector were promulgated in July 2001, setting the stage for consolidation. Up until now, struggling with the problem of the saturated banking sector, together with the hangover of bad loans caused by asset deflation in recent years, the ability of Taiwan's banks to offer new services has been hampered. Nevertheless, a few private

banks are particularly active in introducing the concept of electronic banking to their customers. Taiwan's convenience stores, which boast the highest density of store presence in the world, have also begun introducing banking services to their shoppers. Tying this in with their B-to-C e-commerce, the convenience stores promise to play a major role in electronics-based financial services in the future.

In addition to telecommunications infrastructure and financial services, the development of e-commerce ultimately hinges on human skills. Electronics-related disciplines remain the most favoured programs currently being pursued by college students in Taiwan. Taiwan produced 50,326 college graduates in science and engineering majors (including advanced degrees) in 1998, but that number is still insufficient to support the rapid expansion of the ICT industry and the increasing need for Internet-based services (Ministry of Education, 2000). There were also shortages in managerial and artistic skills to handle things like management information system and web-page design. Because of the rising demand for skilled labor within Taiwan, the number of students going abroad for advanced studies has declined in recent years. Although overseas Taiwanese engineers continue to return to Taiwan, the pool of returning expatriates has shrunk due to the declining numbers of new students. In contrast, the number of Chinese overseas students has continued to rise and the stock of Chinese overseas engineers is accumulating quickly. Taiwan's ICT industry continues to pressure the government to allow Chinese engineers to work in Taiwan; otherwise the industry may have to relocate their R&D centers to Mainland China.

E-commerce Policies

The Taiwanese government has initiated several programs aimed at promoting e-commerce. First of all, it launched the Industrial Automation and Electronic Business (iAeB) program in 1999 whereby tax incentives would be provided for private enterprises investing in computerization, and in related technology development and personnel training to accommodate computerization. A certain proportion of this expenditure can be taken as a tax credit, under the auspices of the Statute for Industrial Upgrading, just as in the case of R&D expenditure. By December 2000, tax credits had been granted in 36,293 cases of e-commerce related investment, with the total investment amounting to NT\$795.5 billion (around US\$24 billion).

In addition to tax incentives, the Industrial Development Bureau (IDB) 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, whilst the B project takes an indigenous producer as the core firm. The government heavily subsidizes the model systems but the technologies accumulated in the process of developing such systems are to be made available to other firms, which intend to emulate them. After reviewing the tenders submitted by the industry, the IDB chose IBM, Compaq and HP to run the A project, and 15 indigenous PC makers, including Acer, Mitac and Asustek, to run the B project.

IBM was the first to complete the A project in June 2001, and Compaq and HP are due to finish by the year-end. With the completion of the project, 20 Taiwanese subcontractors were connected to IBM's e-Procurement system, which was mainly designed to improve the speed of

data exchanges to coordinate orders and work. These subcontractors, most of which also participate in the B project, were subsequently connected to their components and parts suppliers. When both A and B projects are completed, a total of 1,800 components and parts suppliers are expected to be incorporated into the system (Wu 2001).

In fact, it is the existence of an intricate and nimble network of components and parts suppliers that provides the foundation of competitiveness for the Taiwanese PC subcontractors, who serve IBM, Compaq and the like. Therefore the effectiveness of the B project is the key to sealing the bond between Taiwanese subcontractors and their brand marketers. Even before A and B projects were completed, procurements by top US PC firms sourcing in Taiwan, namely Compaq, IBM, HP, Dell, and Apple, had totaled \$25 billion in 2000, a 48.8 percent increase from the \$16.8 billion procurement level in 1999 (IDB 2001). The project was aimed at preserving the subcontracting relationship after some segments of production have relocated to China. 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. The experience of the project so far suggested that data exchange is not a major problem, but real-time logistics can be an insurmountable hurdle for the operation of SCM. For example, security-check procedure in China requires an export commodity to sit in the airport for at least 24 hours before it clears the customs. The absence of direct cargo flights between China and Taiwan also impede any shipment between the two locations. Despite the full-hearted support from the city government of Kunshan in establishing an information highway between Taiwan and Kunshan, lack of real-time logistic support limits the Chinese operations to be the production of stand-alone subsystems that can be shipped directly to the final market, such as the US. This limitation, on the one hand, prevents a wholesale relocation of the entire production network to China, but on the other hand, encourages the Chinese operations to develop their self-sufficiency capabilities, which eventually will compete with Taiwan's headquarters.

