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THE ELECTRONICS INDUSTRY IN THE ASEAN COUNTRIES

SINGAPORE*

Prepared by

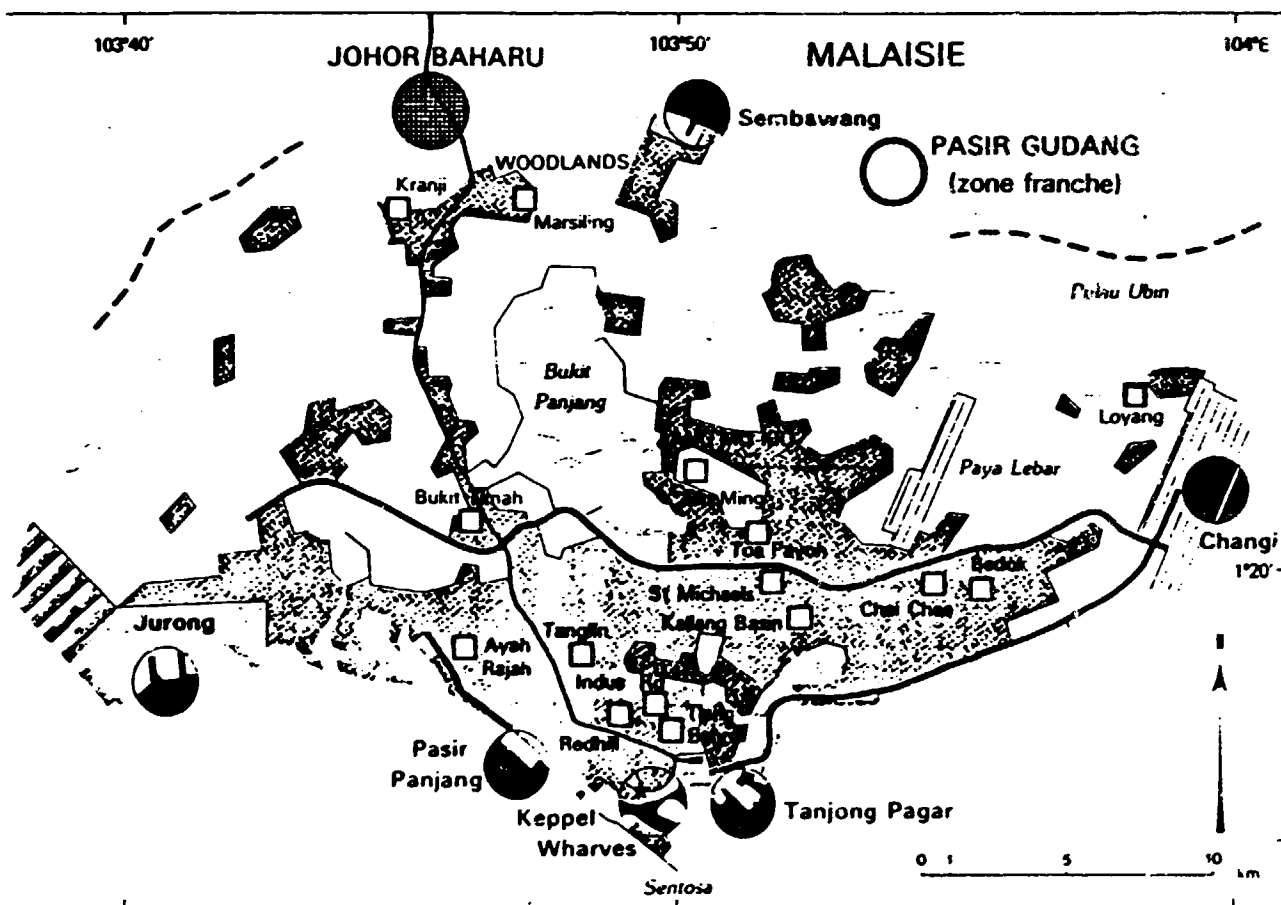
**R. Chaponnière **
R. Tiberghien ****

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* The views expressed in this paper are those of the authors and do not necessarily reflect the views of the Secretariat of UNIDO. This document has been translated from an unedited original.

** Institut de Recherche Economique et de Planification du Développement, Université des Sciences Sociales de Grenoble.

SINGAPOUR



- | | |
|--|----------------------------------|
| Centre ville | Zone franche |
| Espace urbanise | Zone industrielle ouverte |
| Espace industriel et portuaire avec extensions | Centre de commerce international |
| Parcs et jeux | Aeroport |
| Forêt | Voie ferree |
| Plage | Voie rapide |

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1. INTRODUCTION

Singapore is a city-state with 2.5 million inhabitants, situated on an island of 600 square kilometres, separated by a bridge from the Malaysian peninsula.

1.1 Economic development

Singapore (Table 1) is incontestably the champion of the ASEAN countries in respect of growth with an average of 9% since 1965 and a per capita GNP of US\$ 7250, the highest in the ASEAN zone. Three traits characterize this growth and merit being emphasized :

- stable prices : A performance explained by a number of domestic factors, including governmental prudence, free trading, the flow of immigrant workers and a housing plan;

- the level of domestic investment which has progressively replaced foreign investment in the financing of capital investments (from an average of 35% between 1965 and 1973 to 24% between 1974 and 1979. 18% between 1980 and 1984 to 3.5% in 1985);

- the absence of debts : between 1965 and 1985 the net contribution of non-monetary capital was greater than the cumulative deficit of the current balance; the long-term debt (US\$ 2.2 billion) is negligible, and the City-State has accumulated a comfortable level of reserves.

After fifteen years of rapid growth the government promulgated a series of reforms in 1979, the main objective of these being an improvement in productivity: the "Industrial Revolution" was accompanied by a highly voluntarist wages policy to encourage companies to become automated and to launch out into productions of higher value added.

This reform coincided with the world recession. In order to compensate for the slowing-down in trading, which represents nearly three times the GNP, Singapore accelerated its infrastructure and, in 1982 and 1983, the economy recorded a rapid growth, drawn forward by the construction industry. Singapore then profited from the American recovery of 1984. In 1985 the reversal in the American economy began to make itself felt whilst at the same time the collapse of the real estate market resulted in a slowing-down in building work.

