EMPLOYMENT AND TRAINING
PAPERS

13

Jobs, technology and skill requirements in a globalized economy: Country study on Singapore

Linda Low
Associate Professor
Department of Business Policy
National University of Singapore

Employment and Training Department
International Labour Office Geneva

ISBN 92-2-110978-X
ISSN 1020-5322

First published 1998

Foreword

The present study on the occupational and skill composition of labour in the manufacturing sector in Singapore is part of a set of country studies on the project "***Jobs, technology and skill requirements in a globalized economy",*** undertaken by the Employment and Labour Market Policies Branch.

The study by Linda Low from the Department of Business Policy of the National University of Singapore provides an informative and stimulating account of how a fast restructuring economy has been coping with its rapidly changing skills environment. Within a span of 25-30 years, the economy of this small city-state has moved from a rather labour-intensive export economy to a high ranking information technology business and trading centre.

The paper provides a chronicle of how the government and the private sectors, through strategic planning have overcome the critical skills constrain in which in many countries hamper the pace of industrial restructuring. The author discusses the role played by specific labour market policies in the increased competitiveness of new growth sectors.

Specific sectoral policies and measures which encourage the generation of high quality jobs to maintain international competitiveness were also analysed. The paper also mentions, though does not elaborate, the role of the tripartite partners in changing skills development partners.

Other studies to be published in this series cover changes in the structure of employment in view of increased exposure to international trade and technology in Mexico, Brazil, the Republic of Korea, and Canada.

Gek-Boo Ng,
Chief,
Employment and Labour Market Policies Branch,
Employment and Training Department

Contents

Jobs, technology and skill requirements in a globalized economy: Country study on Singapore

1. Introduction

As the Singapore economy is very dependent on trade and direct foreign investment and intimately tied up with the global economy, it is much affected by the new emerging trends in terms of globalization and technology which has prompted substantial industrial and corporate restructuring. In response to these opportunities and challenges, strategies and measures to ensure the productivity and competitiveness of the labour force are constantly being reviewed and finetuned. As far as possible, a tripartite approach involving labour, management and government is taken to ensure the success of these policies and programmes.

To date, the resilience of the economy and socio-political environment consistent with these global changes have served Singapore relatively well. However, with rising competition from the region and further restructuring, the role and contribution of the manufacturing sector vis-a-vis the service sector has attracted some interest. While the service sector is being promoted as another engine of growth, some core manufacturing activities as in high-technology and high-end electronics are deemed essential for a balanced industrial structure.

To meet with the new demands of manufacturing in line with Singapore's comparative advantage and competitive advantage, an in-depth study of the occupational and skill composition of labour in the manufacturing sector is germane. New technologies as well as new realities in economics as affecting trade and investment are impacting on the structure of employment, skills base and other labour market issues. This study will thus be illuminating in identifying the role played by specific labour market policies in the increased competitiveness of new growth sectors. Specific sectoral policies and measures which encourage the generation of high quality jobs to maintain international competitiveness will be analysed.

Some element of supply-led growth from conscious manpower development for certain desired emerging sectors may also catalyse the growth of some sectors apart from demand-led growth which stimulates the production of the requisite skills. While the latter approach is more common and can come from an analysis of sectoral growth and employment over time, a forward-looking strategy is also useful.

1.1 Caveats in information and statistics

For a study relying on published information and statistics, the biggest constraint would be unavailability of vital data to satisfy specific parameters deemed important to establish linkages and relationships affecting jobs, technology and skills requirements. As such, an understanding of various agencies responsible for statistics in Singapore is germane. The sources tapped for this study comprise:

1) The Ministry of Labour (MOL) conducts the annual labour force survey and is the only source with educational qualifications as a variable. But it covers sectors only at one-digit level, that is, manufacturing as a whole with no breakdowns.
2) The Economic Development Board (EDB) conducts census of industrial production (CIP) on establishments with more than 10 workers. It has principal statistics of manufacturing including employment, output, value-added, remuneration, direct exports, net fixed assets

at up to five-digit level. But it does not ask anything of educational qualifications and skills of workers.

3) The Trade Development Board (TDB) is responsible for trade data comprising imports, exports (direct and reexports), both the composition and direction of trade. Like EDB, TDB does not track skill content or technological content of exports and imports. Moreover, the industry classification of TDB differs from that used by EDB.

4) Besides collating statistics and from various agencies and publishes them in an annual yearbook of statistics, the Department of Statistics (DOS) conducts household expenditure surveys and other surveys to produce census of services and census of other service sectors. The household expenditure surveys are conducted every five years to compute consumer price index. Since 1995, it has published a *General Household Survey* pertaining to household information covering economic, labour, employment, demographic and other social statistics over and above what is published in its *Household Expenditure Survey*. It is in charge of population census conducted every ten years, the next in 2000. Output of manpower from various educational institutions of higher learning by courses sourced from the Ministry of Education are found in its *Yearbook of Statistics*. But their employment by sectors beyond one-digit level is not tracked by any agency, perhaps only in population census when such details are collected for administrative purposes.

5) The Skills Development Fund (SDF) provides grants for approved training and provides information on funds committed and training places provided for under very broad categories, namely, manufacturing and services. Where some breakdowns are given, they are to highlight major sectors like electronics which are actively supported.

6) The Production and Standards Board (PSB), formerly the National Productivity Board (NPB) is geared more at running courses, seminars and workshops to help industries to upgrade their workforce. When it does any productivity studies, broad sectors (one-digit) are used. In many senses, PSB is a "junior" board compared to EDB which is the most powerful agency being vested with investment promotion and devoted to manufacturing. The PSB does not conducts any national or sectoral surveys on its own. In fact, national and sectoral productivity are computed by other agencies which conduct the necessary surveys like EDB and DOS, not PSB.

7) The National Science and Technology Board (NSTB) was formed only in 1991 and it concentrates on promoting research and development (R&D) in two main aspects, namely, raising R&D expenditure as a share of gross domestic product (GDP) and increasing the ratio of research scientists and engineers (RSEs) in the labour force. It does not collect any statistics on technology content of output or exports.

Apart from these official agencies, the following were also tapped for information and studies:

8) The National Trades Union Congress (NTUC), the umbrella organization of all registered trade unions in Singapore. Apart from a membership list and keeping track of union interests and collective agreements, it does not run any comprehensive survey or has a database on education and skills by sectoral breakdowns.

9) The Singapore Institute of Labour Studies (SILS) is the training and research arm of NTUC. Apart from *ad hoc* and small sample surveys to address a specific issues of interest, it relies on published sources of statistics and does not generate any of its own.

The universities and other research institutes are also tapped for any micro studies or sectoral studies based on academic exercises or other theses at more detailed levels, two- or three-digit levels. But where studies are done, they rely on published data as running any detailed robust micro surveys is demanding in time and resources. Researchers are wary of poor response rates from enterprises for non-official surveys which are not covered by a statistical act or empowered by an official agency.

This study thus suffers severely from a lack of detailed breakdowns by industry. Even trying to crossmatch databases is futile as the classification systems are different as in the case of EDB and TDB data. There is no possibility of decomposing or reclassifying the manufacturing sector as the crucial variables like educational and skills level, size of firms or intensity of technology (high, medium and low) are non-existent. As Singapore is not a member of organizations like the Organization of Economic Cooperation and Development (OECD), it does not have readily available statistics as one might expect for detailed micro analyses as for developed industrial countries.

1.2 Methodology

Given these constraints, productivity measured as value-added per worker, output per worker and export performance in terms of amount of output exported become key variables to work with. The assumption is that they correlate with high-technology, skill-intensive and export-oriented sectors.

As will be explained, some of these high value added industries are actively promoted through direct foreign investment (DFI) and multinational corporations (MNCs) which bring in the technology, skills and export markets. Because Singapore through the EDB uses worldclass MNCs as the benchmark of any industry identified for promotion, one may safely assume that industries which have a high concentration of such foreign dominance would ensure sufficiently high levels of skills and technology in employment created. Otherwise, MNCs would not have been attracted into Singapore if it were not internationally competitive. Singapore has been consistently rated as the second most competitive economy after the US by Lausanne-based World Competitiveness Yearbook and the most competitive by Geneva-based Global Competitiveness Report.

Singapore has a peculiar attribute that it is more dependent on DFI and MNCs than most newly industrialising economies (NIEs) and other developing countries. This means sectors where MNCs dominate and do well by indicators like productivity, export orientation or ratios of output and net fixed capital to workers, they help Singapore's aspirations to be a developed industrial nation through high technology, capital intensive and high skilled employment creation. With its labour constraint as a small, open economy, it has no other options.

Thus, where it is not possible to demonstrate the linkages and relationships binding jobs, technology and skills requirement directly, other indirect ways or through deduction have to be used in the study. In the main, statistics on the manufacturing sector from the EDB remain the most important source, supplemented by the TDB and Ministry of Labour. The impact of technology or skills upgrading on exports or global competition may not be directly measurable. But where available, qualitative or anecdotal evidence have to be relied upon.

2. An overview of the macroeconomic performance and policies

It is not the objective here to give a detailed description and evaluation of Singapore's industrialization strategies and policies. Industrialization in Singapore has followed the typical low value-added import-substituting phase in the 1960s to export-orientation from the late 1960s after it left Malaysia and with it, the prospects of a common market (Chng, et al, 1986 and Low, et al, 1993). Industrialising by attracting DFI and MNCs brought in the needed expertise, technology and markets.

The openness of the economy has in fact increased over time. Total trade (imports plus exports) to gross national product (GNP) was 209.7 per cent in 1970, rising to 383.6 per cent in 1980. The ratios declined somewhat to 299.9 per cent in 1990 and 258.9 per cent in 1996 but they are still unusually high to reflect the resource scarcity and dependence on external markets for a city state economy.

