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Singapore: A Regional Hub in ICT

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INTRODUCTION

Singapore is a unique island city-state in Southeast Asia, with an area of only 650 square kilometres and a population of 4 million. Despite its small size and dearth of natural resources, it became one of East Asia's miracle economies and emerged relatively unscathed by the Asian financial crisis of 1997–98. The annual GDP growth rate has averaged over 7 percent since political independence in 1965, resulting in a per capita income level that ranks among the highest in the world. Singapore overcomes its size and natural resource constraints by leveraging on the region and the world. It is both a manufacturing base, producing increasingly skill- and technology-intensive goods for the global and regional markets, as well as a services hub, producing largely for the regional market.

Singapore's recently adopted strategy to position itself as a regional information and communications technology (ICT) hub is part of its overall strategy to develop as a knowledge-based economy. Singapore is well placed for this role because of its rapid and advanced development of ICT and because its other hub activities in commerce and transportation complement the activities of an ICT hub. The ICT revolution has created global communications networks. Notwithstanding the trend towards standardisation in the global network, however, regional network nodes exist and thrive because of national and regional differences.

The traditional flying geese pattern of East Asian development, characterised by hierarchical and uni-directional diffusion of technology and production from upper-tier to lower-tier countries, is giving way to a complex network relationship driven by ICT. Trade, investment, and technology flows are multi-directional, leading to the emergence of inter-related clusters. Thus, Penang in Malaysia is specialising in supply of

electronic parts, while the Philippines is leveraging on its educated labour force to be an IT service centre for foreign multinational corporations (MNCs).

Singapore is positioning itself as a service centre and headquarters (HQ) logistics base for Southeast Asia. As a city-state with extensive trade, transportation, and telecommunications connections, Singapore is the recognised hub city of the region. It is the regional entrepôt, and intra-regional trade in Southeast Asia is largely with and through Singapore. It is the major shipping and air transport node of the region, linked by sea and air to all parts of Southeast Asia and by land to Malaysia. It is the region's financial centre, providing an ever-broader range of financial services. Flows of goods, services, and people have been reinforced by outward investments to the region. As a regional hub, Singapore is the location for the regional headquarters of many American, European, and Japanese MNCs. Political considerations often complicate and constrain Singapore's role as a regional hub and its complementarities with neighbouring Indonesia and Malaysia.

Singapore aspires to be more than a regional hub city. It is a global city; with its extensive global commercial, financial, transportation, telecommunications, and information links it serves as the conduit between the region and the world beyond. Singapore also plays host to some 6,000 foreign MNCs and international companies from outside of Southeast Asia.

This chapter develops a picture of Singapore as an ICT hub: its aspirations, its competitive advantages, and its weaknesses. The next section lays out the conceptual framework to understand the emergence of hubs and clusters. Then the chapter examines the role of Singapore as a regional hub and reviews ICT development and policies in Singapore.

CONCEPTUAL FRAMEWORK

The dictionary defines a hub as the central part of a wheel, round which it turns and to which the outside edge or rim is connected by spokes. In economic terms, hubs represent concentrations of certain economic activities, interconnected companies, and institutions in a defined geographical space. Economic hubs and clusters may emerge because of an initial advantage in the availability of specific raw materials (the iron and steel-producing centres in the United States and Europe) or of specific skills (the entertainment industry in Hollywood and the ICT industry in Silicon Valley). Economies of scale and agglomeration lead to the growth

of hubs and clusters. They include companies in industries with related skills, technologies, or common inputs. They also include government and academic research institutions that provide standards, education and training, research, and technical support. Clusters often extend along the value chain to include suppliers and providers of specialised inputs or infrastructure. Hubs can grow to serve hinterlands within national borders, or even beyond national boundaries, as is the case with London's financial centre and the Hong Kong and Singapore entrepôts. Hubs and clusters can emerge and decline in response to market forces.

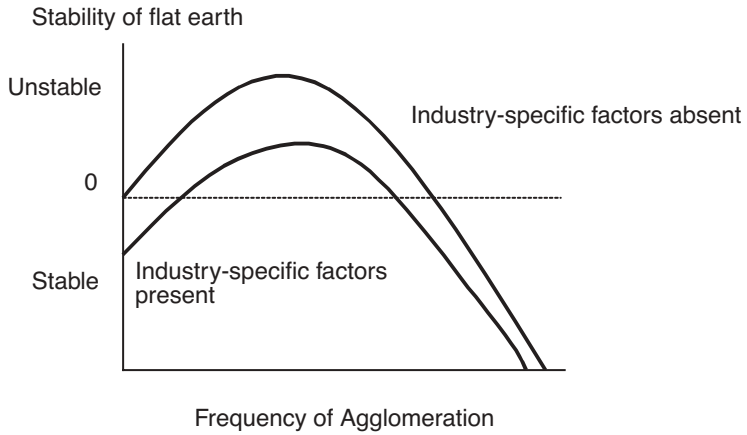
This section reviews two theoretical models that analyse the emergence of industrial clusters and hubs. The Fujita, Krugman, and Venables (1999) model is based on increasing returns from positive externalities due to agglomeration in a borderless world with trade costs. Porter's (1998*a*, 1998b) model introduces important qualitative variables such as knowledge spillovers and institutional benefits and focuses on competitive advantages in cluster location.

Influence of Industry-specific Inputs and Transport Costs on Agglomeration of Industry

In the Fujita, Krugman, and Venables model, forward and backward linkages among firms create centripetal forces that support agglomeration, but trade costs give rise to conflicting centrifugal forces. From an initial "flat-earth" equilibrium in which industry is evenly dispersed, the model examines how industrial clusters eventually develop as a result of slight deviations in the parameters of the model — the size of the manufacturing sector, consumers' elasticity of substitution, trade costs, and factor inputs specific to an industry. These subsequently impact on the frequency of the fluctuations, and result in a "preferred frequency" which is simply the number of agglomerations or clusters that form in a stable equilibrium. Of key interest for the purposes of policy are the two parameters of industry-specific factors and trade costs.

Figure 10.1 illustrates how the existence of industry-specific factors affects the tendency to form industrial clusters. It shows the results of a model simulation with no industry-specific factors and one when they are present. The height of the curves represents the stability of the initial flat-earth equilibrium, or, equivalently, the likelihood that industry clusters emerge. Below the horizontal dotted line, the centrifugal forces dominate, the flat-earth equilibrium is stable, and no agglomeration results. Above the dotted line, the centripetal forces are stronger, the initial equilibrium is

FIGURE 10.1
Effect of Industry-specific Factors on Agglomeration



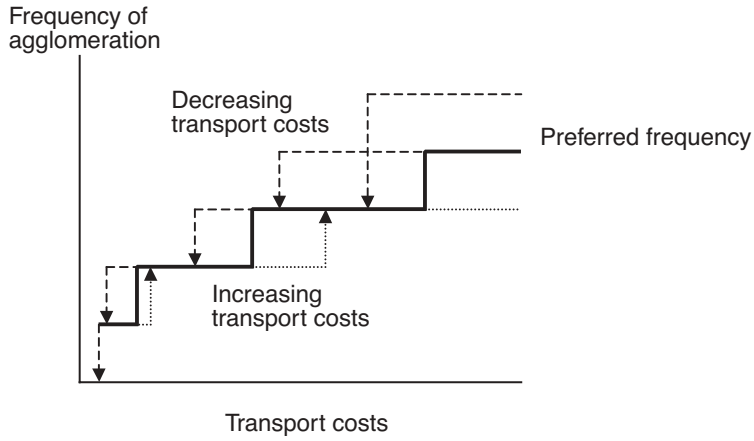
Source: Adapted from Fujita, Krugman, and Venables 1999.

unstable, and some clusters will develop. The point where the curve attains a peak is the preferred frequency of agglomeration, or the number of clusters in a new equilibrium.

In Figure 10.1, the curve for the case with industry-specific inputs lies below the one without such inputs and it covers a narrower range of frequencies. When factor inputs are not industry-specific (the upper curve), an industry can locate in many different places, but when inputs are specific to an industry (the lower curve), industries have greater motivation to pool resources in fewer locations. Therefore, although agglomerations are less likely to occur, if they do, only an intermediate number of clusters will emerge.