Confronted with the first recession (-1.8% in 1985) the government put into effect a series of new reforms. The decisions made in the third quarter of 1985 favoured recovery and allowed Singapore to profit from the reversal in the economic situation inaugurated by the rise of the Yen.

The recovery was remarkable. After the contraction of 1985 the growth in 1986 was 1.8% although the building industry was still in the depths of a recession the growth was 8.6% in 1987.

Table 1
THE PRINCIPAL MACRO-ECONOMIC PARAMETERS

Breakdown of the GDP
as a percentage in 1987

Manufacturing sector	28
Building	7
Services	62
Total	100
or in US\$ billions	20.20

Balance of payments, 1987, in US\$b

Exports	28
Re-exports	10
Imports	32
Trading balance	-4
Current balance	1.10

Exchange rates

1980	US\$ 1 = S\$ 2.09
1985	US\$ 1 = S\$ 2.11
1986	US\$ 1 = S\$ 2.18

i.2. Industrial development

1.2.1. Industrial policy

From 1965 onwards the State relied on foreign companies to ensure its industrial growth. It multiplied the means for attracting them, and constructed a framework which was favourable towards business in terms of infrastructures. These efforts happily coincided with the dispersion of American companies.

Industrial growth was exceptional up until 1973, the inflow of foreign capital investment making it possible to provide employment for the population. The electronics industry became the leading employer in Singapore. The growth of the manpower in this branch represented a third of all job creations between 1968 and 1973, half of them between 1974 and 1979 and practically all the new jobs between 1979 and 1985.

From 1970 onwards the major oil companies invested in Singapore which has subsequently become the third largest centre in the world, refining 0.9 million barrels a day of crude from the Middle East and the local region.

Other key sectors of industry are building and ship repairing in which there are several State companies and large foreign groups.

Industrial policy underwent a marked evolution in 1979 with the Industrial Revolution which involved three main aspects :

- a wages policy : whereas up to 1978 the State had recommended small increases during the next three years it encouraged companies to give very large rises (20% in 1979, 18% in 1980 and 15% in 1981). At the same time the level of deductions from wages (Central Provident Fund; social charges and pensions) was increased.

- a policy of stimulation : The Economic Development Board offered a panoply of measures (fiscal encouragements and subsidized loans) intended to stimulate capital investments in sectors with a higher value added.

- a training policy : the creation of the Nanyang Institute of Technology, increasing the intakes of the polytechnics and the creation of industrial training institutes in collaboration with private industry and foreign countries (IBM for systems development, West Germany for engineering, France for electronics and Japan for informatics).

According to its promoters the Industrial Revolution should operate a genuine selection within companies, separating those which were capable of absorbing the wage increases from those which could only succeed by using cheap labour.

Faced with the slowing-down of the rate of growth and the contraction of 1985 the government revised its industrial policy.

The object of the reforms launched in 1985/86 was to render the economic environment favourable towards the company. The means for achieving this implied a reform of the wages policy, of contributions to the Central Provident Fund, of tax structures, of the prices of public utility tariffs and of the Singapore Dollar. Wages were frozen for two years; the CPF levels were reduced from 25% to 10% (12% in 1988), thus favouring labour-intensive industries and reducing production costs by 2% on average; the tax on companies was reduced from 40% to 33%.

1.2.2. State companies and foreign investments

The State is directly present in 450 companies; its industrial investments are estimated at US\$ 5 billion. It is involved in the heavy industry sectors such as shipbuilding, iron and steel and petrochemicals, but is also present in the high technology sectors. State companies come into direct competition with private companies.

Temasek is a State holding company which manages shareholdings in civil industries. Amongst the principal State companies are Prima Flour (flour-mills), NISM (iron and steel), Singapore Petroleum (refinery), Keppel Shipyard and Sembawang Neptune Orient (shipowners) and Singapore Airlines.

Sheng Li is a holding company which controls activities relating to the defence industries, together with aeronautics and electronics.

Singapore is undoubtedly the ASEAN country which is most open to foreign industrial investments (Table 2). Apart from the public services no activity is closed to them, and there are no restrictions on the level of shareholding.

In no other country do foreign companies play such an important role in industry. Whilst some 1700 foreign companies were listed in 1970 there are now more than 7000 in industry and the services sector. They account for 60% of all employment, 70% of the value added and more than 80% of exports.

American investments are the most important, followed by those of Japan. During the last two years Japanese companies have invested more than those from the USA.

During the seventies the leading investors were the Europeans, but between 1980 and 1987 their share has fallen to the point where they now account for less than 20%. Great Britain and Holland are both strongly represented through BP and Shell.

Table 2
FOREIGN INVESTMENTS IN THE MANUFACTURING INDUSTRIES

	Cumulative investments :			
	1962-1980		1980-1987	
	S\$m	%	S\$m	%
United States	1061	29.5	2105	45.6
Japan	568	15.8	978	21.2
EFC	1320	36.7	1062	23.0
inc. Great Britain	586	16.3	512	11.1
Holland	583	16.2	204	4.4
West Germany		n.d.	124	2.7
Other countries	1061	29.5	467	10.1
TOTAL foreign	3598	100.0	4612	100.0
TOTAL domestic		n.d.	1490	