Foreign investors dominated the manufacturing sector, owning around two-thirds of total equity invested. Five top investors (Japan, US, UK, Switzerland and Hong Kong) accounted for 59.3 per cent of foreign equity, the percentage rising to 73.9 per cent in terms of top eight investors in 1994.

Foreign capital is mainly in high capital-intensive industries such as electronics, electrical, chemicals and petroleum. In 1993 and 1994, investment commitments in the electronics and electrical sectors accounted for 36.6 per cent and 27.1 per cent respectively of total commitments, the largest amounts. The smaller proportion in 1994 was because investment commitments in both industrial chemicals and petroleum were large, accounting for 20.7 per cent and 20.5 per cent respectively of the total that year. These are also the most important manufacturing sectors in terms of output, value added, employment, exports and technology.

But there is the price of vulnerability of such dependence. The slowdown in growth in the manufacturing sector from 10.0 per cent in 1995 to 3.4 per cent in 1996 has been largely attributed to the downturn in global electronics demand. The US is a major market for electronics products as US subsidiaries in Singapore export components and parts back to their parent companies. This chain of double dependence, on electronics and the US market is a vulnerable but an unavoidable aspect of Singapore's industrial structure.

Economic growth in Singapore remains largely generated by external demand, around four-fifths of total demand over the last three decades. In 1996, domestic demand accounted for one-third, a slightly higher share of total demand in line with the regional slowdown and downturn of the global electronics industry.

Another aspect of the open economy comes with Singapore's regionalization policy, that is, a higher rate of outward direct investment to build up the external economy. Overseas operations' contribution to total value-added reached 11 per cent in 1996, twice that in 1996. This is expected to increase as projects in China, Vietnam, Indonesia, Bangalore and elsewhere bear fruits. The performance of such outward direct investment would depend more on growth and macroeconomic policies in these host countries rather than Singapore's fiscal and monetary policies. One dimension in policy for stabilization is thus reduced in this context.

2.1 Economic performance

Table 1 provides some broad economic indicators to show macroeconomic performance and success of policies thus far. Overall positive outcomes are seen in rising indigenous GNP per capita, falling and stable unemployment and inflation rates, strengthened balance of payments surplus reflected in the rising ratio of official foreign reserves to months of merchand imports. But the economy is maturing.

Real GDP growth has stabilized to 7.0 per cent by 1996 with projected long term growth to be between 4 per cent to 6 per cent as resource constraints set in. Some limits also appear to be experienced in productivity growth and growth in total trade as numbers there experience slowing or declining trends. Rising unit labour costs and unit business costs lessen Singapore's international competitiveness. While a strong Singapore dollar keeps imported inflation in check, the adverse impact on exports of both goods and services is the tradeoff.

Table 1. Basic economic indicators, 1970-1996*

	1970	1980	1990	1996
Real GDP growth (1990 = 100)	9.4	7.4	9.0	7.0
Indigenous GNP per capita $S	2 478.1	8 342.8	20 641.9	34 220.4
Gross national saving as per cent GNP	19.3	34.2	43.9	49.7
Unemployment rate %	6.0	3.5	1.8	2.0
Productivity ann change %	4.3	5.0	4.1	0.7
Consumer price index ann change %	5.6	2.7	3.4	1.4
Total trade ann change %	20.2	10.3	11.4	5.1
Unit business cost index of mfr (1988 = 100)	na	98.5	113	125.4
Unit labour cost index of mfr (1988 = 100)	na	81.3	118.7	127.9
Tourism arrivals '000	521.7	2 562.1	5 322.9	7 292.5
Ratio of official reserves to merch imports (mths)	4.9	3.2	5.3	7.0

Source: Singapore, Ministry of Trade and Industry, Annual Economic Survey 1996, Singapore: Singapore National Printers, 1997.

* Effort is made to present data up to 1996 but lags in publication by some agencies do not always make this possible in subsequent tables.

2.2 Industrial restructuring

While still heavily reliant on services (comprising commerce, transport and communication, finance and business services and community, social and personal services), the share of manufacturing has ranged from over 20 per cent to 30 per cent over the period since 1970. The financial and business services sector has overtaken manufacturing as the largest contributor to GDP. In 1990, the manufacturing sector accounted for 29 per cent of nominal GDP while the share of the financial and business services sector was 26 per cent. By 1996, the shares were 26 per cent and 31 per cent respectively.

Reflecting the industrial restructuring is the change in pattern and composition in employment shown in Table 2. Growth in labour force since 1970 is less than 3 per cent (2.8 per cent) which also spurred the restructuring away from foreign worker dependent, low skilled labour-intensive manufacturing.

The employment share of manufacturing has shrunk from 29 per cent to 23 per cent between 1990 and 1996 while the share of services sectors has risen from 63 per cent to 70 per cent over the same period. Within the services sector, employment growth was highest in finance and business services whose share rose from 11 per cent in 1990 to 14 per cent in 1996. The rise in employment was mainly in the insurance, information technology and brokerage services.

Table 2. Distribution of employed persons by industry, 1970-1996 (per cent/no)

	1970	1980	1990	1996	Growth
Agriculture, etc.	4	2	0	0	-5.5
Manufacture	22	30	29	23	3.0
Utilities	1	1	0	0	-0.2
Construction	7	7	8	7	2.8
Commerce	23	21	22	23	2.8
Transport & Communication	12	11	10	11	2.6
Fin & Bus services	4	7	11	14	6.9
Others	27	21	20	21	2.1
Svcs nad	0	0	0	1	9.7
Total	100	100	100	100	2.8
Total (no)	650 892	1 077 090	1 532 400	1 748 100	2.8

Svcs nad = services not adequately defined
Source: Singapore, Ministry of Labour, Report of the Labour Force Survey, various years.

There is also a rising trend in part-time employment which is interesting. It reflects the intensive tapping of housewives and homeworkers in the face of labour shortage. Part-time employment has grown at about the same pace as overall employment growth over the last decade. In 1996, there are about 59,000 part-time workers or 3.4 per cent of total workforce. About two thirds (67 per cent) of them are women and some 60 per cent are at least 40 years and more reflecting the partial return of married women to the labour force when their domestic demands are less pressing. However, the majority (77 per cent) of them are in low skilled jobs in the services sector as the educational and skill content of these older part-time workers would be so.

2.3 Higher skill content of labour force

Two indicators show higher skill content of the labour force. Table 3 shows the highest qualification attained of all employed persons since 1973, the first year that labour force survey was conducted. The proportion of the workforce who have no education or only lower primary and primary or lower secondary qualifications have fallen since 1970. Larger proportions of post secondary, diploma and university graduates are attained.

Table 4 on employed persons by occupation reinforces the upgrading in skills as there is a larger proportion of the workforce as legislators, senior officers, managers; professionals; and technicians and associated professionals. The share of production and manual workers has also fallen as manufacturing employment stabilized. Agricultural, fishing and quarrying workers is almost non-existent by 1996.

Table 3. Distribution of highest qualifications attained of all employed persons, 1973-1993 (per cent)

	1973	1983	1990	1996	Growth
Never/ Low pr	16	23	18	15	2.4
Pr/Low sec	41	31	31	9	-2.3
Low sec +	na	na	na	14	na
Sec	35	30	30	31	2.1
Post sec	5	11	10	12	5.4
Diploma*	na	na	4	7	na
Degree	3	5	6	12	7.6
Total #	100	100	100	100	2.6

+ Lower secondary as a separate category in 1996
* Diploma included in 1970 and 1980
# May include some workers whose activities are not adequately

Source: As in Table 2.

Table 4. Distribution of total employed persons by occupation, 1983-1996 (per cent)

	1983	1990	1996	Growth
Legislator,etc	8	8	12	2.8
Professional	4	5	7	2.8
Tech. & assoc. prof	9	12	18	3.4
Clerical	15	14	15	1.2
Service	15	15	13	0.6
Agr,etc	1	neg	*	na
Prod,manual	43	41	31	0.0
Others,nec	5	4	4	na
Total	100	100	100	1.1
Total (no)	1 251 245	1 469 194	17 48140	1.1

Source: As in Table 2.

2.4 Economic strategies and policies

As a small, open city-state, the government is not apologetic about its highly interventionist and proactive policies. Since the First Development Plan 1961-1965, formal planning has been dispensed with[1], leaving only rolling public sector planning and sectoral indicative plans as in manufacturing, finance and banking or tourism to guide the economy (Low, et al, 1993). Singapore has increasingly paid more attention to fundamental determinants of competition in industries and factors which shape competitive success or failure of firms (Porter, 1983). The determinants of national advantage reinforce and proliferate over time to foster competitive advantage in an industry[2] (Porter, 1990).

In terms of stages of national competitiveness, Singapore is still at the factor-driven stage though its efforts in moving to the investment-driven stage is proceeding.[3] Successful industries in Singapore had included airlines, apparel, beverages, ship repair and trading (Porter, 1990). The point of transition to investment-driven growth coincides with international competitiveness based on price to a more niche and cluster-based strategy.

Two developments have precipitated the transition. One is the increasing factor shortages especially in labour juxtaposed with the increasing competition from regional economies which have ample factors to offer more competitive prices. It was the recession in 1985 which provided the window for stocktaking as the economy plunged to -1.6 per cent in real growth.

The recession in 1985 revealed some structural inflexibilities, mainly in rising domestic costs and growing regional challenges. After putting the economy back on its feet with various cost-cutting and incentive measures, a more drastic reconfiguration was imminent. One involved developing the service sector as another engine of growth. Over and above traditional entrepot services, both domestic infrastructual capabilities and exogenous technological developments favoured Singapore's development into an international business hub. It was complementary and supplementary to the manufacturing sector with the presence of some 4,000 MNCs and a region which is awakening to trade, production and mass consumption.