Following the 'model' program, which was demonstrative in nature, the IDB program has now been extended to other manufacturing industries with a focus on automotive, textile, petrochemical and electrical and electronic sectors where the core-satellite networks are already in place. The government will subsidize up to 50 percent of the costs of establishing such inter-firm electronic exchange systems, with the aim being to promote at least 200 such exchange systems, encompassing 50,000 manufacturing firms, of which 80 percent will be SMEs.

To facilitate electronic-based trade across borders, the IDB has established a vertical web site, called Taiwan Industry Marketplace (TIM), to integrate several major e-marketplaces in Taiwan, including Bikexpo.com for the vehicle industry, Dram exchange, 3C trading.com, Computex Online for information products, ibuyplastic.com for the petrochemical industry, and others. TIM provides a search engine to guide viewers to product-specific marketplaces and company web sites in order to facilitate online trading.

In parallel with the above program, there is a 'Four-Year E-commerce Application Plan' to promote e-commerce in domestic trade, in consortium with the Internet service industry. The program aims to upgrade hardware facilities, provide legal infrastructure and establish e-commerce-enabling institutions for the local service industry; it also aims to cover a wide-range of industries with a target of 40,000 participating enterprises. In addition to domestic trade,

interconnections to international e-commerce networks will also be attempted in consortium with international portals. This program is being undertaken by the Department of Commerce, which is responsible for promoting commercial development.

In the government's promotion of e-commerce, special attention is given to assisting SMEs in establishing integrated online trading mechanisms. The government has set up an SME digitization service team to provide technical support, and to help private enterprises to establish e-marketplace portals to enable online trading.

Privacy is an important issue in e-commerce; without proper protection of privacy, e-commerce cannot prosper. Taiwan inaugurated the Statute for the Protection of Computer-Processed Personal Data in 1995, which was later amended, in 2001, to take into account the new facets of e-commerce. Local e-commerce operators have also organized themselves to establish a 'code of conduct'.

Laws relating to the protection of intellectual property (IP) rights have also been amended to strengthen the IP protection in electronic-based trade. Major amendments to the Copyright Law were made in 2001 whereby the right to transmit and safeguard data was specified and made an integral part of the copyright law. Copyright holders are also entitled to safeguard their copyrighted data with electronic devices and any measures designed to dismantle or circumvent such devices in order to access copyrighted materials without permission are now specified as unlawful. The amended law also frees ISP providers from the liability of copyright infringement if the facilities that they provide are improperly used to fetch or transmit copyrighted data. Finally, with the passage of the Digital Signature Law in 2001, the legal framework governing the establishment and operation of a certification agency in electronic transactions is also in place.

The Readiness for E-commerce

By January 2000, the number of Internet hosts in Taiwan had reached 597,036 units, a number ranking Taiwan in second place in Asia behind only Japan (which has 2.6 million units), and seventh in the world (Network Wizards, 2000). However, only 10.7 percent of Taiwanese enterprises have established their own web sites. The low ratio is attributable to the predominance of SMEs in Taiwan, which either see little benefit from establishing a web site, or are unable to do so.

Table 10 shows the web site establishment status by Taiwanese enterprises classified by firm size. It can be seen that by December 1998, only 9.95 percent of those enterprises with less than 100 employees had established a web site, and that a phenomenal 81.6 percent had no plans to establish a web site in the near future. In comparison, large firms are much more active in establishing web sites. For example, amongst those enterprises employing 1000 workers or more, 69.79 percent had already established a web site and only 11.55 percent of these enterprises had no plans to establish a site in the near future.

Internet usage also varies significantly between industries. Table 11 lists the status of web site establishments by major industries. It can be seen that the utilities industry, namely gas, power and water supplies, had the highest ratio of web site establishments at 23.29 percent; utilities companies are mostly owned by the state, and the web sites were mainly established for the

purpose of providing information to the public. Aside from the utilities, social services, manufacturing and commercial service industries all had web site establishment ratios above 15 percent.