Source : Economic Development Board

Table 3
STRUCTURE OF THE MANUFACTURING INDUSTRY IN 1985

	1	2	3	4	5
Food products	284	9688	3.82	396	3.71
Beverages	14	2273	.90	166	1.56
Tobacco	4	753	.30	77	.72
Textiles & clothing	432	27526	10.86	407	3.81
Leather & footwear	77	1511	.60	23	.22
Timber & furniture	254	11199	4.42	228	2.14
Paper	81	3363	1.33	179	1.68
Publishing	305	13127	5.18	503	4.71
Industrial chemicals	55	3144	1.24	304	2.85
Paints & pharmaceuticals	90	4624	1.82	587	5.50
Refining	12	3494	1.38	873	8.18
Rubber	31	1181	.47	37	.35
Plastics converting	221	8471	3.34	225	2.11
Non-metallic minerals	110	7199	2.84	317	2.97
Iron & steel	15	1510	.60	106	.99
Non-ferrous metals	13	686	.27	37	.35
Metal constructions	435	19453	7.68	656	6.15
Mechanical engineering	349	19693	7.77	813	7.62
Electrical engineering	115	15983	6.31	489	4.58
Electronics	207	66646	26.30	2894	27.12
Transport equipment	220	21768	8.59	1033	9.68
Precision engineering	41	5071	2.00	195	1.83
Miscellaneous	134	5059	2.00	127	1.19
TOTAL	3504	253422	100	10672	100

Key to columns :

- 1 Number of establishments
- 2 Number of employees
- 3 Employees as percentage of total
- 4 Value added
- 5 Value added as percentage of total.

Source : Census of Manufacturing

Table 4
DOMESTIC EXPORTS OF INDUSTRIAL PRODUCTS (in S\$ millions)

SITC	Classification	1986(*)	1987(*)	Percentage in 1987
33	Petroleum products	7664	7494	23.9
51	Organic chemicals	414	587	1.9
52	Other chemicals	31	38	.1
53	Dyes	44	67	.2
54	Pharmaceuticals	138	161	.5
55	Perfumes	51	72	.2
57	Explosives	0	0	.0
58	Plastics	396	681	2.2
59	Industrial chemicals	193	277	.9
61	Leather articles	1.5	3	.0
62	Rubber articles	33	39	.1
63	Timber	123	156	.5
64	Paper products	130	200	.6
65	Textile products	83	130	.4
66	Non-metallic minerals	39	52	.2
67	Iron & steel products	111	133	.4
68	Non-ferrous metals	52	55	.2
69	Metal products	262	293	.9
71	Generators	180	245	.8
72	Specialised machinery	134	160	.5
73	Metal-working machines	53	66	.2
74	General machinery	481	662	2.1
75	Office machines	2630	5030	16.0
76	Telecommunications	1779	3140	10.0
77	Electrical machines and apparatus	3354	4638	14.8
78	Road vehicles	42	73	.2
79	Other transport equipment	111	150	.5
81	Lighting fitments	5	11	.0
82	Furniture	107	162	.5
83	Travel goods	19	32	.1
84	Clothing	763	1209	3.9
85	Footwear	12	23	.1
87	Scientific instruments	195	336	1.1
88	Photographic apparatus	137	160	.5
89	Miscellaneous	681	1013	3.2
	Sub-Total	20449	27548	87.8
	TOTAL EXPORTS	23567	31271	100.0

Source : Customs

(*) - 10 months only

1.2.3. Structure

The traditional industries in Singapore were agricultural food products, timber converting, rubber and tin refining. They have seen their importance considerably reduced and altogether they now account for less than 10% of the value added and employment (Table 3).

Up to 1984 refining was one of the most important sectors in terms of value added, representing up to a fifth of all manufacturing value added; by 1985, taking into account the fall in the price per barrel of oil and of refining margins, this figure was no more than 8%. Another sector in economic decline is shipbuilding and ship-repair work, the main components of the transport equipment sector.

Singapore is becoming more and more a world electronics centre, a sector where there are more than 200 companies, which accounts for one job out of four and a slightly higher percentage of the value added.

The industrial fabric of Singapore is well intermeshed; more than a thousand firms in constructional metalwork and mechanical and electrical engineering; in addition to the major electronics and electrical companies there are numerous sub-contractors.

The massive arrival of multinational companies, "invited" into the country from 1967 onwards, totally transformed the industrial landscape. They generally built large units with more than five hundred and even a thousand employees: it is this which explains the fairly high degree of concentration where 40% of the manufacturing labour force is concentrated in 93 establishments which together account for nearly half the value added.

Within this context the medium-sized companies developed fairly slowly: it is estimated that between 1980 and 1986 those firms with fewer than ten employees recorded an increase of 0.9% in the value added.

1.2.4. Openness

Industry in Singapore is largely open to exporting. Table 4 shows the breakdown of the principal exports of industrial products. It underlines the importance of refining and the products of the electronics industry.

2. THE DEVELOPMENT OF THE ELECTRONICS INDUSTRY

2.1 Historical survey

In 1987 Singapore exported electronic products to the value of US\$ 6b and took the leading place in the electronics industry in the ASEAN countries.

In the middle of the sixties the electronics industry consisted of a few firms assembling radios and television sets for the regional market. This sector might have remained in an embryonic form if the efforts of the EDB in promoting foreign investments had not coincided with the efforts of the multinationals to find new sites.

Over a period of five years the manpower employed in the sector was increased twelve-fold, to become the leading employer in Singapore, a position it has retained ever since. The increased manpower in the branch represented a third of all job creations between 1968 and 1973, half of them between 1974 and 1979 and practically all new jobs between 1979 and 1985. To this direct employment should be added those concerned with sub-contracting (small engineering components, plastic etc.), or about 10,000 persons in 1984. Nearly 80% of the workforce are women, and it is an industry where there are many immigrant workers.

The first activity to be developed in Singapore was the assembling of simple integrated circuits, but this has been progressively transferred to neighbouring countries such as Malaysia and then the Philippines. The companies then introduced into Singapore the manufacture of more complex circuits and the testing of components purchased in the region.

Diversification then continued into the manufacture of consumer goods: finally from 1982 onwards the growth of industrial electronics (mini- and micro-computers and peripherals) has taken over from consumer goods. A new impetus has been given to the manufacture of more sophisticated components, and industrial electronics account for a quarter of the jobs and 40% of the value added of the sector.

The development of the electronics industry has not been without reverses. The production is almost entirely exported, and so suffers from the full impact of all developments in the world electronics industry and, in particular, the effects of fluctuations in the "components cycle". Since 1980 the industry has passed through a period of recession (1981-82) followed at the end of 1983 by a boom which lasted nine months, only to be followed by a second recession which ended in October 1985 when the revaluation of the Yen resulted in a considerable recovery in orders.