After the 1985 recession, the Economic Development Board (EDB) identified a list of priority industries. It focused on high technology as in advanced electronics, product testing and analysis, medical, scientific instruments and other precision products, biotechnology, process control and automation equipment, optical and electro-optical applications, specialized chemicals and plastics among others. Services were given more consideration to develop a twin-engine of growth strategy. Together with finance, banking, insurance, tourism, communication and transportation, information technology became the main prop of the modern service sector.

Planned industrial restructuring into higher value-added and higher technology activities was orchestrated through a multi-agency approach. The emphasis on R&D to shift progressively from factor-driven to more innovation-driven economic growth was clear by the

[1] A Second Development Plan 1966-1970 was prepared but had to be aborted as the premises upon which the plan was made had changed, including the exit from Malaysia, the Indonesian confrontation, the British pound devaluation and withdrawal. These crises demonstrated the vulnerabilities of a city-state and reinforced the contention that ad hoc rolling plans were sufficient. These continued in the public sector and the compact administrative machinery and continuous party in government constituted *de facto* planning. The First Development Plan "cooked up" over a long weekend was also when Singapore needed financial assistance then from the World Bank.

[2] For the structural analysis of industries, it is the five-forces framework of potential entrants, suppliers, industry competitors, buyers and substitutes (Porter, 1995).

[3] The four stages in national advantage are factor-driven, investment-driven, innovation-driven and wealth-driven, the last one depicting decline rather than advance in a nation's competitive advantage (Porter, 1990).

late 1980s. In particular, the NSTB formed in 1991 charted the first National Technology Plan (NTP) which aimed for gross national expenditure on R&D to reach 2 per cent of GDP and 40 research scientists and engineers (RSEs) per 10,000 labour force by 1995 (see Table 18 later).

In the area of information technology, the National Computer Board (NCB) produced the National Information Technology Plan in 1986, followed in 1991 by the IT2000 (Wong, 1992 and NCB, 1992). Also in 1991, the EDB unveiled its Strategic Economic Plan (SEP, Ministry of Trade and Industry, 1991) which identified 11 industry clusters. All these national plans, NTP, IT2000 and SEP are consistent and unambiguous in emphasising a determined policy toward high technology and science (Hobday, 1995). The destination was to have Singapore become a developed country to join the league of industrial nations as in the OECD.

The latest policy initiated in 1993 is to encourage companies and Singaporeans to seek opportunities abroad to take advantage of the economic boom and political and market reforms in China and the Indochinese states as well as deregulatory and marketization policies in the Association of Southeast Asian Nations (ASEAN) and the Asian subcontinent such as India (Singapore, Economic Development Board, 1993, Singapore, Ministry of Finance, 1993 and Low, 1996). Many manufacturing companies have relocated to nearby countries like Malaysia and Indonesia as well as where market potential exists as in China, Mynamar and Vietnam. India is tapped especially in terms of its software skills in Bangalore.

Given the relative short time since the regionalization policy launched in 1993 to encourage Singapore companies and workers outward to leverage regional and global resources as well as to take advantage of the Asia Pacific boom, the impact on the employment and occupational structure is not easy to ascertain. There is a paucity of data collected on such companies and individuals going abroad, especially for employment and skill levels.

However, much as Singapore wishes to "borrow" or leverage on regional resources and markets, it also has to depend to a large extent whether regional countries see the benefits of economic cooperation and complementation. Many regional countries have their own nationalistic agenda for economic growth and development as they grapple with much larger problems of balancing regional growth, poverty and income distribution. In general, Singapore has attained a relatively higher level of efficiency in infrastructure and macroeconomic management of resources compared to other countries in the Asia Pacific region.

2.5 Cluster-based development

Industrial restructuring to engender national competitiveness has adopted a cluster-based development strategy. The government recognises that a Singapore's competitive industries cannot be spread evenly throughout the economy. They can be connected in clusters of industries which are related by links of various kinds. This clustering of a nation's competitive industries is promoted by the systemic nature of the "diamond" as they are linked through vertical (buyer/supplier) and horizontal (common customers, technology, channels, etc) relationships. One competitive industry helps create another in a mutually reinforcing character. Competitive supplier industries arise and they help to encourage worldclass downstream industries. Once a cluster forms, the whole group becomes mutually self-supporting. Service industries are integral parts of clusters.

While clustering connotes both specialization and concentration, it does not preclude diversification. It cannot be widespread diversification into unrelated industries which is rare among international leaders. This is especially so in the case of Singapore where resources are so scarce. Unfocussed and unrelated diversification makes no contribution to innovation, detracts focus, commitment and sustained investment in core industries.

The most crucial question once a cluster-based strategy is decided upon must be how to select the clusters to promote and implement the selection in a market economy. Singapore has two qualities predisposed by its small, city-state environment. One is the extremely open economy which dictates the criteria for the market, foreign investors and MNCs to work together. The other is an interventionist paternalistic government which provide the political will to put plans into motion.

Two approaches to nurturing clusters are obvious. The simpler one is to develop existing clusters with a view to further promote them. The other bolder, but exciting one is to try to identify new clusters which are not so well developed or non-existent. But unless there is some underlying political imperative, the latter approach may mean the state, not the market "picking winners". In practice, some diligent industry studies and explorations with the private sector would prompt fiscal incentives and schemes to encourage certain desirable clusters

In the manufacturing sector, the EDB chose to emphasize on existing clusters in line with the market and MNC investment. Tasked with the new mission of developing and promoting the service sector, both the EDB and the TDB are more aggressive in developing new clusters. With rising income and affluence together with the advent of technology and innovations, more new services are breaking through as in lifestyle services and communications.

In practical terms, three broad strategies are required in cluster development. The first is investment and business promotion which is a traditional function of the EDB with its network of overseas offices and incentive schemes. The second is capability building in terms of developing relevant competence centres in new institutions and agencies to spearhead the clusters.

This is a difficult process not only because it is new and takes time but there is also a large competence gap which exists between foreign MNCs and local capabilities whose needs are also very different. While the MNCs are clearer in their plans and resource capabilities, Singapore lacks local supporting companies which can be effective receivers of output from a national competence centre. Very often, it is a gamble and a dilemma how far the public agencies can and should push. Finally, the third element lies in training and upgrading the requisite manpower especially at the high end of university manpower.

As illustrations, two clusters are discussed which reflect the transition into the high end spectrum of manufacturing. The electronics cluster is almost a natural choice because as far back as the 1970s, Singapore has experienced a steady evolution from consumer to industrial electronics into semiconductors. Electronics gradually overtook oil refining in terms of output and value added and is the largest employer underscoring the continued trend of increased productivity, automation and new product transition. Apart from consumer electronics and semiconductors, other clusters in electronics include data storage, computer and multimedia, communications, office automation, passive components and printed circuited boards (PCBs), display devices and contract manufacturing.

Low-end consumer electronics activities have relocated elsewhere in the region. Core capabilities are being built in human interface, technology, product management, automation, wireless communication, miniaturization, digitization and product intelligence. In manpower development, specialists for wafer fabrication and disk media have to be prepared.

Apart from formal education and training in tertiary institutions, the EDB's INTECH (Initiatives in New Technology) scheme supports training of engineers and technicians. Overseas and other local institutions are also tapped. There are four key national research institutes and centres: the Centre for Wireless Communications (CWC); the Gintic Institute of Manufacturing Technology; the Institute of Microelectronics (IME); and the Magnetics Technology Centre (MTC).

The other manufacturing cluster which has witnessed upgrading is the chemical cluster. It is traditionally underpinned by petroleum and petrochemicals but new industrial and speciality chemicals, pharmaceuticals and health care and materials have joined the cluster. While the outlook for petroleum is cautious with weak refining margins, the rest of the chemical cluster is more optimistic. It is the second largest sector after electronics in output.

3. Long term trends in the manufacturing sector

Table 5 shows the distribution of value added of industrial production by sectors and the growth rate over the period 1970 to 1995. The industrial restructuring to more high value-added, capital and technology-intensive industries is apparent. The contribution to total value-added of more traditional industries like food, beverages and tobacco have fallen from 12.4 per cent in 1970 to 4.1 per cent in 1995, as was also for labour-intensive industries such as textile and apparels (4.3 per cent to 1.2 per cent respectively).

Table 5. Distribution of value added of industrial production, 1970-1995 (per cent)

	1970	1980	1990	1995	Growth
Food,bev,tob	12.4	5.0	4.4	4.1	6.8
Textile,app	4.3	4.9	3.1	1.2	6.3
Leather,foot	0.8	0.3	0.2	0.1	4.5
Timber,furn	6.5	3.2	1.2	0.8	3.8
Paper,pub	5.8	3.7	5.9	5.8	10.1
Ind chem	1.5	0.9	4.9	4.1	13.0
Pharm,paint	3.1	3.6	5.0	4.7	11.3
Petroleum	19.2	20.9	7.7	5.0	6.2
Rubber	1.9	0.4	0.3	0.3	4.8
Plastics	1.1	2.0	2.5	2.6	12.7
Pottery,clay	1.5	0.6	0.4	0.5	7.0
Cement	1.0	0.9	0.9	1.2	10.5
Nonmet min	0.6	0.5	0.3	0.2	7.6
Iron steel	1.6	1.8	0.8	0.4	6.4
Nonferr met	0.5	0.3	0.3	0.2	7.7
Fabmet	6.6	4.2	6.1	6.6	10.1
Machinery	2.6	7.8	5.9	5.7	12.4
Electrical	11.6	21.9	4.1	3.5	6.6
Electronics	na	na	35.7	43.7	na
Tpt eqpt	14.6	13.5	7.5	6.6	7.8
Instru,prec	0.3	2.0	1.7	2.1	15.5
Other	2.6	1.6	1.2	0.6	5.6
Total	100	100	100	100	10.1

Source: Department of Statistics, Yearbook of Statistics 1996.