Figure 10.2 illustrates the effect of transport (trade) costs in this model. The solid line indicates the preferred frequency of agglomeration for the two-industry case when there are industry-specific factors. The dotted lines indicate how the spatial structure (number of agglomerations) evolves as transport costs fall (upper dotted line) or rise (lower dotted line). Most significant is the "punctuated equilibrium" nature of this evolution: the spatial structure remains stable over wide ranges of transport costs and then shifts abruptly. In other words, inertia from the forces that resulted in

FIGURE 10.2
Effect of Transport Costs on Agglomeration

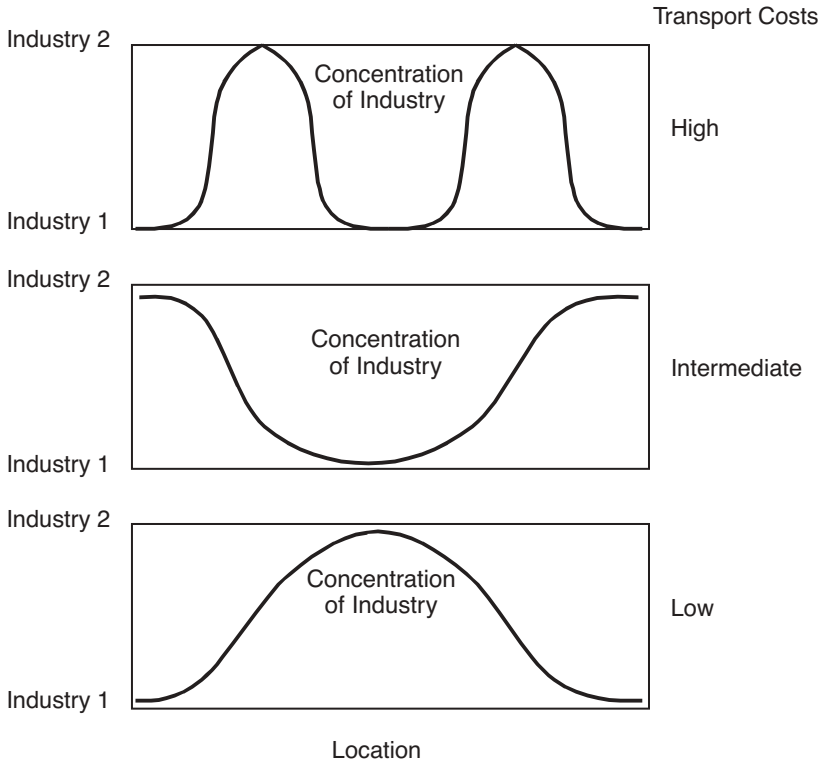


Source: Adapted from Fujita, Krugman, and Venables 1999.

the existing clusters continues to resist the pressure from changing transport costs until a critical point, and then a new economic geography develops, with more clusters forming or some disappearing. This suggests that there is considerable path-dependence in the spatial structure over time. Moreover, the pathways to the new spatial structure are asymmetric between rising and falling transport costs. This suggests that simply reversing changes in transport costs will not lead the economy to revert to a former spatial structure.

Figure 10.3 shows how the spatial distribution of the two industries differs for three levels of trade costs (high, intermediate, and low), with the curves in each panel representing the concentration of industry at each location. As trade costs fall, there is a move towards a lower frequency of agglomeration. In particular, industry 2 (the lower trade cost industry) moves from occupying the core in the middle panel to occupying the periphery in the bottom panel. Likewise, the higher trade cost industry shifts from periphery to core. Intuitively, as trade costs fall across the board, they become low enough that agglomeration forces are no longer as important for industry 2 which relocates to benefit from lower wages at the periphery.

FIGURE 10.3
Effect of Transport Costs on Location

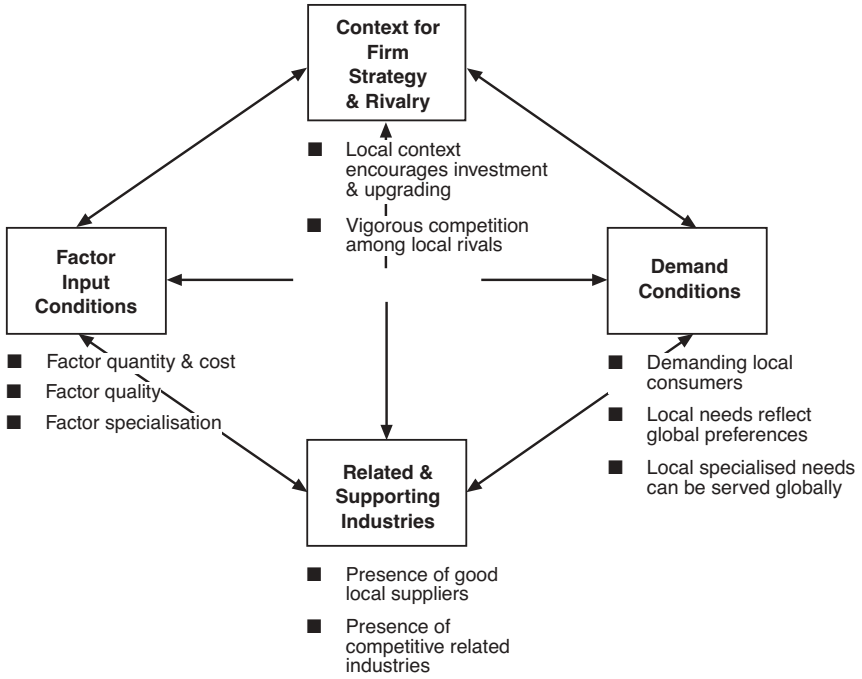


Source: Adapted from Fujita, Krugman, and Venables 1999.

Influence of Location on Competitiveness

Porter used the Diamond Model, shown in Figure 10.4, as the basis of his explanation of the beneficial impact of industrial clusters on productivity and productivity growth. The four points of the diamond represent four categories of influences on a firm's competitiveness that depend on its location: Factor Input Conditions; Context for Firm Strategy and Rivalry; Demand Conditions; and Related and Supporting Industries. Factor Input Conditions include tangible aspects such as physical infrastructure and intangible ones such as information and the legal framework. The Context for Firm Strategy and Rivalry encompasses the local investment climate as

FIGURE 10.4
Porter's Diamond Model of Locational Competitive Advantage



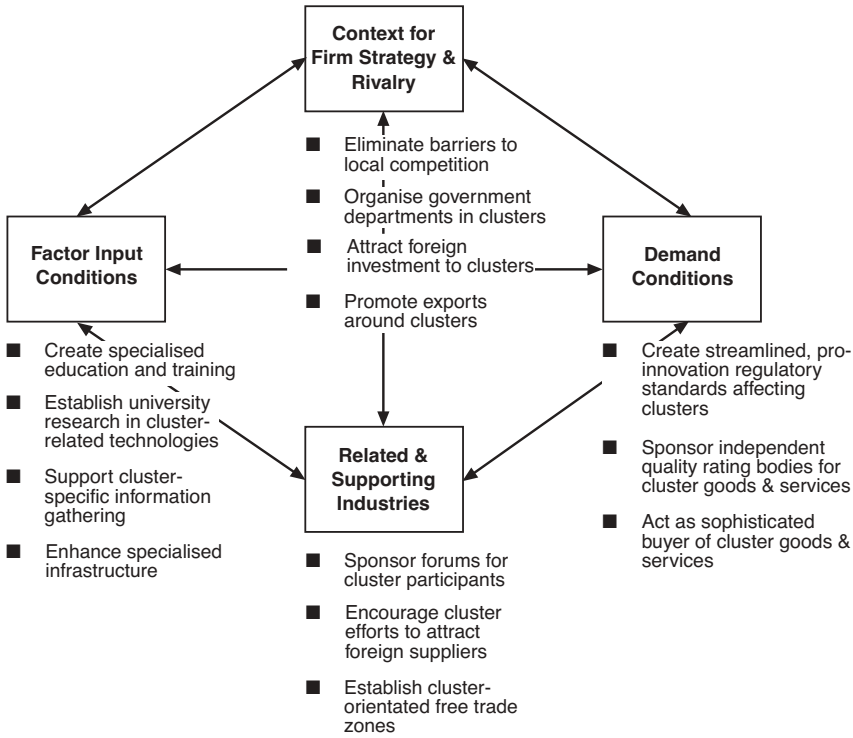
Source: Porter 1998*a*.

well as local policies that affect rivalry. Demand Conditions in the local market influence whether firms can move from imitative, low-quality products and services to competing based on differentiated products. The factors under the Related and Supporting Industries category are the key facet of the diamond that relate to the formation and growth of industry clusters.

Porter argues that the quality of the business environment, defined by these four categories, is of paramount importance to an economy's sophistication and productivity, and hence its competitiveness. Further, he argues that the factors in the Related and Supporting Industries category, or the cluster-specific aspects of the business environment, are the most significant. In particular, clusters influence productivity, innovation (and productivity growth), and new business formation, which in turn supports innovation and subsequently expands the cluster. First, clusters enhance

productivity through more efficient sourcing of inputs, improved access to skilled human resources, suppliers, and specialised information, and various complementarities within the cluster. Second, clusters influence innovation because they normally contain sophisticated buyers who drive the innovation cycle and because they offer innovators better sourcing options, greater supplier support, and pressure from peers, competitors, and consumers. Third, clusters encourage the emergence of new businesses because the complementarities among inputs, suppliers, and technologies on which new businesses might depend are more visible. New businesses, in turn, pick up the slack in innovation left by larger firms, furthering innovation within the cluster.

FIGURE 10.5
Government Influences in Porter's Diamond Model



Source: Porter 1998*b*.