2.2. Statistics

Start of the electronics industry	1965
Number of companies	200
Number of employees	60,000
Production (1986)	US\$ 6b
Exports (1987)	US\$ 6b
Imports (1987)	US\$ b

2.3. Evolution of the macro-economic parameters

2.3.1. Employment and value added.

Table 5 shows the changes in the number of establishments, of employees, of production, of exports and of value added in the electronics industry from 1976 to 1985, together with the equivalent data for the whole of the manufacturing industry.

This makes it possible to visualise the place of this industry and to measure its dynamism between 1976 and 1985, with its two quite distinct periods :

- between 1976 and 1980 jobs increased at an annual rate of 19% and the production and value added at 32% and 31% respectively, in current Singapore Dollars. This rate of growth was much higher than the average for all industry.

- between 1980 and 1985 jobs fell slowly by 1.8% whilst production and value added increased at a much more rapid rate than the average for all industry.

The contrast in regard to the changes in the apparent productivity of labour is most striking: although it increased at the same rate as the rest of industry between 1976 and 1980 it increased almost twice as rapidly between 1980 and 1985 (17% and 9% respectively)

Because of these different rates in the two periods the position of the electronics industry has altered very considerably :

- in terms of number of jobs : 17% in 1976 and 26% in 1985;
- in terms of value added : from 13.7% in 1976 to 19% in 1980 and then to 26.8% in 1985 and also in 1986 and in 1987.

In order to view these changes in greater detail reference may be made to two sets of statistics which give a more detailed view of the industry but which, unfortunately, do not make it possible to construct a historical series.

2.3.1.1. The period from 1974 to 1979

The breakdown makes it possible to analyse separately the components sector and the mass consumer electronics sector (Table 6).

During the period 1974 to 1979 electronics were dominated by the components sector which accounted for two-thirds of the jobs. The two sub-sectors showed parallel growth rates during this period.

By contrast we can see a more rapid growth in productivity (measured by the value added per employee) in mass consumer electronics as compared with the components sector.

Table 5

	1976	1980	1985	1986	growth :	
					76/80	80/85
<u>The electronics industry in Singapore</u>						
Number of establishments	74	172	207	212		
Employees	35756	71727	66646	67692	19.0	-1.8
Production (S\$m)	1722	5344	9179	11152	32.7	14.5
Value added (S\$m)	557	1668	2894	3615	31.5	14.8
Per capita value added	15.58	23.25	43.42	53.40	10.5	16.9
<u>The manufacturing industry</u>						
Number of establishments	2546	3390	3529	3519		
Employees	210822	288165	254802	241364	8.1	-3.0
Production (S\$m)	16175	32800	38820	36611	19.3	4.3
Value added (S\$m)	4041	8652	10797	11281	21.0	5.7
Per capita value added	19.17	30.02	42.37	46.74	11.9	9.0
<u>The place of electronics in the manufacturing industry as a percentage</u>						
Number of establishments	2.91	5.07	5.87	6.02		
Employees	16.96	24.89	26.16	28.05		
Production	10.65	16.29	23.65	30.46		
Value added	13.78	19.28	26.80	32.05		

Table 6
EVOLUTION OF THE ELECTRONICS INDUSTRY, 1974-1979

	1974	1979	1974-1979 increase
<u>Mass consumer electronics (radios, television sets, etc.)</u>			
Number of establishments	19	39	
Employees	11226	22343	14.8
Value added (S\$m)	88.70	301.50	27.7
Per capita V.A. (S\$1000)	7.90	13.49	11.3
<u>Semiconductors, other components and other types of equipment</u>			
Number of establishments	56	104	
Employees	18343	37863	15.6
Value added (S\$m)	281	812	23.6
Per capita V.A. (S\$1000)	15.32	21.45	7.0

Table 7

EVOLUTION OF THE ELECTRONICS INDUSTRY, 1981-1985

	1981	1983	1985	% Increase :	
				81-83	83-85
<u>Mass consumer electronics (radios, television sets, etc.)</u>					
Number of establishments	67	57	46		
Employees	29252	19845	17812	-17.6	-5.3
Value added (S\$m)	239	292	185	10.5	-20.4
Per capita V.A. (S\$1000)	3	15	10	34.2	-16.0
<u>Semiconductors</u>					
Number of establishments	15	14	18		
Employees	17100	13489	12997	-11.2	-1.8
Value added (S\$m)	198	245	135	11.2	-25.8
Per capita V.A. (S\$1000)	12	18	10	25.2	-24.4
<u>Other components (resistors, capacitors and PCBs)</u>					
Number of establishments	37	41	41		
Employees	10791	11301	8309	2.3	-14.3
Value added (S\$m)	98	156	141	26.2	-4.9
Per capita V.A. (S\$1000)	9	14	17	23.3	10.9
<u>Informatics (recorded from 1982 onwards) and telecommunications</u>					
Number of establishments	19	45	49		
Employees	4157	12523	16414	73.6	14.5
Value added (S\$m)	78	372	456	118.4	10.7
Per capita V.A. (S\$1000)	19	30	28	25.8	-3.3
<u>Other electronic products and components</u>					
Number of establishments	47	46	53		
Employees	8058	8796	11114	4.5	12.4
Value added (S\$m)	64	129	116	42.0	-5.2
Per capita V.A. (S\$1000)	8	15	10	35.9	-15.6
<u>T O T A L</u>					
Number of establishments	185	203	207		
Employees	69358	65954	66646	-2.5	0.5
Value added (S\$m)	677	1194	1033	32.8	-7.0
Per capita V.A. (S\$1000)	10	18	15	36.2	-7.5

Table 7 - continued

EMPLOYMENT

(All sub-sectors as on previous page)

	1981	1983	1985	% of Total :		
				1981	1983	1985
Mass con. electronics	29252	19845	17812	42.2	30.1	26.7
Semiconductors	17100	13489	12997	24.7	20.5	19.5
Other components	10791	11301	8309	15.6	17.1	12.5
Informatics and telecommunications	4157	12523	16414	6.0	19.0	24.6
Other electronic components etc.	8058	8796	11114	11.6	13.3	16.7
TOTAL	69358	65954	66646	100.0	100.0	100.0