In contrast, value-added by the instrumentation and precision equipment industry has risen (from 0.3 per cent in 1970 to 2. per cent in 1995) as also for machinery equipment (from 2.6 per cent to 5.7 per cent respectively). What is more significant is the double-digit rates of growth of value-added over the same period for these two industries as well as fabricated metal products and plastics. The electronics industry grew by 35.7 per cent in 1990 and 43.7 per cent in 1995.

Low value-added and labour-intensive industries which experienced slower growth rates over the period 1970 to 1995 include food beverage and tobacco; textile and wearing apparel; leather and footwear, sawn timber and furniture; and rubber products. The others which also had moderate growth rates due to cyclical rather than structural reasons, include petroleum, iron and steel, non-ferrous metals, non-metallic minerals, transport equipment and electrical.

Strong growth rates were experienced by industries related to the construction industry, namely, cement and structural cement. The construction booms in each decade were as much due to infrastructure development as to the government's home ownership policy. Among the high end manufacturing activities which experienced double-digit growth rates in value added are pharmaceuticals and paints; industrial chemicals and gases; plastics; machinery; and instrumentation and precision equipment.

To assess the effects of global competition on employment and skills, the manufacturing sectors are also analysed according to their export performance measured as the percentage of direct exports to output in Table 6. We compare figures in 1990 with that in 1994 (latest available) which are comparable as export data for the industrial structure in earlier years as for electronics are aggregated with electrical. Singapore has lost export competitiveness in textile and apparels, leather and footwear, sawn timber and furniture, rubber, iron and steel, nonferrous and transport equipment between 1990 and 1994. Even electrical and electronics saw a marginal drop in export performance and the worse hit was petroleum products. While certain cyclical rather than just structural factors are responsible export performance, the strong export orientation of some sectors should be noted like textile and apparels, electrical and electronics and instrumentation and precision equipment.

Unfortunately, we cannot analyse the degree of exposure to import penetration in terms of imports to total demand as there are no available statistics on demand. The classification system for trade statistics and manufacturing output and exports also differ. Similarly, there are no published data to analyse productivity by industry classified according to characteristics of production technology like physical capital-intensive, human capital and physical labour-intensive industries.

Table 6. Export performance*, 1990 and 1995

	1990	1995
Food,bev,tob	49.2	52.2
Tex,app	74.8	72.1
Leather,footw	41.3	35.3
Sawn tim,furn	44.2	30.4
Paper,printing	26.2	28.5
Ind chems,paints	69.8	73.7
Petroleum	55.7	18.5
Rubber,plastics	55.7	22.2
Nonmetallic	11.8	13.1
Basic metals	34.0	33.1
Fabmet	29.4	29.7
Mach	55.9	55.7
Electrical	63.9	56.6
Electronic	86.2	78.0
Tpt	62.5	50.2
Instru,precision	91.4	94.4
Total	65.9	61.0

Source: EDB, Census of Industrial Production, 1990 and 1995.

* Measured as direct exports to output, per cent

3.1 Manufacturing 2000

The Manufacturing 2000 (M2000) programme represents the long term plan for manufacturing in Singapore. The strategic intent of M2000 is to sustain the share of manufacturing in GDP at more than 25 per cent and employment share at 20 per cent in the medium to long term. The M2000 also seeks to upgrade capabilities across the entire value chain of each cluster, including product and process development, production, manufacturing engineering and strategic marketing.

The key clusters in M2000 are aerospace, biotechnology, chemicals, electronics, precision engineering systems, supporting industries and light industries. Technology and innovation are focused areas under M2000. Sufficiency of specialist manpower is a huge challenge and foreign expertise is tapped to augment the local pool of talents.

To galvanise M2000, new projects in line with the cluster development stately were secured. An innovation development programme is formulated and targeted to build up technological and innovation content. New electronics and chemical projects were secured through intensive investment promotion efforts. For instance, Exxon has invested in a US$2 billion petrochemical plant, a worldwide facility with 800,000-tonne ethylene capacity. This is the third petrochemical complex in Singapore and supports a wide range of other chemical and manufacturing activities.

The government has set up a new Cluster Development Fund of S$1 billion for risk sharing partnerships. Infrastructure building in a wafer fabrication park to prepare for many new wafer fabrication projects has been initiated. Reclamation around an offshore island, Jurong island, is another infra structural development to support the growing chemical sector.

However, employment in the manufacturing sector is expected to fall further to be 20 per cent by the year 2000 while the skill level of manufacturing jobs is expected to rise with more high-technology and value-added activities. In particular, there is a sharp decline in the proportion of production and related jobs between 1990 and 1996, from 45 per cent to 31 per cent respectively.

The fall in manufacturing employment is in tandem with the shift from manufacturing to services as the engine of growth. Nonetheless, more than half (52 per cent) of the workers in the manufacturing sector in 1996 are production and related workers. Presently, the top 100 manufacturing companies in Singapore accounted for 60 per cent of value-added but employ only 36 per cent of the workforce in manufacturing according data from the NTUC.

4. Changes in structure of employment in manufacturing sector

Following the broad analysis in Section 2, more detailed tandem changes in employment and occupational structure are scrutinized here. More than in other economies, Singapore is an interesting case where intense international competition has prompted acquisition of higher technology and productivity which will be reflected in changes in employment and occupational structure.

An explanation of labour and employment statistics must be clarified. Such statistics in this section and Section 5 are obtained from the Ministry of Labour's Labour Force Survey which provides employment by educational levels attained of workers. While the Census of Industrial Production also has employment figures by industrial groupings, there is no information about education and skills. Thus, a choice has to be made in Sections 4 and 5 to show employment and occupational structure by educational levels which is of primary concern but lose the focus by industry.

This is an unfortunate situation because it obviously is most crucial to the study to draw out some implications on changes in employment composition in the manufacturing sector in relation to changes in international trade and productivity growth. As noted earlier, even the industrial classification used by the TDB differs from that of the EDB which is responsible for the manufacturing sector.

Table 7 shows workers in the manufacturing sector in greater detail. Over the period since 1970, the growth in the number of workers in industrial chemicals; plastics; fabricated metals; and machinery is higher than the industry average. Negative growth is found in leather and footwear; timber and sawn products; and pottery and clay products. Low employment growth is found in food, beverage, tobacco; textile and wearing apparel; and rubber products.

According to the Department of Statistics' household survey, the distribution of working persons by highest qualification attained in more recent years, between 1990 and 1995, shows rising academic qualifications of younger cohorts years have resulted in rapid upgrading of skills. The workforce was more qualified and better trained in 1995. In particular, there is a significant increase in the number of university graduates from 6.0 per cent in 1990 13.4 per cent in 1995. Similarly, the proportion of polytechnic graduates doubled from 4.2 per cent in 1990 to 8.0 per cent in 1995 (Table 8).

Table 9 shows the distribution of employed persons in the manufacturing sector by highest qualification attained. Those with no education, lower primary or less than secondary education has fallen from 52 per cent in 1973 to 44 per cent in 1996. Those with secondary, post secondary and diploma education have risen from 40 per cent to 44 per cent over the same period. Graduates working in the manufacturing reached 10 per cent of the total labour force by 1996 from a mere 2 per cent in 1973.

To show the market orientation of the manufacturing sector, Tables 10, 11 and 12 show the export, domestic export and import structure in the manufacturing sector. As the sector is highly oriented toward exports, domestic sales form only a very small proportion of total sales. For exports (Table 10), the highest rates of growth between 1970 and 1995 are for machinery and transport equipment (15.5 per cent) followed by chemicals (12.6 per cent).

The same pattern is repeated for domestic exports in Table 11, with the two sectors growing at 16.9 per cent and 14.1 per cent respectively. For imports (Table 12), the top fastest growing sectors are machinery and transport equipment and chemicals again at 11.8 per cent and 9.8 per cent respectively over the same period. Thus, the trade pattern based on market forces of demand and supply is entirely consistent with the trend in industrial restructuring.

Table 7. Distribution of workers engaged in industrial production, 1970-1995 (per cent)

	1970	1980	1990	1995	Growth
Food,bev,tob	10	5	4	4	0.5
Textile,app	14	13	9	5	0.2
Leather,foot	2	1	0	0	-2.7
Timber,furn	9	6	3	2	-1.3
Paper,pub	8	6	6	6	2.5
Ind chem	1	1	1	2	5.8
Pharm,paint	3	1	1	2	2.1
Petroleum	2	1	1	1	1.0
Rubber	2	1	0	1	0.2
Plastics	2	3	4	5	6.2
Pottery,clay	2	0	0	0	-1.8
Cement	1	1	1	1	3.7
Nonmet min	1	0	0	0	1.8
Iron steel	1	1	0	0	1.2
Nonferr met	0	0	0	0	2.0
Fabmet	7	5	8	9	4.0
Machinery	3	9	7	8	6.0
Electrical	11	30	6	5	1.2
Electronics	na	na	35	34	na
Tpt eqpt	13	11	7	10	2.3
Instru,prec	1	4	2	3	na
Other	7	2	2	1	-1.2
Total	100.0	100.0	100.0	100.0	3.3

Source: As in Table 5.

Table 8. Distribution of working persons by highest qualification attained, 1990-1995 (per cent)

	1990	1995
No formal edu	6.6	3.9
Lower primary	12.1	7.4
Primary	15.0	13.3
Lower secondary	16.8	11.5
Secondary	30.4	30.4
Upper secondary	8.9	12.1
Polytechnic	4.2	8.0
University	6.0	13.4
Total	100.0	100.0

Source: Singapore, Department of Statistics, General Household Survey 1995, Socio-Demographic and Economic Characteristics, Release 1, Ministry of Trade and Industry, 1996.