Cluster analysis takes a broad, dynamic view of competition that emphasises growth in productivity. As such, it advocates the development of all clusters, not just selected ones. This stance implies that foreign imports and firms are important contributors to agglomeration externalities and therefore that competition and trade are a positive-sum game.

From the perspective of Porter's Diamond Model, government policy to support industrial clusters involves four key aspects: maintaining macroeconomic and political stability; improving micro-economic capacity; establishing micro-economic rules and incentives for competition; and facilitating cluster development and upgrading (Figure 10.5).

SINGAPORE AS REGIONAL HUB

Singapore's status as a regional hub for Southeast Asia and sometimes for the broader East Asia and Pacific region is evident from its role as a regional trading, financial, transport, and telecommunications hub as well as manufacturing base for foreign MNCs (Chia 2000). As a regional hub, Singapore also has extensive commercial, financial, transportation, telecommunications, and information links around the world. It is the conduit for global commercial and financial penetration into Southeast Asia and for Southeast Asian goods entering the world market. Manufactured goods produced in Singapore are destined largely for markets in North America and Western Europe rather than Southeast Asia, although intra-regional trade in intermediate goods is very active. With the growth of ICT in international trade and investment, Singapore has added another dimension to its hub activities and aspirations.

Manufacturing-Services Nexus

Singapore grew rapidly as a manufacturing base (Chia 1997). However, by the end of the 1980s, it renewed emphasis on the development of services to provide a broader economic base and in recognition of the manufacturing-services nexus. Policymakers adopted Porter's cluster model as the basis for developing Singapore's industrial competitiveness. The Strategic Economic Plan (1991) identified thirteen clusters in manufacturing and services for development. For each cluster, Singapore's advantages and core capabilities were examined and strategies and initiatives undertaken to close identified gaps. Strategies for manufacturing were grouped under Manufacturing 2000, which stressed the need to retain a manufacturing base in Singapore in view of the manufacturing-services nexus, rather than

to follow Hong Kong on the path to de-industrialisation. The target was to keep manufacturing at no less than 25 percent of GDP. Strategies for services were grouped under International Business Hub 2000, which aimed at developing Singapore as a global city and a hub for business and finance, logistics and distribution, and communications and information.

Industry 21 was launched in 1999 as a ten-year plan to develop Singapore into a vibrant and robust global hub of knowledge industries in manufacturing and traded services, giving new emphasis to knowledge-based activities as the frontier of competitiveness. The new plan continues the cluster strategy. Manufacturing and service clusters identified for development are electronics, logistics, communications and media, chemicals, life sciences, engineering, education and health care, and regional headquarters. Programs are drawn up to promote enterprise and innovation in these clusters.

Singapore's hub strategy is based on the understanding that key economic activities such as finance, shipping, air transport, telecommunications, and information are increasingly concentrated in a few strategic nodes around the world, each one servicing an extended hinterland and linking it with the rest of the world. Singapore seeks to secure the first-mover agglomerative advantage and in so doing hopes to secure its lead on the competition. It does so by planning far ahead, developing a world-class physical infrastructure (airport, seaport, telecommunications network, financial and industrial facilities), investing in human resources (education and training), providing the institutional and incentive frameworks, and building good relations with regional countries through political diplomacy, outward investment, and joint ventures to combine its competitive strengths with regional and international partners. To be accepted as a regional hub, Singapore must provide added value to its economic hinterland through world-class products and services and reputation for quality, reliability, and excellence.

Regional Entrepôt

Singapore has served as a regional entrepôt since the early nineteenth century. Its initial advantages were the specific factors of a natural deep harbour and strategic location astride sea lanes for ships plying between East Asia and Europe. In addition, the British colonial administration's enlightened free-port policy was crucial to Singapore's early success since many nearby locations were also deep harbour possibilities. The development of transportation, commercial, and financial infrastructure and facilities and the accumulation of expertise in trade and finance

reinforced the first-mover advantage arising from geographic and policy factors. Singapore's entrepôt function led to the growth of ancillary storage and warehousing, shipping, and banking services as well as resource processing activities.

The entrepôt provided intermediary services for the geographic hinterland — importing Western manufactures for redistribution in the Southeast Asian region and collecting the region's primary commodities for marketing to the West. Singapore's intermediation role facilitated the region's import and export trade and reduced the various transaction costs for buyers and sellers. Neighbouring countries did not always understand the economic function Singapore served, however, creating friction in bilateral relations and a strong desire to bypass Singapore as an intermediary.

As neighbouring countries achieved political independence in the early post-World War II period, the national governments developed their own ports, engaged in direct marketing of primary products, and fostered import-substituting industrialisation. These policies dimmed the prospects of Singapore's entrepôt development and led the city-state to seek the economic alternative of developing export manufacturing spearheaded by foreign MNCs.

In actual fact, Singapore's entrepôt function did not decline as anticipated but followed a different path of development. With the region's industrialisation since the 1960s and particularly with the shift in emphasis since the early 1980s towards manufacturing for export, Singapore played an increasing role as intermediary for Southeast Asian trade in machinery and equipment and procurement of electronics parts and components (Chia 2001*a*).

Transportation and Logistics Hub

Singapore is one of the world's busiest seaports handling ships carrying goods and passengers from all over the world. Some 400 shipping lines link Singapore to over 700 ports. In year 2000, 145,383 ships with a gross weight of 910.2 million tonnes and 325.6 million tonnes of cargo called at Singapore. The range and efficiency of its port and port-related services enhance its position as a leading global and regional port. For example, with container throughput of 17.1 million TEU (twenty-foot equivalent units), Singapore is one of the largest container ports in the world.

Singapore is a major regional air transport hub recording 86,853 aircraft landings, 28.6 million passengers arriving, departing, or in transit, and 1.7 million tonnes of air cargo loaded and discharged in year 2000. Changi Airport has repeatedly ranked among the world's top airports in efficiency

and quality of services. Singapore Airlines and some 70 other carriers provide over 3,300 scheduled flights a week, linking Singapore directly to 133 cities in 54 countries. Singapore has bilateral air service agreements with nearly 100 countries. A planned third terminal at Changi will enable the airport to handle over 60 million passengers a year.

ICT has made the global market more competitive and led to radical changes in organisation of production and distribution and the cost and efficiency of managing supply chains. Manufacturers and businesses are looking to third-party logistics (3PL) providers for supply chain management, time-critical deliveries, and innovative fulfilment solutions. Many leading MNCs have already established manufacturing bases in the region to tap its resources and growing markets. Singapore is building up its supply chain capabilities by encouraging 3PL providers, cargo airlines, value-added distributors, and manufacturers to locate their Asian supply chain centres in Singapore. These companies will provide world-class logistics services and be able to configure logistics solutions to enhance manufacturers' global supply chains.

In March 1999 the Economic Development Board (EDB) announced that it would develop thirty integrated 3PLs capable of delivering an integrated chain of services and solutions for manufacturers. To date, Singapore has developed many world-class integrated 3PLs, including Circle International Headquarters, UPS Worldwide Logistics, Accord Reverse Logistics Centre, DHL Express Logistics Centre, BAX Global, and YCH Integrated Logistics Centre. A 26-hectare Airport Logistics Park (ALP) has been established at Changi Airport to promote quick turnaround and value-added logistics activities, including postponement, configuration, subassembly, returns and repairs, and vendor-managed inventory services. Singapore is wooing leading players with strong global networks and capabilities in value-added logistics to co-locate at ALP.

In telecommunications, operator-assisted, STD, and IDD telephone services connect Singapore with almost every country in the world. Within Singapore, the emphasis is on communications infrastructure and information technology education. The entire city-state is being networked by fibre-optic cable, which links households, businesses, government agencies, and other institutions into a giant information system.

Base for Foreign MNCs and Regional Headquarters

Singapore hosts some 6,000 foreign MNCs and international companies performing manufacturing and service functions and serves many American,

European, and Japanese MNCs as their regional headquarters (RHQ) for Southeast Asia and also East Asia and the Pacific. MNCs and international companies established RHQs to serve the regional market and co-ordinate their regional subsidiaries and affiliates in East Asia, which experienced extraordinary economic growth for over two decades until the financial crisis in mid-1997.

The EDB actively encourages international companies and foreign multinationals to base their RHQ and business headquarters in Singapore. Such hub activity is seen to create high-value jobs and to introduce valuable technology, management, and marketing expertise. Its RHQ projects include chemicals, electronics, engineering, life sciences, logistics, and supply chain management, hospitality, and infocomms and media. RHQs provide a wide range of services to subsidiaries in the region — business planning and co-ordination, treasury and risk management, sourcing of raw materials and components, marketing and sales promotion, personnel management and human resource development, production engineering and product design, technical support, and research and development.