VALUE ADDED in S\$ millions

	1981	1983	1985	% of Total :		
				1981	1983	1985
Mass con. electronics	239	292	185	35.3	24.5	17.9
Semiconductors	198	245	135	29.2	20.5	13.1
Other components	98	156	141	14.5	13.1	13.6
Informatics and telecommunications	78	372	456	11.5	31.2	44.1
Other electronic components etc.	64	129	116	9.5	10.8	11.2
TOTAL	677	1194	1033	100.0	100.0	100.0

2.3.1.2. The period from 1980 to 1985

The statistics covering this period are more detailed. Table 7 breaks down the sector into mass consumer electronics (television sets and audio products), semiconductors, other specific electronic components, informatics and telecommunications equipment and other products and components.

Production increased at a mean rate of 12% from 1981 to 1985: taking the opening up of the sector into account it is not surprising to note two periods of recession, in 1981/82 and 1985, which correspond to two periods of slowing down on the electronics industry at global level.

The performance of the various sub-sectors is very different during this period.

One can observe :

- the decrease in mass consumer electronics;
- the very considerable fluctuations in the production of semiconductors: growth between 1981 and 1983 followed by a decrease which is explained by the world recession in this industry;
- the production of professional equipment (informatics and telecommunications) which showed a very rapid increase.

Employment in the sector fell between 1981 and 1985; in 1985 the reduction was very sudden because of the recession. The recovery in 1986 and 1987 was accompanied by a trend towards re-employment, and the number of employees in 1987 was similar to the number in 1981.

There are several explanations for this general trend in employment :

- In the semiconductors sub-sector the companies relocated their assembly operations in other countries in the region and redeployed their own activities towards testing and the manufacture of more sophisticated components which required more automated equipment. This movement began at the end of the seventies and was accelerated by the implementation of the "Industrial Revolution" with its rapid increase in wage rates.
- In the mass consumer electronics sub-sector the wages policy also accelerated the restructuring of activities: relocation of the production of audio products (a 41% fall in jobs between 1981 and 1985) and the automation of the production of television sets.
- By contrast in the informatics and telecommunications equipment sub-sectors there was a definite increase in employment; because of the creation of jobs the manpower in these two sub-sectors increased from 6% of the total employment in the electronics sector to 24%.

The structure of the value added in the electronics industry showed a major change: measured in constant prices the value added in the traditional sub-sectors, mass consumer electronics and semiconductors, fell in absolute terms. Their contribution to the total value added of the electronics industry fell from 35% and 29% respectively in 1981 to 18% and 13% in 1985.

By contrast the telecommunications and informatics sub-sectors have recorded a very high rate of growth: their contribution to the total value added of the electronics industry increased from 11.5% in 1981 to 44.1% in 1985, and has undoubtedly increased still further in 1986 and 1987 as a result of the capital investments made in them (see below).

The apparent productivity of labour, measured by the ratio between the value added and the total manpower in the branch, has shown very different trends in the various sub-sectors: low in mass consumer electronics and semiconductors but very high in informatics and telecommunications equipment.

Because of the measures taken by the government wages increased rapidly between 1981 and 1985: in current Singapore Dollars the increase in per capita income was 52% over this period. Wages were then frozen for two years

Table 8 shows how the rise in wages was more rapid in this sector than in industry generally, and consequently wages in the electronics industry, which were well below the mean for industry, have now moved towards it.

There are several explanations for this :

- tensions on the labour market;
- increases in skills in this industry.

Examination of the Added Value/Production ratio is of interest. Measured for the whole of the electronics industry this ratio has fallen since 1975. This is due to several factors: in mass consumer electronics the reduction in the number of sub-assemblies reduces the importance of the assembly operations; in semiconductors the appearance of increasingly complex circuits transfers part of the value added to the stage of wafer manufacture.

Table 9 shows the evolution of this ratio for the various sub-sectors. It can be seen that :

- the ratio is higher for professional communications and electronics equipment, lower in the case of components.
- however it has not changed very significantly in these sectors with the exception of semiconductors where one can see a fall which will perhaps be interrupted by the entry into service of the diffusion units (see below).

Table 8
MEAN WAGES IN INDUSTRY

	1981	1983	1985
<u>Annual mean in S\$</u>			
All industry	10445	13382	15924
Electronics	8318	11403	14557
Clothing	6433	7935	9171
 <u>Percentage of mean</u>			
All industry	100.0	100.0	100.0
Electronics	79.6	85.2	91.4
Clothing	61.6	59.3	57.6
 <u>Percentage increases</u>			
All industry	100.0	100.0	100.0
Electronics	100.0	107.0	114.8
Clothing	100.0	96.3	93.5

Table 9
RATIO OF VALUE ADDED TO SALES VALUE (as percentages)

	1981	1983	1985
Professional electronics		32.0	37.5
Communications equipment	40.8	41.8	41.9
Mass consumer electronics	26.0	28.0	28.0
Components	26.0	22.0	26.0
Semiconductors	23.0	19.0	18.0

Source : Calculated from manufacturers' statistics

Table 10
 TRADING BALANCE OF THE ELECTRONICS INDUSTRY
 for 10 months of 1987, in US\$m

SITC	Imports less re-exports	Exports	Balance
761	19	320	301
762	104	516	412
763	164	108	-56
Sub-Total	287	944	657
764	537	557	20
776	1660	1304	-356
75	960	2406	1446
TOTAL	3444	5211	1767

Table 11
 STRUCTURE OF ELECTRONICS EXPORTS FROM SINGAPORE in US\$ thousands

SITC	1980	1984	1987	As percentages :		
				1980	1984	1987
75	159546	1211931	2406908	5.86	27.80	46.17
761	264832	268967	320218	9.73	6.17	6.14
762	643605	532654	516523	23.65	12.22	9.91
763	104376	207492	107995	3.84	4.76	2.07
764	362058	475572	557821	13.31	10.91	10.70
776	1186788	1662106	1304045	43.61	38.13	25.01
TOTAL	2721205	4358722	5213510	100.00	100.00	100.00