Table 9. Distribution of employed persons in manufacturing sector, highest qualification attained, 1973-1996 (per cent)

	1973	1983	1990	1996	Growth
Never/ Low pr	12	21	18	16	3.6
Pr/Low sec	40	40	40	12	-2.0
Low sec +	na	na	na	16	na
Sec	35	28	27	27	1.7
Post sec	3	8	5	8	6.3
Diploma*	na	na	5	9	na
Degree	2	3	5	10	7.5
Total#	100	100	100	100	2.5

+ Lower secondary as a separate category in 1996
* Diploma included in 1970 and 1980
# May include some workers whose activities are not adequately

Source: As in Table 5.

Table 10. Distribution of exports, 1970-1995 (per cent)

	1970	1980	1990	1995	Growth
Food	12	5	5	2	5.4
Bev&tob	2	0	0	1	10.0
Crude mat	30	11	5	1	1.5
Min fuels	19	29	32	8	8.2
Ani&veg oil	3	3	3	0	4.7
Chemicals	3	3	5	6	12.6
Mfr	9	8	7	6	9.3
Mach&tpt	11	27	33	66	15.5
Misc	5	6	7	7	11.4
Misc trans	9	7	2	1	3.7
Total	100	100	100	100	10.3

Source: As in Table 5.

Table 11. Distribution of domestic exports, 1970-1996 (per cent)

	1970	1980	1990	1995	Growth
Food	6	2	2	1	7.0
Bev&tob	1	0	1	0	10.7
Crude mat	2	1	1	1	8.6
Min fuels	43	45	27	14	8.3
Ani&veg oil	3	2	1	0	5.6
Chemicals	2	2	6	6	14.1
Mfr	9	5	3	3	8.2
Mach&tpt	11	25	52	69	16.9
Misc	8	7	8	5	10.4
Misc trans	16	10	0	1	1.8
Total	100	100	100	100	11.5

Source: As in Table 5.

Table 12. Distribution of imports, 1970-1996 (per cent)

	1970	1980	1990	1995	Growth
Food	13	6	4	3	4.9
Bev&tob	2	1	1	1	8.0
Crude mat	11	7	2	1	2.6
Min fuels	13	29	16	8	7.6
Ani&veg oil	2	2	1	0	5.2
Chemicals	5	5	8	6	9.8
Mfr	22	14	13	11	7.1
Mach&tpt	23	30	45	58	11.8
Misc	7	6	10	10	10.1
Misc trans	2	1	1	1	7.4
Total	100	100	100	100	9.1

Source: As in Table 5.

Table 13 shows changes in productivity defined as value-added per worker in 1990 and 1995. Except for food, beverage and tobacco, petroleum, basic metals, machinery and transport, positive growth is observed for all other sectors over the period. Nonmetallic (8.7 per cent) and electronics (8.2 per cent) sectors enjoyed the highest productivity growth, both reflecting greater automation and higher skills and technology.

Table 13. Productivity increases*, 1990 and 1995

	1990	1995	Growth pa
Food,bev,tob	0.069	0.060	-2.6
Tex,app	0.015	0.017	1.8
Leather,footw	0.024	0.031	4.9
Sawn tim,furn	0.028	0.038	5.5
Paper,printing	0.062	0.069	1.9
Ind chems,paints	0.216	0.199	-1.7
Petroleum	0.505	0.350	-7.3
Rubber,plastics	0.039	0.038	-0.4
Nonmetallic	0.064	0.038	8.7
Basic metals	0.097	0.099	-7.5
Fabmet	0.047	0.067	1.4
Mach	0.052	0.050	-1.1
Electrical	0.040	0.046	3.0
Electronic	0.063	0.094	8.2
Tpt	0.062	0.047	-5.3
Instru,precision	0.044	0.058	5.6
Total	0.061	0.074	3.7

Source: As in Table 6.

* Measured as a ratio of value added per worker

To probe the relationship between capital intensity and productivity, Table 14 shows growth rates of net fixed capital per worker and productivity. In both sectors where highest productivity growth were enjoyed, namely, nonmetallic (8.7 per cent) and electronics (8.2 per cent) their capital intensity in terms of capital to labour ratio were also relatively high (8.7 per cent and 10.6 per cent respectively). Even higher capital intensity was observed for precision and optical instruments (29.6 per cent) against its lower productivity growth (5.6 per cent). But overall for the whole manufacturing industry, growth in capital intensity (6.7 per cent) far exceeds that of productivity growth (3.7 per cent). The implication that higher technology and skilled jobs have been created logically follows.

If a crude classification of high-technology industries in the manufacturing sector is attempted based on those which are actively promoted by the EDB, it has to include traditional ones as well as new areas. Food and beverage production as well as textile and garments would be the older sectors which had been labour intensive. Competition through innovation intensifies with new generic technology has revived and resuscitated stagnant and declining industries. Thus, labour intensive textiles, clothing, sawn timber, furniture and food processing may regain competitiveness through adjustment and adoption of new technology. In Table 14, a distinct improvement in net fixed capital to labour in these traditional industries is observed.

Table 14. Net fixed asset* per worker and productivity, 1990-1995

	1990	1995	Growth pa	Prod pa
Food,bev,tob	0.084	0.106	4.7	-2.6
Tex,app	0.015	0.018	3.6	1.8
Leather,footw	0.019	0.027	7.5	4.9
Sawn tim,furn	0.020	0.041	14.6	5.5
Paper,printing	0.044	0.059	5.9	1.9
Ind chems,paints	0.246	0.243	-0.2	-1.7
Petroleum	0.933	1.205	5.1	-7.3
Rubber,plastics	0.035	0.047	5.6	-0.4
Nonmetallic	0.081	0.125	8.7	8.7
Basic metals	0.097	0.104	7.4	-7.5
Fabmet	0.042	0.051	3.8	1.4
Mach	0.040	0.050	4.1	-1.1
Electrical	0.0436	0.045	4.7	3.0
Electronic	0.031	0.052	10.6	8.2
Tpt	0.047	0.012	-27.0	-5.3
Instru,precision	0.046	0.206	29.9	5.6
Total	0.052	0.072	6.7	3.7

Source: As in Table 6.

* Net fixed asset comprises land, buildings and structures; machinery and equipment; transport equipment; office equipment in S$million.

Moreover, with information technology and clustering based on flexible specialization enable collective efficiency, reduces transaction costs as buyers, intermediaries and suppliers are attracted together. Small batch production of garments made possible by new equipment further allows quick and flexible responses to frequent changes in fashion demands.

In another traditional industry, namely, petroleum industry which has been in Singapore for the last 100 years and more, the MNCs have added new capital as in new hydrocracker plants and sophisticated machinery and equipment. As historical costs had been low, these new investment still make them competitive to newer plants in the rest of ASEAN and Asia. This traditional sector is not as footloose as for instance, textile and garments, making it worthwhile for them to stay with the locational and strategic advantages of the Singapore economy also considered.

The development of new materials has similarly given greater scope to industries like aerospace, precision tools and professional instruments. New machines and equipment with the right, skilled workforce have lowered rejection rates and improved the degree of competitiveness. With further upgrading of the electrical and electronics cluster, further changes in occupation, skills and technology are occurring. Wafer fabrication is one clear example within the electronics cluster as will be seen shortly.

5. The skill upgrading process incentives for the manufacturing sector

In response to technological and globalization changes, the government has also institutionalized certain activities like a tripartite wage policy (National Wage Council), training (Skills Development Fund levy), promoting better and more participatory management-labour relations and industrial relations (through employers' associations and NTUC) which have effects on occupational structure. For the manufacturing sector, critical skills supported by the SDF include robotics, products and systems design, factory automation, advanced manufacturing technology and precision engineering.

These tripartite efforts suit the political economy in Singapore where state intervention and government dominance in almost all socio-economic areas are tolerated despite its claim as a market economy. The consensual environment in industrial relations enables the government, employees through NTUC and employers through the Singapore National Employers Federation (SNEF) to work toward maintaining competitiveness. The huge presence of DFI and MNC depicting a high proportion of foreign employers as much reflects that tripartism is not coerced as demonstrates Singapore is indeed internationally competitive.

The SDF is particularly interesting as a tripartite mechanism as it directly helps to upgrade skills at the lower end. The 1 per cent of payroll as the SDF levy is collected from employers with employees below a certain monthly payroll. In turn, employers with approved training programmes apply to PSB which administers the SDF for disbursement of subsidies and grants. There is some cross subsidization by small companies which tend to be liable for the SDF levy but cannot run or support training programmes the way MNCs can. However, the national objective of upgrading skills is attained as overall productivity is raised.

Table 15 shows the amounts of grants and training places committed in 1994 and 1995 in the manufacturing sector. A drop in training places in two industries, namely, electronic products and components; and computer manufacturers and vendors in 1994 was mainly due to some restructuring of companies and relocation of their activities to nearby countries. Computer manufacturing is entering a consolidated stage with various takeovers among key players and Singapore is clearly affected.

In general, there is one training place for every three persons in the workforce in 1995 compared to one in four in 1992. More employers are seeing the benefits of training as a

competitive strategy and way to motivate workers. The salary ceiling for SDF levy was raised from S$750 to S$1,500 in 1995 to widen its coverage and raise levy collection to train more workers. National investment in training has risen to an average of 3.6 per cent of annual payroll in 1995 and the SDF aims to push this up to 4 per cent. There is also an emphasis in training older workers aged 40 and above. One out of eight older workers is provided with an opportunity to train every year in 1995 compared to one in 25 in 1988. More small, medium enterprises are also being reached.