TABLE 10
Web Site (WWW) and Intranet Establishment Plans, by Firm Size

Size (employment)	Already established		Establish in 1 Year		Establish in 2 Years		No immediate plans	
	WWW	Intranet	WWW	Intranet	WWW	Intranet	WWW	Intranet
Under 100	9.95	7.0	5.79	3.9	2.66	2.7	81.6	86.4
100-499	34.26	21.2	11.4	13.36	6.5	9.92	47.84	55.53
500-999	55.85	39.88	17.36	20.63	5.06	7.54	21.73	31.94
1000 or more	69.79	55.0	15.5	22.46	3.16	6.09	11.55	16.45

Source: Ministry of Economic Affairs, ITIS Project, 1999; data of December 1998.

TABLE 11
Web Site (WWW) and Intranet Establishment Plans, by Industry

Industry	Already established		Establish in 1 Year		Establish in 2 Years		No immediate plans	
	WWW	Intranet	WWW	Intranet	WWW	Intranet	WWW	Intranet
Mining	2.63	2.63	-	-	-	-	97.37	97.37
Manufacturing	15.64	9.2	1.07	2.46	2.94	1.79	80.35	86.56
Utilities	23.29	21.92	-	1.37	2.74	2.74	73.97	73.97
Construction	7.59	5.48	1.82	3.22	2.50	1.70	88.08	89.6
Wholesale/Retail	7.4	6.1	8.66	5.95	4.03	3.74	79.91	84.21
Transport/Warehousing	13.16	10.51	1.9	1.21	1.44	0.92	83.5	87.36
Finance	4.32	6.86	1.5	1.23	3.51	2.7	90.66	89.21
Commercial Services	15.77	15.63	13.42	7.32	0.13	0.4	70.67	77.25
Social Services	21.2	6.74	3.51	2.27	4.11	2.65	71.18	88.34

Source: Ministry of Economic Affairs, ITIS Project, 1999; data of December 1998.

The establishment of intranets shows a similar pattern across industries, but the spread of web site establishments is generally higher than that of intranets, except in the finance industry where intranets are more pervasive than web sites. This indicates that in December 1998, most industries in Taiwan placed more importance in using electronic networks for customer services or public relations than for internal management.

The expansion of Internet usage came along with a growing demand for ERP systems. According to the III's Market Information Center (MIC), sales of ERP software reached NT\$6.13 billion in 1999 (around US\$185 million), and are expected to exceed NT\$10 billion in 2001. Surprisingly, even SMEs are active in adopting ERP because of the pressure coming from their buyers. A survey by MIC in 2000 indicated that 38.2 percent of Taiwan's SMEs had some plan to adopt ERP (*DigiTimes*, 5 October 2000).

The relocation of mass production facilities to China is also seen as reinforcing the demand for ERP by Taiwanese firms whose marketing, R&D, pilot production and parts procurement functions are still conducted at the headquarters. Multi-site ERP systems are more effective in coordinating headquarters/subsidiary activities than traditional centralized management information systems (MIS) enabled by EDI. Major multinational firms such as SAP or Oracle develop most of the ERP software adopted by Taiwanese manufacturers, and can accommodate multiple portals, but modifications are needed to adapt it to the special circumstances of the internal management system.

The Diffusion of E-Commerce

According to estimates by Forrester Research Inc. (Forrester Research 2000), the value of B-to-B trade in Taiwan reached \$3,843 million in 2000, almost doubling the trade volume in 1999. As compared to other countries in Asia-Pacific B-to-B trade in Taiwan is still under-developed (see Table 12). B-to-B in Japan is estimated at \$29,618 million in 2000, and that of Korea at \$5,164 million. Rapid growth is expected to continue for some time, however. Institute for Information Industry (III) estimated the B-to-B trade to grow at an annual compound rate of 53 percent until 2003. III cited the need to hook up with international buyers and the rapid development of e-marketplaces in Taiwan as the reasons for optimism.

TABLE 12
E-Commerce in Asia-Pacific

	B-to-B trade in 2000 ^a (US\$ million)	B-to-C trade in 2000 ^a (US\$ million)	% Internet users who purchased online in past month 2000 ^b
Australia	5,160.55	394.09	10%
China	954.37	72.88	n.a.
Hong Kong	1,773.28	135.42	7%
India	675.72	51.60	5%
Indonesia	110.48	8.44	3%
Japan	29,618.20	2,261.84	20%
Korea	5,164.42	394.39	16%
Malaysia	311.85	23.82	5%
New Zealand	632.33	48.29	n.a.
Philippines	111.70	8.53	2%
Singapore	1,097.84	83.84	5%
Taiwan	3,842.73	293.46	4%
Thailand	432.15	33.00	1%
United States	449,900.00	38,755.00	27%
Asia Pacific	49,885.63	3,809.59	
OECD	588,900.80	52,184.17	

Note: ^aSource: Forrester Research Inc., Global eCommerce Model, 2000.