Singapore's locational advantages are geographic, economic, and institutional. These include: a strategic location in the dynamic East Asian region; world-class transport and telecommunications infrastructure, logistics, and financial services; established corporate governance and Western legal and accounting systems; skilled manpower and widespread use of English; political stability, a conducive business environment, and a comfortable living environment; a regulatory framework that is not too intrusive for business; low transaction costs for movement of goods, services, funds, and persons; a financial centre with free movement of capital and foreign exchange; and a favourable tax regime that includes very generous tax incentives (Chia 1997).

Regional Financial Centre

Singapore's financial centre is the third largest in Asia, after Tokyo and Hong Kong. Its primary business is offshore — collecting offshore funds for offshore lending. The business grew rapidly from the start in the late 1960s, when banks were encouraged to set up Asian Currency Units (ACUs) to handle foreign currency deposits and loans. Over the years, the strategy has also been to establish Singapore as a risk management centre with active foreign exchange trading, money market operations, and trading in capital market instruments, equities, and futures.

A wide variety of foreign financial institutions are located in Singapore, linking it to the international financial network and other global cities. Before the onset of the Asian financial crisis in mid-1997, there were 152 commercial banks (including 140 foreign banks with full, restricted or offshore banking licences), 80 merchant banks, 5 representative offices of banks and merchant banks, and 9 international money brokers. The number of financial institutions has shrunk since the financial crisis in response to global, regional, and domestic consolidation and restructuring. The financial crisis and the slow recovery of regional economies have also led to a sizeable shrinkage in regional lending activities.

Foreign financial institutions based in Singapore enjoy the time-zone advantage (straddling Asia and Europe), efficient transport and telecommunications infrastructure, transparent legal framework and financial regulations, ready availability of professional manpower, attractive investment incentives, and political, social, and economic stability. Singapore's financial system stood the test of the 1997–98 financial crisis, remaining sound while many systems in the region collapsed.

Regional Investment Strategy

Singapore's hub strategy also calls for outward investment and joint ventures to combine the competitive strengths of Singapore with those of the region. Although Singapore has been a net capital exporter since the mid-1980s, in 1993 the government began actively encouraging investments in the region due to a number of push and pull factors.

On the push side, the maturing economy was facing severe land and labour constraints and rising costs, necessitating outward investment to sustain its growth performance. Outward investment in manufacturing complements domestic industrial upgrading and productivity improvement. In addition, Singaporean subcontractors followed as their foreign MNC clients relocated some production operations to such neighbouring countries as Malaysia and Thailand because of increasing labour shortage and rising wages in Singapore.

On the pull side the improving conditions in East Asia in the early 1990s attracted outward investments. The region offered abundant natural resources, low-cost labour, and rapidly expanding markets, providing opportunities for Singapore to invest in manufacturing, services, and infrastructure projects. Choice of investment location depended on market and cost considerations. Proximity to Singapore was a key factor for some, as it facilitated procurement of inputs and shipments of output and provided

ready access to support staff based in Singapore. Outward finance, commerce, and real estate investments were attracted more by opportunities in the host countries than by the cost-push factor.

With limited outward investment experience Singapore's domestic enterprises preferred investing within the region to investing on a global scale. Geographic proximity and cultural and linguistic familiarity helped to reduce asymmetric information and other transaction costs. Also, for small and medium-sized enterprises with limited managerial resources, nearby investments facilitated management supervision from the home base.

Singapore's regionalisation strategy includes the government and private firms establishing co-operative joint ventures with government agencies and enterprises in host countries. Singapore's development agencies and state enterprises have entered into partnership with foreign authorities and private enterprises to develop regional infrastructure projects. These include Batam Industrial Park, Bintan Industrial Estate, Bintan Beach International Resort, and Karimun Marine and Petroleum Complexes in the Indonesia-Malaysia-Singapore (IMS) growth triangle, Suzhou Industrial Park in China, the Bangalore Information Technology Park in India, and the Vietnam-Singapore Industrial Park. These industrial parks provide quick and effective start-up platforms for companies, as they are generally self-contained, with ready-built factories and industrial land located near commercial, medical, educational, residential, recreational, and other facilities.

SINGAPORE AS AN ICT HUB

Advances in technology have sharply reduced the cost of information and communication and are driving globalisation. Information and communications technology has reduced the barriers of space and time. It is an enabling technology that improves the productivity of production and distribution; decreases the cost and speed of information gathering, processing, and dissemination; and rapidly changes lifestyles. ICT is also increasingly viewed as a high-growth economic sector to be promoted and nurtured. The differential development and diffusion of ICT across and within countries and societies has given rise to concern about a "digital divide". According to various indicators, Singapore is among the most advanced economies in East Asia in the development and diffusion of ICT (Table 10.1).

The ICT sector cuts across traditional economic sectors. The Department

TABLE 10.1
ICT Diffusion in East Asia

	Telephone Main Lines per 1,000 people		Cellular Mobile Subscribers per 1,000 people		Internet Hosts per 1,000 people		Waiting List for Main Lines per 1,000 people		Cost of a Three-minute Local Call PPU US$ 1990=100	
	1990	1999	1990	1999	1990	1999	1990	1999	1999	1999
Japan	441	558	7	449	2.3	49	0	0	0.06	91
China	6	86	–	34	–	0.1	1	–	0.06	–
Korea	310	438	2	500	0.8	4.8	–	0	0.06	94
Hong Kong	450	576	24	636	5.2	33.6	1	0	0	–
Singapore	349	482	17	419	7.4	72.3	–	0	0.03	–
Indonesia	6	29	–	11	–	0.2	2	–	0.08	44
Malaysia	89	203	5	137	0.3	2.4	5	–	0.06	44
Philippines	10	39	0	38	–	0.4	9	–	0	–
Thailand	24	86	1	38	0.1	1.6	18	7	0.23	–
Brunei	136	246	7	205	0.5	8	52	–	–	–
Cambodia	–	3	0	8	0	–	–	–	0.15	–
Laos	2	7	0	2	0	0	–	–	–	–
Myanmar	2	6	0	–	0	0	–	2	–	–
Vietnam	1	27	0	4	0	–	–	–	0.37	–

Source: United Nations Development Program (UNDP), *Human Development Report* 2001, Table A2.4.

of Statistics (DOS) defines the ICT sector as encompassing the entire chain of ICT-related activities, ranging from manufacturing to the wholesale and retail distribution of ICT products, as well as knowledge-based industries such as Internet service providers, computer software development, desktop publishing, and computer schools. The DOS definition is broader than the OECD's definition of the ICT sector, which excludes activities such as publishing, reproduction of recorded media, broadcasting, library, and archives.

The ICT sector is a major contributor to Singapore's economy with output amounting to S$26 billion in 1996 or 20 percent of GDP (DOS 1998). The main subsector is ICT manufacturing, (12.3 percent), with ICT services (including wholesale and retail trade, telecommunications, business information and technical services and computer-related services) of lesser importance, although the latter has grown rapidly since the data were compiled (Table 10.2). The main ICT-manufacturing industries are computers and electronic office equipment and electronic components. Singapore is an important East Asian production centre for electronics

TABLE 10.2
Value Added of ICT Activities by Sector in Singapore, 1990 and 1996

	Value Added (S$ million)		Share of GDP (%)	
	1990	**1996**	**1990**	**1996**
Manufacturing	8,256	16,039	12.2	12.3
Computers and electronic office equipment		7,909		6.0
Electronic components		4,910		3.8
Other		3,220		2.5
Wholesale and retail trade	1,709	4,228	2.5	3.2
Telecommunications	1,433	2,745	2.1	2.1
Computer-related services	245	982	0.4	0.8
Business information and technical services	590	1,796	0.9	1.4
Other services	240	353	0.4	0.3
Total	12,473	26,143	18.4	20.0

Source: Department of Statistics, *The Information and Communication Technology Sector in the Singapore Economy*, 1998.

products, parts, and components. It is also an important marketing and distribution hub for ICT products, particularly office machinery and telecommunications equipment. The number of establishments in the telecommunications subsector grew from three in 1990 to 39 by 1996 and has come to include Internet service providers, mobile cellular and paging services, and satellite-link services. In the business information and technical services subsector, the largest industry is business and management consultancy services, reflecting the growing importance of information and technical services. The major share of the computer-related services subsector is comprised of software development and consultancy, which is a rapid growth industry.

The Infocomm Development Authority's (IDA) *Survey on Infocomm Manpower 2000* shows total manpower in the information and communications (infocomm) sector of over 100,000, constituting some 5 percent of the total workforce. The infocomm workforce has the following characteristics: 73 percent have at least a university degree; two-thirds are male; over half are in the 25–34 age group. By occupation, two-thirds are employed in infocomm sales and marketing, technical support and helpdesk, applications development and integration, and management, with sizeable numbers also in systems infrastructure, multimedia development and integration, infocomm education and training, software development and integration, network infrastructure, and Internet infrastructure.