Table 15. Distribution of SDF grants and training places, 1994 and 1995 (per cent)

	1994	1994	1995	1995
	Grants	Training places	Grants	Training places
Computer	15	29	24	32
Electronic	24	40	20	24
Transport	2	10	15	17
Fab metal	13	7	15	10
Chemical,petrochem	6	4	10	7
Others*	30	9	16	10
Total S$m/no	19	180582	14	127612
Total mfr +	100	100	100	100

* Include food & beverage, textile, wearing apparel & leather, basic metallic industries.
\+ May not add up due to rounding.

Source: Skills Development Fund Annual Report 1995/96.

The SFF aims to raise investment in training from the current 3.6 per cent of annual payroll in financial year 1995 to 4 per cent. In the manufacturing sector, industries which are most intensive trainers are also most productive. One example is the computer, disk drive and peripherals industry where value added per worker exceeds S$138,000, almost twice the manufacturing average and it accounted for more than 30 per cent of training places in manufacturing. Critical skills areas of training supported include robotics, product/systems design, factory automation/advanced manufacturing technology and precision engineering.

A rise in the managerial, administrative and professional categories in Table 16 in the manufacturing sector further reflects more high skilled and professional jobs created over the period since 1983. Even the share of production and manual workers has fallen from 76 per cent to 52 per cent between 1983 and 1996.

Table 16. Distribution of total employed persons by occupation in manufacturing sector, 1983-1996 (per cent)

	1983	1990	1996	Growth
Legislator,etc	5	6	11	3.1
Professional	3	5	7	3.8
Tech&assoc prof	5	9	16	4.7
Clerical	10	10	12	1.2
Service	1	1	1	-0.5
Agr,etc	neg	neg	*	na
Prod,manual	76	69	52	-0.7
Others,nec	neg	0	0	na
Total	100	100	100	0.5
Total (no)	347602	424968	406317	0.5

* Included in others, nec in 1996

Source: As in Table 2.

Table 17 shows a significant shift of the workforce to more highly skilled jobs as the proportion of professional and technical workers rose from 15.7 per cent in 1990 to 23.1 per cent in 1995. Those in administrative and managerial capacities also increased from 8.6 per cent to 12.8 per cent over the same period. The rapid growth in the financial and business services sector accounted for much of the rise in the number of professional and technical workers. In 1996, about 47 per cent of workers in this sector are professional and technical workers.

Table 17. Distribution of working persons by occupation, 1990-1995 (per cent)

	1990	1995
Professional & technical	15.7	23.1
Administrative & managerial	8.6	12.8
Clerical	13.1	12.7
Sales & service	13.8	12.3
Production & related	44.5	34.6
Agriculture & fishery	0.3	0.1
Not classifiable	4.0	4.2
Total	100.0	100.0

Source: As in Table 16.

From a technical angle, a substitution has occurred as executives and managers are enabled with direct access to information, cutting down clerical and data input functions. This could not have occurred at a more opportune time as by 1980, Singapore has turned from being labour abundant before industrialization in the pre-1960s to labour deficit. The tight labour situation is compounded by an anti-natalist population policy, over and above the tendency for demographic growth to slow down with universal education and enlarging job opportunity for women. In line with human resource development policies in education and training to utilize manpower efficiently and attain a higher standard of living, the demand for skilled and white collar jobs rose in commensuration.

Although the educational level of the workforce has risen over the last five years, it was mainly found among the younger workers. More workers in the 20-29 age group have diplomas or university degrees relative to other age groups in 1996. The percentage for those aged 30-39 was 21 per cent, 13 per cent for those aged 40-49 and only 8 per cent for those aged 50 and above.

Table 18. Graduates from institutions of higher learning*

	1986	1996	Growth pa
Universities			
Art, Soc Sc	1122	690	-4.9
Science	945	872	-0.8
Med, Dentistry	185	121	-4.2
Law	160	75	-7.6
Business	531	1206	8.2
Accountancy	411	695	5.3
Engineering	924	1863	7.0
Total univ	4521	5800	2.5
Polytechnics			
Engineering	3802	7648	7.0
Arch,Bldg	492	628	2.4
Business/Acc	686	2800	14.1
Computer	193	383	7.1
MassComm	nil	545	na
Others	nil	533	na
Total poly	5173	12547	8.9
TOTAL	9694	18347	6.4

Source: Singapore, Department of Statistics, Yearbook of Statistics, 1997.
* Only full-time and excludes teaching

While there were no significant changes in the proportion engaged in clerical, sales and service related occupations, the proportion of production and related workers in the workforce

declined sharply from 44.5 per cent in 1990 to 34.6 per cent in 1995 which may reflect both labour-saving automation and robotization as well as more skill and technology-intensive activities requiring less manual labour.

It is further reiterated that the educational qualifications of the work force available only in the Ministry of Labour's labour force survey gives no further breakdown than the broad categories of education at the primary, secondary and tertiary levels. A full accounting of skill composition by occupation and export sectors is unfortunately not available in Singapore.

Another way to look at skills upgrading is the larger pools of graduates emerging from universities and polytechnics for professional, managerial and technical manpower (Table 18). The most significant growth over the period 1986 to 1996 in university graduates has been for those trained in business (8.2 per cent) and engineering (7.0 per cent). The negative growth for the arts, humanities and even medicine and law is significant not because there is no demand for the graduates but in a situation of dire shortage, it becomes a policy imperative to deal with the most critical shortages first. Inevitably in ramping up technological and industrial upgrading, it is in engineering and technology where the shortage is more pressing.

Similarly, for polytechnics producing technologists and technicians, the respective growth rates were 14.1 per cent and 7.0 per cent with those in computer courses at 7.1 per cent. In additions 17,132 workers completed skills training courses sponsored under SDF of whom 80.0 per cent were in engineering and technical training in 1996. Another 29,182 completed primary and secondary courses under continuing education in 1996.

It is by no accident that there is growth in professional, managerial and technical manpower commensurating with industrialization. A Council for Professional and Technical Education (CPTE) under the Ministry of Trade and Industry (MTI) does manpower projections using a demand approach based on targeted GDP and sectoral growth. The CPTE makes recommendations for intakes into the universities, polytechnics and other industrial and vocational training institutions which are all state-run. While such manpower requirement approach (demand extrapolation) may have been less successful in other countries resulting in mismatch of skills, there is a chronic shortage of skills of all sorts in Singapore. It has the distinction that its supply of manpower based on current low demographic and labour growth is too low to support its desired rate and quality of growth. Demand for manpower has to be satisfied with a very liberal immigration policy as well as an intensive hunt for foreign talents. Continuous training and upgrading as noted to keep up with new technology and changing global conditions coexist with a chronic labour shortage especially in skilled and professional manpower.

The MTI has projected that given current growth rates, Singapore will be short of some 7,000 graduates annually by year 2000 (Singapore Straits Times, 1 August 1997). University intake has been pushed up to 10,000 to 11,000 with more foreign students attracted (up to 1,000 in 1997) as a policy reversal of controlling intakes to avert problems of graduate unemployment. Both rising aspirations and economic growth have been driving up the demand for university education and the employment of graduates in a more highly skilled and technologically advanced economy.

The emphasis on high productivity and high skills coupled with low growth rates in population and labour force resulting in low unemployment rates posits the pursuit of a "jobless" growth strategy. With no official statistics ever released, the proportion of foreign labour in Singapore has been estimated to range from 20-30 per cent. There is a conscious policy through a foreign worker levy and quota system to restrain the importation of unskilled and low skilled labour. The main reason is that otherwise industrial restructuring into more technology, high value-added activities would be subverted. Socio-political factors revolving

around an excessively large foreign labour pool also matter. There is no formal ASEAN regional labour/skills exchange arrangement as workers are attracted into Singapore based on high wages and employment prospects. But as traditional labour sources from nearby countries are drying up as these economies themselves grow, non-traditional sources from further away have to be tapped. Clearly, such labour infusions affect skills and productivity trends.

The resulting industrial and skills restructuring has created a skills hierarchy which has widened wage and social inequalities. The lowest 10 per cent of households has 5.1 per cent share of income or consumption, rising to 9.9 per cent for the lowest 20 per cent of households compared with the top 10 per cent of households commanding 33.5 per cent or top 20 per cent of households enjoying 48.9 per cent of income or consumption in 1982/83 (World Development Report, 1997). But as much as such inequity will increase with further education and skills upgrading, the government is resolute in its meritocracy policy and a reward system based on effort and productivity. Its social policy does, however, aim at levelling up low-income households through subsidies in education, health and housing and other direct improvement programmes. As long as economic growth is buoyant and robust, it enables the thrifty government to run up budget surpluses to be spent back into the economy. By implementing the appropriate incentives in the economic and social arenas, they create conditions conducive to more economic growth and socio-political stability.

The impact of the technology factor on trade and the export sectors is similarly not possible to assess due to paucity of statistics. Data on R&D which is collected by yet another public agency the NSTB again has no industrial breakdowns compatible with the categorization found in census of industrial production, trade data and labour force surveys. A serious attempt to try to reconcile and make the statistics consistent and compatible is indicated.

6. Trends in the leading export sector

The leading export sector is electronics. Electronic exports grew at an average rate of 6.6 per cent over the period 1980 to 1996 as shown in Table 19. They constituted 17 per cent of total exports and 15 per cent of total domestic exports in 1996. In 1996, electronic products accounted for 45.5 per cent of value-added, 52.5 per cent of output, 35.0 per cent of employment and 31.8 per cent of remuneration in the manufacturing sector. But they only accounted for 6.0 per cent of total establishments.