Source : UNIDO and Singapore Customs' statistics

Table 12
 STRUCTURE OF ELECTRONICS IMPORTS INTO SINGAPORE

SITC	1980	1984	1987	As percentages :		
				1980	1984	1987
75	229203		1204386	10.23	0.00	23.79
761	88731	126636	194663	3.96	4.44	3.85
762	229377	200641	295439	10.24	7.04	5.84
763	42626	282897	342902	6.37	9.93	6.77
764	373140	471577	718624	16.65	16.55	14.19
776	1177625	1769472	2305618	52.56	62.05	45.56
TOTAL	2240702	2850223	5062632	100.00	100.00	100.00

2.3.2. Exports and imports

The electronics industry in Singapore is directed towards exports which account for more than 85% of the production.

These will now be analysed in terms of products and geographical areas.

The point must first be made that trading in electronics shows a credit balance: total exports have always been greater than imports.

Because of Singapore's importance as a trading centre part of the imports are re-exported, so the figure for domestic exports makes it possible to evaluate the exports coming from the industry in Singapore. If one deducts the imports of electronics products from the re-exports a more pertinent measure of the trading balance can be obtained. Thus for the first ten months of 1987 it may be seen that the industry generates a credit trading balance of US\$ 1.48 billion.

As may be seen from Table 10 the balance is slightly negative in the case of components but is very high in the case of professional electronics.

2.3.2.1. Structure by products (Table 11)

Changes in the breakdown of domestic exports illustrate the changes in production which it is intended to measure.

The data for 1980 and 1984 comes from UNIDO, those for the first ten months of 1987 from the Singapore customs' statistics.

It is possible to see the very rapid transformation of the structure of exports :

- office equipment and informatics products (SITC rev.2 : 75) have increased in seven years from 6% to 46%;
- telecommunications equipment (SITC rev.2 : 764) has shown a slight contraction of its relative share, the increase in exports being less rapid than that for the whole industry;
- mass consumer electronic products (SITC rev.2 : 761, 762 and 763) fell slightly in absolute value but rapidly in relative value, dropping from 37% to 18% of all electronic exports;
- exports of components (SITC rev.2 : 776) were steady in terms of absolute value but fell in relative value from 43% to 25%. The statistics which are available do not make it possible to break down these exports into types of components so as to reflect the importance acquired by the more sophisticated types.

The structure of imports has changed far less rapidly (Table 12) with components (SITC rev.2 : 776) remaining the principal items, and it is possible to see the growing importance of office equipment which represented nearly a quarter of imports in 1987. These are sub-assemblies, but also include equipment re-exported to the other ASEAN countries.

2.3.2.2. Geographical distribution (Table 13)

Exports

The principal trading partners of Singapore are the United States and the ASEAN countries which respectively accounted for 48.7% and 22.9% of exports in 1980 and 60.1% and 21.1% in 1984.

Part of the exports to the United States are made within the Generalized System of Preferences; about 15% of all such exports come under this, and these are largely components exported by American companies.

Some products from Singapore were removed from it in 1986 (radios, microwave ovens), and in 1988 the United States decided to cease granting GSP status to Singapore as from January 1989.

Imports

The geographical distribution of these emphasises the function of Singapore :

- imports of sub-assemblies from Japan or ASEAN countries for mass consumer products which are then re-exported to Europe or the USA;
- imports of integrated circuits (or parts of these) to be assembled or tested. The importance of ASEAN integrated circuits can be seen, bearing witness to the testing function of the region.

2.3.3. The domestic market

2.3.3.1. Mass consumer products.

With only 2.5 million inhabitants Singapore is not an important market when compared with its principal export outlets. It must however be recalled that, because of its high per capita income level, the domestic market in Singapore is comparable to that of the other ASEAN countries (see diagram).

2.3.3.2. Components.

By contrast, and because of its exporting vocation, Singapore is a very important market for semi-products:

- whether these are sub-assemblies for the manufacture of informatics equipment, peripherals or telecommunications equipment;
- or electronic components.

It is the growth of this market for intermediates which attracts new industries or which encourages capital investments, leading to greater national integration. These points will be analysed in the section devoted to integration.

Table 13
GEOGRAPHICAL BREAKDOWN OF EXPORTS

Breakdown of exports of products under SITC 75

				As a percentage :		
	1980	1984	1987	1980	1984	1987
USA	69419	828820	1647513	43.51	68.39	68.45
Japan	3668	7485	10644	2.30	0.62	0.44
Netherlands	2037	3458	136505	1.28	0.29	5.67
Germany, Fed. Rep.	25583	55084	136574	16.03	4.55	5.67
France	4037	8668	42581	2.53	0.72	1.77
Brunei	2403	6286	415	1.51	0.52	0.02
Malaysia	17923	55345	11739	11.23	4.57	0.49
Philippines	554	2066	1468	0.35	0.17	0.06
Thailand	628	34190	48911	0.39	2.82	2.03
ASEAN Sub-Total	21508	97887	62533	13.48	8.08	2.60
Hong Kong	6640	27488	28515	4.16	2.27	1.18
WORLD Total	159546	1211931	2406908			

Breakdown of exports of products under SITC 761

				As a percentage :		
	1980	1984	1987	1980	1984	1987
USA	24748	67667	63818	9.34	25.16	19.93
Japan	107	789	250	0.04	0.29	0.08
Netherlands	12030	9540	5789	4.54	3.55	1.81
Germany, Fed. Rep.	20960	18459	45404	7.91	6.86	14.18
France	13382	29074	32262	5.05	10.81	10.08
Brunei	1456	2931	20	0.55	1.09	0.01
Malaysia	33865	19804	2088	12.79	7.36	0.65
Philippines	2	20	1	0.00	0.01	0.00
Thailand	1161	5363	3906	0.44	1.99	1.22
ASEAN Sub-Total	36484	28118	6015	13.78	10.45	1.88
Hong Kong	27273	12179	6796	10.30	4.53	2.12
WORLD Total	264823	268967	320218			