^bSource: Taylor Nelson Sofres, Global eCommerce Report, 2000. Data are from a survey conducted in 27 countries. Internet users are defined as someone who has personally used the Internet in the past month: an online shopper is an Internet user who has bought or ordered goods or services on the Internet during the past month.

The volume of B-to-C was much smaller and estimated at \$293 million in 2000. The low volume is reflected by the reluctance of Taiwan consumers to purchase goods and services on line. As shown in Table 12, only 4 percent of Internet users in Taiwan purchased something online, as compared to 27 percent in the US, 20 percent in Japan, and 16 percent in Korea. Low participation rate in online shopping is partly attributable to the inadequacy of security measures and partly to the lack of attractive products. A survey conducted by III indicates that 52 percent of online shopping went to travel-related services, such as airline or hotel booking, 27 percent went to IT-related products such as PC and PC parts, and the rest went to miscellaneous items such as books and music and video products (MOEA 2000). It is fair to say that except for travel services and IT products, no other consumption goods or services have taken advantage of new trading technologies.

Slow development of B-to-C trade also suggests that real stores in Taiwan have been competitive vis-à-vis the virtual stores. Taiwan's high population density is accompanied by a high density of stores, which has tended to spoil local consumers with around-the-clock local shopping availability; thus Internet shopping does not seem to present much of a challenge to conventional stores. Taiwan's convenience stores have recently launched hybrid-shopping services combining Internet booking at neighborhood convenience stores with local delivery. Taiwan's '7-eleven' chain stores first launched such a service in August 2000. In consortium with several B-to-C portals, 7-eleven stores offer real venues for product pick-up and settlement of accounts for Internet shoppers, a combination which provides security for both buyers and sellers. The service handled 30,000 transactions in its inaugural month alone, and this number had grown to 150,000 by May 2001 (*Commercial Times*, 11 June 2001). Other smaller chain stores have also acted together to launch a competitive product.

The Impact of E-commerce

At this point, any evaluation of the impact of e-commerce is preliminary. Early development experience in Taiwan shows that B-to-B e-commerce has grown much more rapidly than B-to-C e-commerce. Large firms are forced to adopt the new form of trading because they are contract manufacturers for multinational firms, whilst small firms are forced to adopt it because of the pressure from larger manufacturers. 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 take advantage of the opportunities that it reveals.

The exchange of information is essential to the coordination of activities among members in B-to-B trade, but much of this information is proprietary knowledge, which its owner will be willing to share only with long-term strategic partners. This implies that the members involved in recurring B-to-B trading tend to be engaged in long-term relationships, implying that the buyer-supplier relationship in B-to-B trade is more stable than traditional commerce. For one thing, buyers and suppliers have to invest in ERP to accommodate the portals commonly adopted for trade, and ERP is invariably system-specific.

Because the flow of information is more rapid and the ability to process information is strengthened with new technologies, producers can now respond more readily to consumer-related information. Therefore, the traditional way of planned production is replaced by BTO. Since the processing of information is characterized by increasing returns to scale, large firms with the ability to produce a large variety of products tend to be the winners in the new-age competition. The industry will become more concentrated and SMEs have to become collaborators of large firms to survive.

The emergence of e-commerce also makes a producer's proximity to the market inconsequential to competition; production is globalized, and the ability to organize global production is essential to competition. This trend again favors large firms over small firms, given their greater capacity for overseas investment. Nevertheless, long-distance commerce will not make on-site services obsolete, as they will continue to be valued by consumers. If global sourcing is to attenuate the differences between producers, the ability to provide on-site services will probably determine the

competition winners in the end. This is why 'virtual' Internet stores will play no significant role in trade if they are not accompanied by 'real' services.

It seems, therefore, that e-commerce should be considered a new 'technology' of production more than a new product itself falling within the category of trade. As a new technology, it affects production in all facets of industry, including the methods of organizing production, the role of inputs, the location of production, and so on. Research in these areas promises fruitful insights into the effect of e-commerce on the functions of the new economy.

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