Table 19. Value of exports and domestic exports of electronic products, 1980-1986* (S$ million)

	1980	1990	1996	Growth %
Exports				
Electronic	2657	7084	29707	6.6
Total	41452	95206	176272	3.9
Elect as % tot	6	7	17	na
Dom export				
Electronic	2203	5148	15111	5.2
Total	25805	62754	103589	3.8
Elect as % tot	9	8	15	na

Source: As in Table 1.

The high double-digit growth of over 20 per cent since 1993 has tapered off to 6.7 per cent in 1996 with mixed performances from major segments in the industry. While export demand boosted the output of disk drives, computer peripherals and printed circuit boards and accessories, reduced orders adversely affected the output of personal computers, semiconductors, consumer electronics and telecommunication equipment.

In Table 20, capacitors and resistors registered the highest growth in output of 10.0 per cent between 1985 and 1992 followed by computer, peripherals at 9.6 per cent. Production of semiconductor devices grew the least at 4.8 per cent over the same period. Exports of data processing machines and parts for office and data processing machines grew at 11.8 per cent and 11.2 per cent respectively in Table 21 followed by electricity distributing equipment at 10.1 per cent between 1985 and 1992.

Table 20. Domestic production of electronic products, 1985-1992

	1985	1990	1992	Growth
Comp,periph	3	13	16	9.6
Consumer	2	5	5	6.2
Semicond	2	3	4	4.8
Capacitor	neg	neg	1	10.0
PCBs	1	4	4	8.4
Other	1	3	3	6.2
Total	9	27	32	7.8

Source: Economic Development Board, Census of Industrial Production, various years.

Growth has slowed since 1991 due to restructuring in the disk drive segment as disk drive manufacturers scaled down output of low-end products and shifted into high-capacity drives in response to changing market conditions. The industry recovered in 1992 as local manufacturers shifted into new product lines. The high growth between 1993 and 1994 was in line with the development of global trends in electronics just as the downswing in 1996 was externally induced by lower demand.

In the early 1990s, exports of data-processing machines, telecommunication equipment, electrical circuit apparatus and electronic valves doubled (Table 21). The largest product group was disk drives which accounted for 17.4 per cent of total electronic exports in 1995. Singapore was the world's largest producer of hard disk drives accounting for 45 per cent of global output in 1994.

The government is spearheading the expansion in the semiconductor industry by actively promoting investment in wafer technology which will also reduce the dependence on disk drives. Nine wafer fabrication plants have been committed, five of which are projects under government-linked companies (GLCs) and joint ventures with other MNCs.

As wafer fabrication is promoted, manpower demand for engineering graduates and postgraduates becomes more acute. The shortfall is expected to continue into 2010 or thereabout. A conversion course to help practising engineers and new science graduates who

are basically non-microelectronics engineering and science graduates the basics of microelectronics technology and fabrication process has been mounted. Similarly, in view of the demand for research personnel in wafer fabrication, the NSTB has funded the university with facilities to train postgraduate students in semiconductor technology. A part-time master in wafer fabrication science is offered to working staff in the industry with a full-time programme also being worked at. Foreign candidates from ASEAN, India and China are targeted at.

Table 21. Main electronic and electrical machinery exports by product, 1985-1995 (S$ million)

	1985	1990	1995	Growth
Office mach	236	606	741	5.0
Data proc	1825	12329	27675	11.8
Parts	948	3686	12608	11.2
TV	677	2405	2452	5.6
Radio	1093	2848	2973	4.3
Video	370	2003	3204	9.4
Telecom	1011	4221	9737	9.8
Power mach	194	601	1482	8.8
Circuit app	1539	1397	3472	3.5
Distrib eqpt	72	323	734	10.1
Med app	16	45	84	7.3
H/h gds	423	588	685	2.1
Valves	3044	6635	26052	9.3
Mach	417	1162	3577	9.3

Source: Singapore Trade and Development Board.

The science faculty is also reengineering itself starting on programmes like physics in technology and semiconductor technology designed to meet the manpower needs of the wafer fabrication industry. Chemistry of microelectronic processing, courses in materials science are attempts to meet new manpower needs and upgraded skills and higher postgraduate manpower in a very dynamic and highly geared economy. Singapore has to reach the upper ends of the technology ladder to stay competitive.

The active promotion of investments in electronics and petrochemical, chemical and other high technology industries will definitely have a considerable impact on employment and skills content of the labour force. As such, it is germane to discuss some of these new projects in the making. The cluster-based strategy of industrial development also means that the whole manufacturing sector is to be taken as a whole rather than the electronics sector in isolation. This is especially when on the side of services sector promotion, an international business hub concept is being promoted. In line with that objective, fiscal and other incentives to encourage MNCs to set up overseas headquarters (OHQs) and business headquarters (BHQs).

But before that, one micro study on the electronics sector found positive workers' perceptions of automated production work in respect of increased levels of skills, responsibility and workload (Ngin and Wong, 1997). The consensus view was higher level of education is required for automated work. Unfortunately, neither the educational and skills levels of workers surveyed nor the higher level of education deemed necessary were specified. The three main reasons for automation from the management's point of view include to improve quality of product, to overcome labour shortage and for better design capability.

6.1 New projects and upgraded manpower needs

Within electronics, Seagate Technology has opened a S$200 million facility in Singapore in early 1997 which is its largest single disk drive facility and most productive with a capacity of 50,000 drives a day. Seagate's operations cover the entire business value chain in terms of designing, engineering development and support, manufacturing, sales and marketing, and regional management. The company is the largest industrial employer in Singapore with over 19,000 employees.

Its R&D centre had developed its first disk drive in 1996 and more drive designs are envisaged on a more regular basis. With Seagate Singapore being made the bedrock of the company's growth in the Far East, Singapore will stand to gain in technology upgrading and skills.

Another electronics giant, IBM Microelectronics has also chosen Singapore as its Asia Pacific headquarters to spearhead its business expansion in the region. The strategic intent is to offer customers in the region total support in education and training, technical issues and value added services in applications engineering and platform and architectural development. A regional design centre will provide turnkey services such as design, customer specific application support and training, taking advantage of Singapore's skilled manpower. Singapore will play a leading role in IMB Microelectronics' forays into major markets in Taiwan, japan, Hong Kong, South Korea as well as in emerging markets in Malaysia, China, India and Thailand.

Sony Display Device has invested another S$95 million in its production line to make picture tubes for computer monitors, bringing its total investment to S$600 million in Singapore. The Singapore company is Sony's largest cathode ray tube maker worldwide. Computer monitor tubes are high value added products requiring twice the resolution of television tubes. The new investment created another 400 jobs, raising the company's total staff strength to 1,500.

Sony is particularly proud of the high productivity attained by its Singapore plant. It boasts of the shortest index time in the cathode ray tube industry turning out one in less than 10 seconds. The kind of manpower and skills to support such performance has to be high and satisfactory as Singapore competes worldwide with other locations which Sony might have ventured to. Besides the manufacture of cathode ray tubes, Sony's activities in Singapore include optical pick-up devices and electronic guns as well as integrated circuit design, warehousing and shipping services. Singapore is also Sony's regional headquarters.

7. Policies for promoting employment, education and skill development

Policies for promoting employment, education and skill development constitute the lynchpin of economic strategy in Singapore. Employment creation today is geared not so much to the quantitative as the qualitative dimension in terms of higher skills and productivity. Revamping the education system to gear more toward science and technology saw the rapid expansion of new courses and curricula in universities, polytechnics and schools (Low, et al,

1991). The improvement in educational qualifications of the labour force as shown in Tables 3 and 4 provides the evidence of such successful educational policies.

In terms of acquisition of new technologies in manufacturing with special reference to skill development and upgrading, the development of the Science Park along the western part of Singapore where the universities, research institutes, most of the polytechnics and industrial establishments are located is an important effort. Many fiscal and other incentives are offered by the EDB and NSTB for R&D in the Science Park.

While gross expenditure on R&D (GERD) has yet to reach its target of 2 per cent by 1995, the number of 40 research scientists and engineers to 10,000 labour force has been attained by 1993 (Singapore, NSTB, 1995). The figure was 41.0 in 1994 but by international comparisons, Singapore still has a long way to go (Table 22).

Table 22. International comparisons of GERD/GDP ratio and RSE per 10,000 labour force

	Year	GERD/GDP	RSE/10000 lab force	GERD/RSE US$'000
Japan	1992	2.72	80.72	194.63
US	1993	2.65	74.33	172.27
Switzerland	1992	2.51	69.89	249.30
Germany	1993	2.48	62.25	154.75
SKorea	1993	2.33	52.26	77.10
UK	1993	2.18	49.52	147.49
Taiwan	1992	1.82	55.58	76.99
Spore	1993	1.08	40.54	93.20

Source: Singapore, NSTB, 1995.

The projections in the second National Science and Technology Plan launched in 1996 will see the government pumping in S$4 billion until 2000. This represents twice the amount allocated in 1991 and will be 1.6 per cent of gross national output. It seems to be a downward revision from the more ambitious 2 per cent target set out in the first NTP (NSTB, 1993). The number of RSEs will be 65 per 10,000 population. Twelve to fifteen more research laboratories will be set up in the two universities.

The economy has reached a more matured high technology stage and a strong indigenous base has also begun to bear fruits. A key thrust in the second plan lies in manpower development where another 10,000 engineers and 5,000 researchers are projected on the demand side. The private sector is still encouraged to be in the lead.

But a shortage of skilled and professional manpower, especially engineers and technicians is exacerbated by the tight labour situation which only encourages disturbing turnovers (Wong, 1995). Foreign expertise is already being tapped but there is both a drying up and

competition effect as regional countries like Malaysia develops its multimedia supercorridor. [4] Thus, more than anything, talented manpower constraint will be a real constraint in Singapore's next phase of economic growth. It has launched an aggressive policy in 1997 to scour foreign talents as well as encouraging all Singaporean students studying abroad to return through its Contact Programmes set up in leading foreign universities.