ICT Goods Production and Trade

The ICT hardware industry in Singapore, broadly defined to be the electronics goods industry, is a key industrial sector. The industry contributes over half of Singapore's total manufacturing output (EDB 2000*a*). Singapore is a major production as well as trading node in the region for electronics products, parts and components, and supporting services. Electronics production is dominated by American, European, and Japanese MNCs with local firms mainly in subcontracting and supporting industries. It is concentrated in the industrial electronics and electronic component subsectors and it is strongly oriented towards exports. The industry is subject to the boom and bust characteristics of the global electronics business cycle as well as to swift restructuring and relocation in response to rapid technological advances and changing competitiveness and comparative advantage.

The industry has passed though four phases of development (Chia 1997; Chia and Freeman 2001).

Phase 1: Late 1960s to Late 1970s

The Singapore industry was established in the late 1960s with the initial influx of electronics assembly plants set up by MNCs from the United States followed by ones from Europe and Japan. These foreign MNCs were pushed into offshore production and outsourcing because of maturing product cycles and rising domestic labour costs. For U.S. firms, the relocation of labour-intensive processes such as semiconductor assembly was also facilitated by the U.S. tariff schedule that imposes tariffs only on the value added of the imports. At that time, Singapore's locational advantages included ready availability of trainable low-wage labour and stable industrial relations; well-developed industrial, transportation, and telecommunications infrastructure that facilitated early start-ups and just-in-time manufacturing; and strong government support and assistance to train the required human resources, develop local supporting industries, and provide attractive investment incentives. In this phase, human skill requirements were low and there was an abundant pool of young and easily trainable female workers.

Phase 2: Late 1970s to Late 1980s

The earlier investments in semiconductor assembly plants in which American investors dominated were followed by investments in consumer electronics in which Japanese investors were prominent. The mid-1980s restructuring of the industry saw an influx of American MNCs in industrial electronics, particularly disk drives and other computer peripherals, computer systems and integrated circuits (ICs), reflecting the increasing globalisation of the U.S. electronics industry. Singapore became a major manufacturing site for computers and peripherals. The earlier wage cost advantage had eroded and Singapore's continuing competitiveness depended increasingly on its skilled workforce and excellent infrastructure. Also, a critical mass of local electronics supporting industries emerged, especially in printed circuit board (PCB) assembly and precision engineering, in part with government support. In 1986, the EDB introduced the Local Industry Upgrading Program (LIUP), which seeks to link specific foreign MNCs with local suppliers to improve the latter's operational efficiency and technical capabilities. The human skills required in this phase were higher, necessitating significant improvements in technical education and training programmes.

Phase 3: Late 1980s to Mid-1990s

Rapid technological change and ever-shortening product cycles intensified global and regional competition. This, as well as a growing labour shortage, pressured the Singapore electronics industry into two responses. The first was to upgrade by investing in more technology-intensive operations through automated manufacturing, shifting to higher-end products such as semiconductor wafer fabrication, computer printers, telecommunications equipment, and hard disk drives, as well as product design and R&D. The second response was to relocate labour-intensive operations and mature and lower-priced product lines to neighbouring countries with greater availability of low-wage labour. The local supporting industries gained in strength and took on contract manufacturing or OEM production, as American, European, and Japanese MNCs increasingly engaged in outsourcing. Again, the upgrading of the industrial structure is evident, with the rise in technology-intensive production and the relocation of lower-end products and processes to other economies in the region.

Phase 4: Late 1990s and After

Singapore possesses core capabilities in digitisation, wireless technology, miniaturisation, automation, human interface technology, product intelligence, product management and memory wafer fabrication, and application-specific integrated circuit (ASIC) production. The semiconductor industry has been involved in IC design, automated assembly and testing, metal injection moulding and high-density multi-layer PCB manufacture (Low 2000). These diverse production processes and products are characterised by high added value and high precision, with increasing inputs from computer science, engineering, and artificial intelligence research. Singapore's Industry 21 Masterplan identified electronics as a key cluster for nurturing. The aim is to position Singapore as a world-class electronics hub, by bringing in global leaders with the latest product design, manufacturing, and applications in semiconductors, infocomm products, data storage, and key modules, and management of new products, applications and markets.

Current Status

In year 2000 Singapore's electronic products and components industry had an output value of S$82.3 billion and employed over 100,000 workers

TABLE 10.3
Electronic Products and Components Manufacturing in Singapore, 1990–2000

	1990	1995	1999	2000
Number of establishments	239	239	205	208
Output (S$ million)	27,749	57,873	68,719	82,281
Computers	1,058	9,477	10,221	–
Disk drives	7,655	13,899	18,924	–
Computer peripherals	3,420	101	–	–
Communications equipment	1,354	1,914	3,640	–
Printed circuit boards	2,909	2,930	1,143	–
Semiconductors	3,227	48	9,885	–
Wafer fabrication and integrated circuits	–	1,153	4,464	–
Value added (S$ million)	5,922	11,988	15,234	19,759
Direct exports (S$ million)	24,027	45,161	53,125	–
Employment	122,325	126,891	105,826	105,416

Source: *Yearbook of Statistics, Singapore; Census of Industrial Production*.

(Table 10.3). With the shift towards higher value-added products, employment has shrunk despite the continuing growth in output. Growth was largely driven by the semiconductor and infocomm products sub-clusters. However, the industry has been undergoing a major cyclical downturn since 2001 and closures and relocation of plants have accelerated in the more labour-intensive and low-value-added segments of the industry.

Output of the *semiconductor sub-cluster* reached S$14 billion in 1999, riding on the buoyant global demand for chips. There are currently forty semiconductor companies in Singapore, involved in wafer fabrication, assembly and test, and IC design activities; and another 160 companies supporting this knowledge-intensive industry. Singapore semiconductor companies are encouraged to team up with key industry innovators to access advanced manufacturing processes and services. However, 2000 and 2001 were not good years for semiconductor producers in Singapore with intense regional competition and the global electronics down-cycle resulting in plummeting prices and severe underutilisation of capacity.

The *infocomm products sub-cluster* includes telecommunications equipment, computers, consumer electronics, office automation, and contract manufacturing. In the telecommunications industry, the need for

instantaneous information and services continues to drive up demand for bandwidth, infocomm devices, and new applications (via wireless networks) and also in developing technologies such as 3G mobile systems, secured smart-card transactions, and Internet applications and devices. In the computer industry, strong growth in PC output is largely attributed to higher demand for desktops and services in the region, increased emphasis on outsourcing of manufacturing as MNCs focus on core competencies, boosting of supply chain management to better manage inventories and supplies, and direct sales to end-users. Singapore is building up its contract manufacturing base and supply chain management capabilities to be flexible and fast. In the consumer electronics industry, major players have moved significantly from analogue to digital technology, and Singapore's consumer electronics companies are retraining researchers and engineers to build capability in digital technology. Strong demand in the office automation industry is propelled by global demand for printers and digital imaging products. Outsourcing in this industry is creating more opportunities for contract manufacturers worldwide and in Singapore.

The *storage sub-cluster* of the electronics products and components industry has experienced intense competition and eroding prices. Hard disk drive (HDD) companies in Singapore, especially Seagate and Maxtor, have responded by automating and designing for ease of manufacturing. These firms leverage on Singapore's world-class engineering, technical, and managerial expertise and experience to restructure and streamline their operations and supply chains.

In the *key modules sub-cluster*, production of passive components and advance interconnects reached high volumes as all major industries adopted more sophisticated electronics (especially such telecommunications devices as mobile phones and pagers) and as the automotive industry increased its use of electronics systems. Passive components and PCB manufacturers performed well.

The value chain in Singapore's electronics industry includes not only manufacturing but also regional co-ordination and procurement activities. With the rapid growth of the electronics industry in the region, Singapore has become an important international trading hub for electronics. A large number of foreign MNCs have established affiliates in Singapore. Some function as international purchasing offices (IPOs) sourcing components and parts from the region for their manufacturing needs around the world and others are RHQs that co-ordinate their various activities in the Asia-Pacific region and provide support services (Chia 1997). Singapore is furthering the integration of East Asia through such procurement activities.

Electronics accounts for a very high share of Singapore's exports. This reflects not only the large volume of domestic production for export, but also Singapore's role as an electronics trading hub. Chia's (1997) study based on 1992 data, revealed three salient features of Singapore's electronics trade:

- First, the largest category of domestically produced exports was disk drives, computers and subassemblies, ICs, TV receivers, and subassemblies. Domestic exports were destined primarily for the U.S. and EC markets (64.1 percent), with Japan accounting for only 5.1 percent. The small Japanese share is noteworthy in view of the large presence of Japanese electronics firms in Singapore. It may be explained by Japan's high import barriers as well as by the strategy of Japanese electronics firms to use Singapore as an export platform for third-country markets.
- Second, entrepôt exports (from other countries' production) were concentrated in ICs, computers and subassemblies, disk drives, colour TV sets, radios and videocassette recorders, and telecommunications equipment.
- Third, East Asian countries, particularly Malaysia, provided large markets for Singapore's domestic exports of electronic components, indicating the increasingly integrated production pattern in East Asia and Singapore's role in the value chain.