Breakdown of exports of products under SITC 762

				As a percentage :		
	1980	1984	1987	1980	1984	1987
USA	152918	221570	199568	23.76	41.60	38.64
Japan	7615	13878	3617	1.18	2.61	7.00
Netherlands	7917	7279	82	1.23	1.37	1.59
Germany, Fed. Rep.	36468	25626	2452	5.67	4.81	4.82
France	79624	47225	28678	12.37	8.87	5.55
Brunei	1298	1002	22	0.20	0.19	0.00
Malaysia	30167	27897	6362	4.69	5.24	1.23
Philippines	8	11	113	0.00	0.00	0.02
Thailand	4278	2943	1414	0.66	0.55	0.27
ASEAN Sub-Total	35751	31853	7911	5.55	5.98	1.53
Hong Kong	11323	13790	14098	1.76	2.59	2.73
WORLD Total	643605	5354	516523			

Table 13 (continued)
GEOGRAPHICAL BREAKDOWN OF EXPORTS

Breakdown of exports of products under SITC 764

	1980	1984	1987	As a percentage :		
				1980	1984	1987
USA	181451	293475	378501	50.12	61.71	67.85
Japan	3935	4454	10752	1.09	0.94	1.93
Netherlands	18878	3918	5535	5.21	0.82	0.99
Germany, Fed. Rep.	11677	10331	5925	3.23	2.17	1.06
France	11266	5011	3718	3.11	1.05	0.67
Brunei	2045	2988	217	0.56	0.63	0.04
Malaysia	46462	61212	75190	12.83	12.87	13.48
Philippines	911	795	1264	0.25	0.17	0.23
Thailand	10734	17982	4262	2.96	3.78	0.76
ASEAN Sub-Total	60152	82977	80933	16.61	17.45	14.51
Hong Kong	6642	11898	14211	1.83	2.50	2.55
WORLD Total	362058	475572	557821			

Breakdown of exports of products under SITC 776

	1980	1984	1987	As a percentage :		
				1980	1984	1987
USA	521953	646275	587290	43.98	38.88	45.04
Japan	45143	71815	56295	3.80	4.32	4.32
Netherlands	744	346	533	0.06	0.02	0.04
Germany, Fed. Rep.	114060	81786	75678	9.61	4.92	5.80
France	15455	23349	10558	1.30	1.40	0.81
Brunei	65	211	87	0.01	0.01	0.01
Malaysia	156794	396352	108571	13.21	23.85	8.33
Philippines	34183	33824	16382	2.88	2.04	1.26
Thailand	102297	42930	27750	8.62	2.58	2.13
ASEAN Sub-Total	293339	473317	152789	24.72	28.48	11.72
Hong Kong	67416	119180	92672	5.68	7.17	7.11
WORLD Total	1186788	1662106	1304045			

Table 14
GEOGRAPHICAL BREAKDOWN OF IMPORTS

Breakdown of imports of products under SITC 75

				As a percentage :		
	1980	1984	1987	1980	1984	1987
USA	101595	414303	440942	44.33	41.43	36.61
Japan	63881	114396	232647	27.87	11.44	19.32
Netherlands	5181	5572	4726	2.26	0.56	0.39
Germany, Fed. Rep.	8581	21899	35507	3.74	2.19	2.95
France	7277	5109	10574	3.17	0.51	0.88
Brunei	48	7	14	0.02	0.00	0.00
Malaysia	3906	28425	8046	1.70	2.84	0.67
Philippines	96	20769	135	0.04	2.08	0.01
Thailand	10	38847	18257	0.00	3.88	1.52
ASEAN Sub-Total	4060	88048	26453	1.77	8.80	2.20
Hong Kong	2485	52339	11481	1.08	5.23	0.95
WORLD Total	229203	1000000	1204386			

Breakdown of imports of products under SITC 761

				As a percentage :		
	1980	1984	1987	1980	1984	1987
USA	526	558	182	0.59	0.44	0.09
Japan	45055	75712	65827	50.78	59.79	33.82
Netherlands	3747	336	49	4.22	0.27	0.03
Germany, Fed. Rep.	24859	5123	7447	28.02	4.05	3.83
France	21	282	174	0.02	0.22	0.09
Brunei	0	1	0	0.00	0.00	0.00
Malaysia	572	37428	110087	0.64	29.56	56.55
Philippines	0	1	128	0.00	0.00	0.07
Thailand	1	283	1310	0.00	0.22	0.67
ASEAN Sub-Total	573	37713	111525	0.65	29.78	57.29
Hong Kong	205	5325	1743	0.23	4.20	0.90
WORLD Total	88731	126636	194663			

Breakdown of imports of products under SITC 762

				As a percentage :		
	1980	1984	1987	1980	1984	1987
USA	897	482	791	0.39	0.24	0.27
Japan	182815	161712	104815	79.70	80.60	35.48
Netherlands	3	72	24	0.00	0.04	0.01
Germany, Fed. Rep.	706	2238	2570	0.31	1.12	0.87
France	67	39	231	0.03	0.02	0.08
Brunei	0	0	0	0.00	0.00	0.00
Malaysia	11012	10366	128654	4.80	5.17	43.55
Philippines	1	0	49	0.00	0.00	0.02
Thailand	54	257	16	0.02	0.13	0.01
ASEAN Sub-Total	11067	10623	128720	4.82	5.29	43.57
Hong Kong	22142	7803	14379	9.65	3.89	4.87
WORLD Total	229377	200641	295439			