A new scholarship scheme to groom a new breed of industry and business leaders to better understand from a total perspective, the competitive environment and constraints Singapore faces has been initiated. Private companies, government-linked companies and statutory boards are participating in a scheme in 1997 called Singapore Inc Scholarship which is targeting for a pool of 500 leaders and managers over the next ten years.

Scholars will be deployed to various organizations to expose them to the work environment. Industry and business leaders will be groomed with private sector disciplines and an appreciation of government economic policies to meet with economic issues in a very practical, hands-on approach. The government recognises that plans for industrial restructuring and upgrading require the crucial market test and involving the private sector under such a scheme would help to develop strong industries to support national objectives.

All scholars trained under the scheme will be rotated every two years or so to sponsoring and member organizations to externalize the benefits and exposure to experience. This is another example of the government's efforts to ensure Singapore face up well with the new millennium and leverage on MNCs to rise to the challenges of the new age of globalization, information and networking.

[4] According to the Global Competitiveness Report for 1996, Singapore is ranked in second position in terms of computer literacy while Malaysia is ranked 28th. It however, cannot afford to be complacent as Malaysia is all out in terms of its policies on education, foreign investment and foreign expertise to spur its multimedia supercorridor ahead. It is changing its cyberlaws and its bright ideas are only impeded by difficulties in implementation.

Conclusion and policy implications

Apart from fine infrastructure, stable socio-political conditions, location and an overall efficient macroeconomy, a more crucial factor in Singapore's competitiveness lies in its educated and skilled manpower. The cluster-based development approach optimizes Singapore's scarce resources to provide certain concentration and critical mass effects in both manufacturing and services. Increasingly, the employment and occupational structure will be increasingly skewed toward more professional, skilled workers to support such a strategy.

However, a shortage of talents exists with lower demographic growth, itself constrained by land and other physical endowment. The competition for foreign talents and workers is also getting keener as neighbouring countries which are the traditional sources of foreign labour are also growing and developing rapidly. The challenge in making Singapore a more lucrative and interesting place for brain and knowledge industries is many-fold.

The issue of Singapore's small size as affecting its future development as a knowledge and information economy is double-edged. On one hand, it lacks the critical mass as in labour and talent pool. On the other, if competitive advantage can be acquired by the right policy environment and government direction, this is not an issue. There is advantage of ease in administration and nimbleness to be flexible and opportunistic.

In fact, the partnership with private sector extending to tripartism involving government, business and labour is a proven record which ensures support and cooperation from all parties once a development strategy is identified. In particular, the tripartite spirit for skills upgrading and retraining is entrenched under the SDF, programmes run by the NTUC and PSB. The mass of production workers covered by these agencies has to be upgraded while the universities and polytechnics are working at the higher levels of education and skills.

The issue of so much government-directed orchestration in economic strategy is also reexamined in the light of government intervention in promoting high-technology industries and concomitant high-technology R&D. High technology industries and R&D have externalities which call for government support. Apart from high investment required, the security aspects of high-technology industries are often raised. Because microelectronics is the basic resource which is powering growth and development in the age of information and knowledge industries, the government's help to secure intellectual property rights is vital.

More R&D activities not only mean more RSEs and related workers but also a special R&D culture. Moreover, R&D thrives in an environment of constant change, dynamism and the unknown. A rigid education and working environment cannot nurture the necessary creativity, innovativeness, dare and boldness of vision which are the *leitmotif* of R&D work. This challenge for mindset change must permeate throughout the society to teachers, parents, employers and their charges, being students, children employees respectively. Futuristic thinking, strategising and taking opportunities constitute a new cult which Singaporeans may yet or will find difficult to cultivate and practise.

Thus, the employment and occupational structure is far from being stabilized. One more wave of change into higher technology and skill intensive workers, innovators and creators have to take place in the next couple of decades. The momentum has started but competition from regional countries similarly aspiring to be high technology and knowledge economies is likely to quicken the pace. All will have to compete for the right talents and manpower.

The policy areas in next millennium are however, not necessarily very drastically different from what Singapore has been doing so far. It is not quite a quantum leap change as it is fortunate that the foundation and basic policies have been in place for quite some time. Longer term changes as in education and mindsets have also been foreseen though the evolution of human traits and attitudinal changes may require a bit more time. Nonetheless, Singapore has quite a headstart over other countries and having to change constantly is in-built into the opportunist philosophy of the small city-state.

Very broad deductions have to be relied upon like if certain manufacturing sectors like electrical and electronics continue to feature in Singapore's exports or direct foreign investment especially more high quality capital investments are made, we can only deduce that they are globally competitive. Thus, one important policy suggestion emanating from this case study in Singapore must be for statistics to be collected and collated on more compatible bases among various agencies as well as for them to be more in line with those published in other industrial countries. Otherwise, useful cross country studies of this nature becomes highly unsatisfactory. The missing parameters noted in this study to link jobs, skills and technology include education attainment and skills of workers by more detailed industrial classification, impact of size of firms as affecting skills upgrading, technology content of exports and imports, contribution of technology to productivity and others.

Whatever improvements in education and skills upgrading as well as in labour market and industrial relations appear to be taken in broad and aggregative terms in Singapore. They must have generally been favourable as one cannot go altogether wrong in ramping up skills and industrial relations positively. But more industry based or sectoral impacts are unfortunately not possible to do given the available and published data. Policy design appears to be undertaken in good faith of certain broad trends and developments. Singapore may have just studied the results from industrial countries or responded to what MNCs and industries have indicated as necessary. Such a reactive way of policy making cannot be all faulted as they to a certain extent proven or are successful elsewhere.

Bibliography

BREHENY, Michael J. and McQUAID, Ronald, (1987), *The Development of High Technology Industries: An International Survey*, Croom Helm, New York.

CHNG MENG KNG, LOW, Linda, TAY BOON NGA and TYABJI, Amina, (1986), *Technology and Skills in Singapore*, Institute of Southeast Asian Studies, Singapore.

GALENSON, W. (1992), *Labour and Economic Growth in Five Asian Countries: South Korea, Malaysia, Taiwan, Thailand and the Philippines*. Praeger. New York:

HOBDAY, Michael, (1995), *Innovation in East Asia: The Challenge to Japan*, Edward Elgar, Aldershot.

KUO, Eddie C.Y., and CHEN HUEY-TSYH, (1987), "Toward an Information Society: Changing Occupational Structure in Singapore", *Asian Survey*, Vol XXVII, No. 3, March, pp. 355-370.

McDANIELS, C., (1993), *The Changing Workplace*, Josey-Bass Publishers, New York.

LOW, Linda, TOH MUN HENG and SOON TECK WONG, (1991), *The Economics of Education and Manpower: Issues and Policies in Singapore*, McGraw-Hill Book Company, Singapore.

LOW, Linda, TOH MUN HENG and SOON TECK WONG, and TAN KONG YAM with special contribution from Helen HUGHES, (1993), *Challenge and Response: Thirty Years of the Economic Development Board*, Times Academic Press, Singapore.

NGIN, Phyllisis M. and WONG POH KAM, (1997), "Workers' Perceptions of Aumated Production Work in Singapore"s Electronics Industry", in *Asia Pacific Journal of Management*, Vol. 14, Issue 1, April, pp. 67-87.

LOW, Linda, (1996), "Singapore's Regionalisation Drive in the Context of APEC Cooperation", in Yamazawa Ippei and Hirata Akira (eds), *APEC: Cooperation from Diversity*, Institute of Developing Economies, Tokyo, pp. 189-204.

PORTER, Michael E., (1983), *Cases in Competitive Strategy*, The Free Press, New York.

PORTER, Michael E., (1990), *The Competitive Advantage of Nations*, The Free Press, New York.

SINGAPORE: Economic Development Board, (1993), *Your Partners In Regionalisation: Singapore Government Agencies*, EDB, Singapore.

SINGAPORE: Ministry of Finance, (1993), *Report of the Committee to Promote Enterprise Overseas*, Interim, May and Final, August, Singapore National Printers, Singapore.

SINGAPORE: Ministry of Trade and Industry, (1986), *New Directions for the Singapore Economy*, Report of the Economic Committee, Singapore National Printers, Singapore.

SINGAPORE: Ministry of Trade and Industry, (1991), *The Strategic Economic Plan: Towards A Developed Nation*, Singapore National Printers, Singapore.

SINGAPORE, Ministry of Trade and Industry, (1996), *General Household Survey 1995, Socio-Demographic and Economic Characteristics*, Department of Statistics, Release 1.

SINGAPORE: Ministry of Trade and Industry, (1997), *Annual Economic Survey - 1996*, Singapore National Printers, Singapore.

SINGAPORE: National Science and Technology Board, (1993), *Science and Technology: Window of Opportunities: National Technology Plan, 1991*, September, SNP Publishers, Singapore.

SINGAPORE: National Science and Technology Board, (1995), *National Survey of R&D in Singapore 1994*, NSTB, Singapore.

SIO SUAT KHENG and PUAH TOH LIM, (1995), "Occupational Trends, 1980-1990", *Singapore Statistical News*, Vol. 16, No. 2, pp. 1-5, Singapore, Department of Statistics.

WONG POH KAM, (1995), "Developing Technology Managers in Singapore: Issues and Challenges", in Minden, Karen and Wong Poh Kam (eds), *Developing Technology Managers in the Pacific Rim: Comparative Strategies*, ME Sharpe, New York, pp. 62-92.

WORLD BANK, (1995), *World Development Report - 1995*, Oxford University for World Bank New York.

YAMAZAWA, Ippei and HIRATA, Akira (eds), (1996), *APEC: Cooperation from Diversity*, Institute of Developing Economies, Tokyo.