Singapore's role as a trading hub in electronic products and components is evident from Table 10.4, which shows Singapore's large electronics trade with East Asia, particularly with ASEAN, in the 1990s. Table 10.5 shows that for year 2000 electronic valves (including ICs, semiconductors, colour TV tubes, CR tubes for computer monitors, TV camera tubes, microwave tubes, and parts for these products) comprised the largest share of imports, domestic exports, and entrepôt exports of machinery and transport equipment.

The progressive elimination of import tariffs and non-tariff barriers under the Common Effective Preferential Tariff (CEPT) scheme of the ASEAN Free Trade Area (AFTA) should boost intra-regional trade in electronics. The ASEAN Secretariat (2000) estimated the average tariff rate would fall to 2.7 by 2003. A similar boost is expected to come from the Information Technology Agreement (ITA) under the WTO, which committed countries to eliminate customs duties and other charges on IT products by January 2000.

Falling trade barriers with the implementation of AFTA, a general

TABLE 10.4
Singapore–East Asia Trade in Electronics, 1990–99
(S$ millions)

	1990	1995	1999
Trade with:			
East Asia	25,772.35	77,140.38	82,740.15
ASEAN	10,319.68	34,946.30	40,637.77
Brunei	73.70	171.89	101.71
Indonesia	–	–	–
Malaysia	8,402.00	26,875.62	29,576.95
Philippines	457.86	1,639.03	5,436.42
Thailand	1,335.19	5,878.49	5,065.29
Cambodia	–	73.86	23.76
Myanmar	50.93	93.11	72.99
Vietnam	–	214.32	360.65
Japan	8,975.38	20,406.18	16,396.76
China	828.62	1,888.53	4,014.74
Taiwan	2,203.57	5,793.37	8,461.27
South Korea	1,477.69	6,259.60	5,898.46
Hong Kong	1,967.41	7,846.40	7,331.16

Source: Singapore Trade Development Board.

decline in transport costs due to advances in transportation technology, and the growth of e-commerce have facilitated the emergence and growth of production networks in IT goods in the East Asian region. This accelerates the trend brought about by changing comparative advantage and cost-competitiveness. Singapore has seen the progressive shift of labour-intensive products and processes to lower-cost destinations in the region, while higher value-added and more technology-intensive products and processes take their place in the Singapore production structure.

Prior to the outbreak of the 1997–98 Asian financial crisis demand for ICT goods in East Asia and Singapore grew at a phenomenal rate. This reflected developments on several fronts including increasing range and sophistication of ICT products and their rapidly falling prices as a result of productivity gains; rising affluence and urbanisation of the population; spreading use of ICT by businesses seeking to improve efficiency and productivity; and increasing adoption of ICT by the government sector. Electronics trade and demand in the region were adversely affected by the financial crisis but rebounded significantly in 1999 as a result of the sharp

TABLE 10.5
Trade in Machinery and Transport Equipment 1990–2000

	Amount (S$ millions)			Composition (%)	
	1990	1995	2000	1990	2000
Total trade in machinery and transport equipment	96,798	212,062	301,470	100.0	100.0
Electronic valves	14,743	56,336	112,159	15.2	37.2
Parts for office and data processing machines	8,014	23,143	36,460	8.3	12.1
Data processing machines	15,487	35,114	44,527	16.0	14.8
Communications equipment	8,454	18,207	19,218	8.7	6.4
Electrical machinery	2,936	7,849	12,314	3.0	4.1
Electrical circuit apparatus	3,781	8,387	11,972	3.9	4.0
Subtotal	53,415	149,036	236,650	55.2	78.5
Imports of machinery and transport equipment	49,065	102,055	141,068	100.0	100.0
Electronic valves	8,108	30,284	52,729	16.5	37.4
Parts for office and data processing machines	4,328	10,535	17,030	8.8	12.1
Data processing machines	3,159	7,439	11,000	6.4	7.8
Communications equipment	4,234	8,470	8,814	8.6	6.2
Electrical machinery	1,774	4,272	6,468	3.6	4.6
Electrical circuit apparatus	2,384	4,915	6,343	4.9	4.5
Subtotal	23,987	65,915	102,384	48.9	72.6

continued on next page

TABLE 10.5 – cont'd

	Amount (S$ millions)			Composition (%)	
	1990	**1995**	**2000**	**1990**	**2000**
Total exports of machinery and transport equipment	47,733	110,007	160,402	100.0	100.0
Electronic valves	6,635	26,052	59,430	13.9	37.1
Parts for office and data processing machines	3,686	12,608	19,430	7.7	12.1
Data processing machines	12,328	27,675	33,527	25.8	20.9
Communications equipment	4,220	9,737	10,404	8.8	6.5
Electrical machinery	1,162	3,577	5,846	2.4	3.6
Electrical circuit apparatus	1,397	3,472	5,629	2.9	3.5
Subtotal	29,428	83,121	134,266	61.7	83.7
Domestic exports of machinery and transport equipment	32,352	67,751	85,851	100.0	100.0
Electronic valves	4,844	13,501	26,533	15.0	30.9
Parts for office and data processing machines	3,079	10,507	13,417	9.5	15.6
Data processing machines	10,995	22,810	24,867	34.0	29.0
Communications equipment	2,985	5,745	5,343	9.2	6.2
Electrical machinery	755	1,976	2,432	2.3	2.8
Electrical circuit apparatus	981	2,178	2,974	3.0	3.5
Subtotal	23,639	56,717	75,566	73.1	88.0
Entrepôt exports of machinery and transport equipment	15,381	42,256	74,551	100.0	100.0
Electronic valves	1,791	12,551	32,897	11.6	44.1
Parts for office and data processing machines	607	2,101	6,013	3.9	8.1
Data processing machines	1,333	4,865	8,660	8.7	11.6
Communications equipment	1,235	3,992	5,061	8.0	6.8
Electrical machinery	407	1,601	3,414	2.6	4.6
Electrical circuit apparatus	416	1,294	2,655	2.7	3.6
Subtotal	5,789	26,404	58,700	37.6	78.7

Source: *Yearbook of Statistics*, Singapore.

recovery in global electronics demand, thus spearheading a V-shaped recovery for several regional economies in year 2000. The downturn of the global electronics industry in 2001, reflecting the rapid slowdown of the U.S. economy, cast a new pall on economic growth in the region in 2001 and on the first half of 2002 however.

ICT Services and Policies

Singapore's IT "software" industry is much younger than its "hardware" counterpart. Data on Singapore's trade in ICT services are not readily available. It is increasingly difficult to distinguish ICT services from traditional non-ICT services as ICT penetrates into all economic sectors, including retail trade and transport. The importance of the ICT services industry including software, content, and other ICT services came to be recognised with the rapid computerisation during the 1990s. Government agencies were in the forefront promoting the development and use of ICT services in Singapore. Four phases can be distinguished.

Phase 1: 1980–85

The government launched a national information technology drive, embodied in the National Computerisation Plan in 1981 outlining three objectives: computerisation of the civil service, training of software professionals, and building the local IT industry to expand software and services (NCB 1992). The Civil Service Computerisation Programme (CSCP) was launched in 1982 to spearhead the national computerisation effort and set the pace for the application of ICT in the rest of the economy. CSCP applications were designed to improve productivity within the government sector and to link and co-ordinate the various government ministries and agencies. The pool of ICT professionals produced by the CSCP as well as technology transfers by foreign MNCs supported the spread of ICT in the private sector, but domestic R&D in ICT remained weak.

Phase 2: 1985–92

In 1985, the National Computer Board (NCB) introduced the National IT Plan (NITP) for Singapore. The plan outlined a seven-pronged ICT strategy — developing IT professionals and experts; improving the ICT infrastructure; promoting the ICT industry; co-ordinating and collaborating

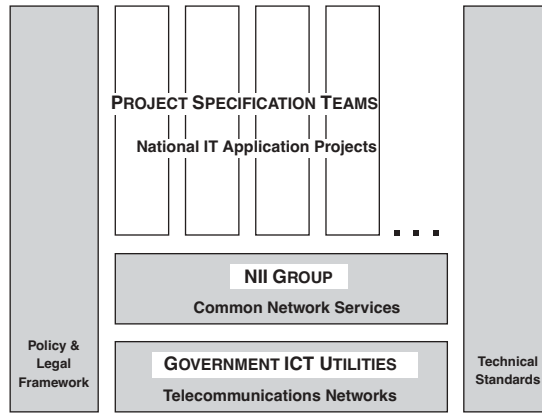
between various ICT-promoting organisations; establishing a culture that welcomes ICT; encouraging creativity and entrepreneurship; and increasing ICT application in workplaces (Tan et al. 1985). Use and development of ICT accelerated during this period through:

- expanded computerisation of the civil service;
- diffusion of ICT in key industries;
- alliances with international software firms to develop local engineering skills and IT segments;
- organised events promoting ICT culture;
- installation of fibre optics and integrated services digital network (ISDN) capabilities;
- one-stop and non-stop public service facilities;
- introduction of a national electronic data interchange (EDI) system;
- revamped educational system, with computer awareness programmes and increased emphasis on mathematics and technical competencies in schools and on ICT training in polytechnics and universities;
- increased emphasis on R&D, with expenditures rising to S$374.7 million and 0.9 percent of GDP by 1988; and
- growth in IT manpower.

Phase 3: 1992–2000

In 1992 NCB released the IT2000 Plan outlining a vision of Singapore as an "Intelligent Island", based on an advanced National Information Infrastructure (NII), which would interconnect computers in virtually every home, school, and workplace. IT2000 aimed at intensified development of ICT-related manpower; improved quality of life; improved personal and community communications; use of the NII to establish a competitive advantage both within and beyond Singapore; and the positioning of Singapore as a regional hub by plugging into international business networks. Figure 10.6 shows the overall organisational framework for the NII. A high-level steering committee co-ordinated policy across government ministries and agencies. Major IT and telecommunications projects were the responsibility of NCB and the Telecommunications Authority of Singapore (TAS) respectively. EDI applications included TradeNet, LawNet, MediNet, and PortNet. Cashless transactions included the GIRO service which provides for automatic transfer of funds from bank accounts to designated merchants or government bodies and the Network for Electronic Transfer System (NETS) which enables electronic fund transfers at point

FIGURE 10.6
Framework for Singapore's National Information Infrastructure (NII)



Source: National Computer Board, IT2000 Report.

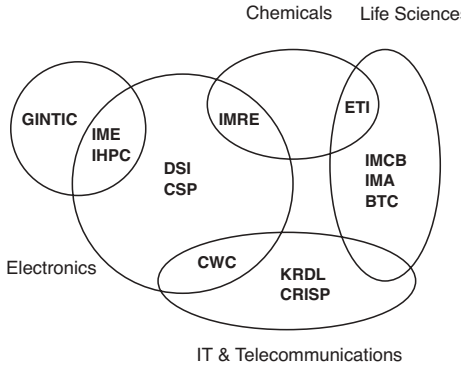
of sale for credit and debit card transactions. Singapore ONE was launched commercially in June 1999 as an island-wide broadband high-speed infrastructure of high capacity networks and switches for multimedia applications — entertainment, news, education, online shopping and other e-commerce services, video-conferencing, government transactions and fast Internet.

Key developments on the ICT policy front during this phase were the liberalisation and consolidation of the telecommunications industry as well as the convergence of information technology, broadcasting, and communications media. As licensing restrictions were lifted and new players entered the market, service operators' fees collapsed and fees for international calling services, mobile phone use, and Internet access plummeted. NCB was merged with TAS to form the Infocommunications Development Authority (IDA). The National Science and Technology Board (NSTB) was restructured to work on six key thrusts — to promote science and technology to students, professionals, and the public via growing technopreneurial businesses; to develop a conducive environment; to promote finance and investment; to develop manpower for R&D and technopreneurship; to establish international operations; and to strengthen the technology infrastructure.

Technopreneurship 21 (T21) was launched in 1999 to foster creativity, innovation, and entrepreneurship. It focused on three areas of ICT development:

- Revamping the education system (schools, polytechnics, universities) to foster creativity. Polytechnics and universities were restructured to emphasise laboratory work. Public research institutes/centres (RICs) were positioned to bridge basic research by universities and applied research by the private sector. Figure 10.7 shows the RICs and the industry clusters that they support.
- Creating a US$1 billion Technopreneurship Investment Fund (TIF) to develop the venture capital industry. In 1998–99, seventy-one start-ups received venture capital funding totalling S$252 million, with the majority of funds going towards ICT-related ventures. NSTB also has a S$150 million Technology Development Fund.
- Revamping the legal and regulatory framework to make it more ICT-friendly and bring it in line with international standards and models. A study group convened in February 1997 recommended providing an environment more conducive to e-commerce, including a commercial code, public key infrastructure, and review of existing legislation.

FIGURE 10.7
Public Research Institutes and Centres (RICs) Grouped by Industry Focus



Key:

BTC	Bioprocessing Technology Centre
CRISP	Centre for Remote Imaging, Sensing & Processing
CSP	Centre for Signal Processing
CWC	Centre for Wireless Communication
DSI	Data Storage Institute
ETI	Environmental Technology Institute
GINTIC	Gintic Institute of Manufacturing Technology
IMRE	Institute of Materials Research & Engineering
IME	Institute of Microelectronics
IMA	Institute of Molecular Agrobiology
IMCB	Institute of Molecular & Cell Biology
KRDL	Kent Ridge Digital Labs
IHPC	Institute of High Performance Computing

Source: NSTB 2000.

By 1999, the infocomm sector (excluding manufacturing) generated revenue of S$20 billion, amounting to 6 percent of Singapore's GDP. Internet penetration of companies and businesses reached 81 percent; 57 percent of the population had dial-up Internet and 66 percent had mobile phones; and 59 percent of households had PCs and 99 percent were broadband-ready.

Phase 4: Infocomm 21 Masterplan

The Infocomm21 Masterplan marks a concerted effort to transform Singapore into a dynamic and vibrant global ICT hub with a competitive e-economy, an infocomm-savvy e-society, excellence in e-government, and e-learning hub. It builds on the earlier foundation of the NII and encompasses ICT goods, services, human resources, and infrastructure.

The interactive broadband and multimedia (IBBMM) and mobile wireless network represents the next step in physical infrastructure after the NII, which was the focus of ICT policy during the 1980s and 1990s. The Masterplan aims for a pervasive infocomm network that would support high-speed wireless data access by 2005 (IDA 2000*b*). This would be realised through xDSL and cable modem technologies, optical fibre installations, fixed wireless technologies, and 3G mobile networks. Development of the broadband infrastructure, broadband industry, and broadband user base progressed steadily in 1999–2000. The wireless broadband market is also expected to grow very rapidly. With developing technological capabilities, industry investments, and falling broadband access costs, more consumers can access the Internet at much higher speeds. With a mobile phone penetration rate of two-thirds of the population, Singapore will be one of the leaders in Asia to embrace mobile Internet. SingTel, Mobile One, and Starhub have launched commercial wireless application protocol (WAP) service. Singapore CableVision currently provides cable broadband in Singapore. Full liberalisation of telecommunications services is expected to expand the choices and competition in this area. The economic recession in 2001 forced postponement of the issuance of 3G licences.

A key component of Infocomm 21 is a fully liberalised telecommunications market with competitive pricing and wider choices. The government had already revised and accelerated the schedule for liberalisation of telecommunications and for convergence of information technology, broadcasting, and communications media. By the year 2000, Singapore had issued or expanded more than 150 telecommunications

licences. Coaxial cable access has been installed in many homes and optical fibre reaches more than 90 percent of homes. A host of leading satellite content providers has set up regional centres in Singapore, including HBO, ESPN, MTV, and Discovery Channel.

Another key component of Infocomm 21 is the legal and policy framework for the development of the ICT sector. The existing legal, regulatory, and enforcement framework was revised to conform to international standards and regulatory changes were made to enhance provision of ICT services. The Electronic Transactions Act and amendments to the Computer Misuse Act aimed at promoting and enhancing trust and confidence in e-commerce and ICT services.

Manpower strategies for the infocomm sector include enhancing the environment to nurture an Internet-savvy workforce by providing top-flight education and training in infocomm skills and establishing standards for infocomm professionals and users; attracting and retaining international infocomm talents; and establishing Singapore as the e-learning hub for the region. Policy increasingly favours the recruitment of ICT service professionals as well as more use of electronic methods for training and education. The goal is to have a body of 250,000 infocomm workers, or 10 percent of the workforce, by 2010 (IDA 2000*a*).

Internet, E-government, and E-commerce

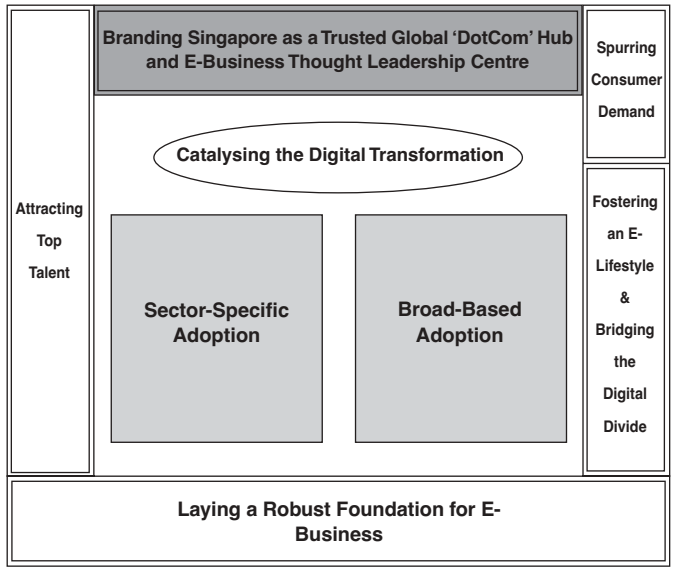
Singapore is an important regional Internet hub, with many companies using Singapore as their key data centre. For example, in 1999, Citibank set up its only Global IT and Data Centre to service fifty-six countries from Singapore. Other notable projects included 1-Net and the ST Telemedia/Sun-Netscape Alliance which announced plans to provide facilities infrastructure and services for web hosting. Several ISP/IX deregulation measures paved the way for more competition and new entrants including DataOne, Cable and Wireless, and UUNet. Netlife AG, one of the top players in Internet application software, established its first R&D centre outside Hamburg and its Asia headquarters in Singapore. Origin BV, a global leader in IT consulting and services, became the first European IT services company to establish a business headquarters in Singapore. It will set up five competency centres including a global enterprise management system and an enterprise resource planning outsourcing centre. In addition, Internet companies such as Lycos, Monster.com, Acer's 1to80.com, E! Online Asia, and MTV Asia have also based their Asia-Pacific operations in Singapore. Companies that have

located Asia-Pacific e-commerce hubs in Singapore during the past two years include HP, Compaq, Apple, GES, NatSteel, BeXcom, IBM's e-procurement, Advanced Manufacturing Online, and Federal Express.

The Singapore government was one of the earliest to provide its services online, although it encountered systems development costs and security issues problems along the way. Following the CSCP of the early 1980s, government departments aggressively expanded computer systems in the late 1980s under the National IT Plan (NITP), and computers and computer applications penetrated all areas of government during the 1990s (under IT2000). Under Infocomm 21, an e-Government Action Plan was initiated to succeed the CSCP, with a S$1.5 billion budget to fund programs over a three-year period, paralleling efforts to change the mindset of civil servants to the ways of doing business in the New Economy. Government online services for the public include the electronic filing of income tax forms and the e-citizen website.

E-commerce requires a self-sustaining, complete framework with mutually reinforcing components including a telecommunications

FIGURE 10.8
Framework for Electronic Commerce in Singapore



Source: IDA 2000.

infrastructure to support the growth of software developers, Internet builders, and application service providers; portals and intermediaries to support e-commerce; and a supporting sound financial system and efficient supply chain management process. Singapore launched an e-commerce master plan in September 1998, marking the start of a campaign to bring e-commerce to mainstream businesses and the public and to attract international e-commerce activities. Singapore also has a vision of becoming a hub for processing e-commerce transactions from the region and the rest of the world. Figure 10.8 summarises the framework of the strategy to develop e-commerce in Singapore. At its foundation are the infrastructure services and setting. The other aspects of e-commerce policy are to spur online consumer spending, to enhance e-business readiness, and to foster digital transformation by encouraging broad-based community use of e-commerce and a more sector-specific cluster policy to encourage adoption of e-commerce.

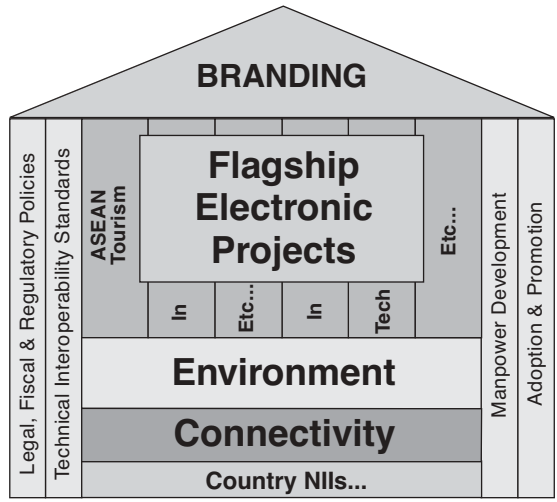
Development of e-ASEAN

The ASEAN region (and the broader East Asia region) has become a major export production platform for ICT goods, but the region has not developed fully the production and use of ICT services (i.e., the production of information and the application of ICT to improve productivity and competitiveness). Apart from Singapore, the other ASEAN countries have fallen behind in the adoption and diffusion of ICT, especially with regard to e-commerce and the Internet.

The Third ASEAN Informal Summit of November 1999 established an e-ASEAN Task Force to develop a broad and comprehensive action plan for an ASEAN e-space and to develop competencies within ASEAN to compete in the global information economy. This led to the e-ASEAN Framework Agreement of November 2000. The Agreement's objectives are to promote co-operation to develop, strengthen, and enhance the competitiveness of the ICT sector in ASEAN; to promote co-operation to reduce the digital divide within individual countries and among ASEAN countries; and to promote the liberalisation of trade in ICT products, services, and investments (Figure 10.9).

The e-ASEAN agreement and the liberalisation of trade in ICT products and services will hasten the process of regional integration through declining transaction and trade costs. Intra-regional ICT production and distribution can be expected to change. The business sector as well as policymakers are

FIGURE 10.9
Conceptual Pillars of e-ASEAN



Source: *Summary Report on the Feasibility of the AII*.

poised to pursue the opportunities that e-ASEAN presents to develop Singapore's role as an ICT hub.

CONCLUSION

ICT plays two roles. It is a growth sector in its own right and it enhances competitiveness and efficiency throughout the economy. Increasing returns to scale and spillover externalities of the ICT revolution heralded the New Economy. The ICT revolution is spurring globalisation and changing comparative advantages and economic competitiveness. By lowering transaction costs, including costs of transportation and communication, the ICT revolution has facilitated industrial clustering and the emergence of nodes and hubs. In East Asia, the flying geese pattern of industrial geography with unidirectional flows and hierarchical production networks is transforming into a web of nodes and clusters inter-linked through multi-directional flows of trade, capital, investment, and people reflecting complementarities in demand and supply.

Singapore is striving to become a knowledge-based economy, as it can no longer compete in traditional activities. It is essential for Singapore to develop ICT as a growth sector as well as to use ICT to raise productivity, enable business, and transform society. Crucial factors in ICT development are a good physical and institutional infrastructure, human resources, science and technology development, and entrepreneurial drive. The public sector has poured tremendous resources into developing an advanced physical infrastructure, supported by necessary changes in co-ordinating and supporting institutions and in the legal and regulatory framework. The science and technology development is being put in place by increasing funds allocated to R&D and greater emphasis on partnerships among research institutions, the business sector, and the government sector.

Building a critical mass of human resources and entrepreneurs is a challenging problem, given Singapore's small population base and risk-averse mindsets. Efforts to expand ICT-related education and training in schools, polytechnics, universities and at the workplace are progressing well, complemented and supplemented by the aggressive recruitment of international talent. In past decades the prevalence of Confucian values, a political culture that emphasised stability and order in society, and an education system geared to examinations contributed to Singapore's economic success, but these characteristics are now increasingly viewed as stifling creativity and the ability of the economy and society to move forward.

The dominance of government and state-owned enterprises ("Singapore, Inc."), pervasive presence of foreign MNCs, and attractive remuneration and career paths in the bureaucracy and foreign MNCs have stifled the development of domestic entrepreneurship. Changing mindsets is an uphill task, but efforts are being made to revamp the educational system, lighten the heavy hand of government, and create an environment that is more conducive to the emergence of entrepreneurship.

With increasing returns, an economy that aspires to take on a hub role benefits from moving first. Growth in the new framework is crucially contingent on having the right initial conditions for the interplay of market forces as well as on policymakers putting in place necessary policy and institutional frameworks. We have seen that Singapore has realised many of the quantitative and qualitative conditions that the Fujita, Krugman, and Venables and Porter models suggest influence the formation and development of industrial clusters and agglomerations. These characteristics will reinforce the city-state's continuing competitiveness as a regional hub, including its goal of becoming a hub for ICT goods and services. Its

solid legal framework and supporting ICT infrastructure — in terms of the physical IBBMM network and the science and technology environment — attract ICT players, including both large foreign MNCs and smaller domestic (and possibly regional) technopreneurial start-ups.

For Singapore to become an ICT hub for Southeast Asia or the wider East Asia region first its ICT sector must be competitive *vis-à-vis* other existing and potential hubs in the region and beyond. In addition, though, it must co-operate politically and economically with the region's economies so that the region as a whole advances. The hub and the hinterland will mutually benefit as all the economies take advantage of the ICT revolution. As the most ICT-ready economy and society in the ASEAN region, Singapore can help its neighbours overcome the digital divide. Singapore's experience in ICT development can have demonstration effects for what to do and how to do it, and the rest of Southeast Asia can benefit from Singapore's lead to lower their learning curve and leapfrog. Singapore can provide training for lesser-developed Southeast Asian economies. As a hub, Singapore can link up the economies of Southeast Asia and it can link the Southeast Asian economies to the wider world. Singapore can be a key player in e-ASEAN, to help integrate ASEAN as well as ensure ASEAN's competitiveness *vis-à-vis* the rest of the world. As other economies in the region develop their own ICT hubs, the competition and co-operation will result in a more ICT-vibrant Southeast Asia and East Asia.

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