Table 14 (continued)
GEOGRAPHICAL DISTRIBUTION OF IMPORTS

Breakdown of imports of products under SITC 764

				As a percentage :		
	1980	1984	1987	1980	1984	1987
USA	49139	78602	67195	13.17	16.67	9.35
Japan	173617	238196	371238	46.53	50.51	51.66
Netherlands	11398	6531	2722	3.05	1.38	0.38
Germany, Fed. Rep.	8693	9177	11724	2.33	1.95	1.63
France	6147	4842	8900	1.65	1.03	1.24
Brunei	12	29	64	0.00	0.01	0.01
Malaysia	31878	45907	112426	8.54	9.73	15.64
Philippines	87	53	307	0.02	0.01	0.04
Thailand	49	312	2261	0.01	0.07	0.31
ASEAN Sub-Total	32026	46301	115058	8.58	9.82	16.01
Hong Kong	10371	9999	10421	2.78	2.12	1.45
WORLD Total	373140	471577	718624			

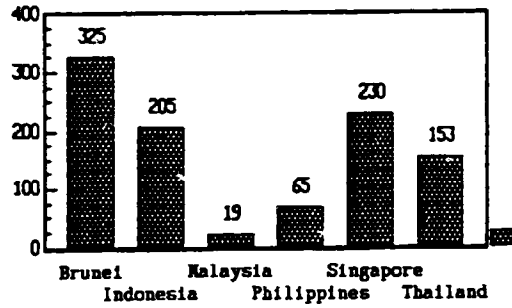
Breakdown of imports of products under SITC 776

				As a percentage :		
	1980	1984	1987	1980	1984	1987
USA	543166	598008	745447	46.12	33.81	32.32
Japan	161533	398664	597618	13.72	22.54	25.91
Netherlands	2214	3656	10865	0.19	0.21	0.47
Germany, Fed. Rep.	40704	33522	86073	3.46	1.90	3.73
France	5223	10558	15087	0.44	0.60	0.65
Brunei	1	0	4	0.00	0.00	0.00
Malaysia	190461	390960	338700	16.17	22.11	14.68
Philippines	27327	48632	69227	2.32	2.75	3.00
Thailand	105832	83750	148250	8.99	4.74	6.43
ASEAN Sub-Total	323621	523342	556181	27.48	29.59	24.11
Hong Kong	31416	35722	38300	2.67	2.02	1.66
WORLD Total	1177625	1768472	2306618			

Table 15

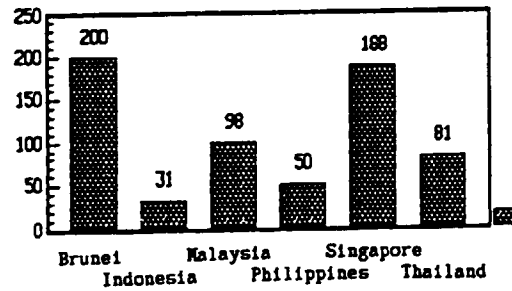
EQUIPMENT IN HOUSEHOLDS

Radios per 1000



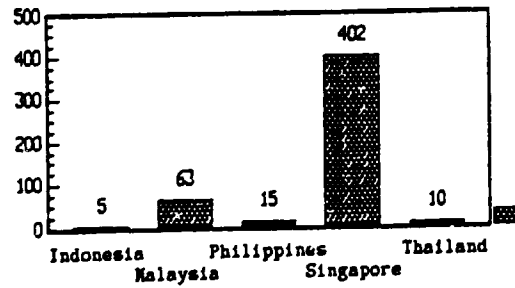
EQUIPMENT IN HOUSEHOLDS

Television sets per 1000 persons



TELEPHONE EQUIPMENT

Subscribers per 1000 inhabitants



3. PRODUCTION AND THE ORGANISATION OF PRODUCTION

3.1. The structure of production

3.1.1. Mass consumer electronics

Electronic products for mass consumption was the first of the electronics activities in Singapore: a unit for the assembly of television receivers was installed in 1965. After having undergone rapid growth from 1975 to 1980 this sector stagnated from 1980 onwards.

Confronted with the wage rises provoked by the "Industrial Revolution" (see above) many companies relocated their audio divisions in Malaysia or in Thailand, at the same time investing in automation without enlarging their production capacities.

Amongst the most spectacular decisions was that of General Electric, the leading employer in 1980, which reduced its workforce by more than 7000, abandoning the assembly of television sets to invest in converters for cable television and in automatic receivers. Philips (600,000 television sets per year) introduced a CAD system which integrated the design and manufacture of receivers. Thomson (2000 employees) and Hitachi relocated their audio divisions in Malaysia.

As may be seen from Table 16 audio products still represent more than half the production of mass consumer electronics. Production of colour television sets is increasing and should increase still further in the coming years as a result of the new capital investments made in 1986 and 1987.

In fact since the revaluation of the Yen in October 1985 there has been a very obvious recovery in investment in mass consumer electronics.

Amongst the most recent examples of this are Aiwa and Kenwood in hi-fi, whilst the Sony Engineering Center will provide the software for the other Sony units in the ASEAN countries and will produce precision components including magnetic reading heads. Matsushita is to manufacture telecopiers, and this unit will provide 40% of the facsimile machines exported by the enterprise. Hitachi has built a unit to produce 2.25 million colour tubes a year.

These extensions are accompanied by capital investments in automation together with greatly increased industrial integration. For example the Japanese Asashi company is to build a major unit to produce glass tubes for television sets.

3.1.2. The components industry

The components industry in Singapore is the most highly developed of all those in the ASEAN countries and one of the most developed in the Third World. The production, practically all of which is exported, reached US\$ 1.3 billions in 1986.

As may be seen from Table 17 the most important activity is that of manufacturing active components.

A reduction in the manpower in this sub-sector began before the restructuring policy launched by the State. The companies had, in fact, begun to relocate the assembly of simple semiconductors in order to

redeploy themselves in the direction of more sophisticated components (LSI and VLSI memories) and testing activities. This movement is accompanied by the increasing automation of the operations, explained by the wage levels and by technological exigencies.

Until the beginning of the eighties manufacture was exclusively concerned with simple bipolar circuits intended for mass consumer products: the other semiconductors were imported.

The components industry took an important step forward in 1984 when SGS/ATES, already established in Singapore with an assembly and testing unit, invested in a diffusion unit for integrated circuits intended for mass consumer products (discrete semiconductors and integrated CMOS circuits for electronic watches and calculators). The Italian company had been attracted by the financial facilities offered by the EDB for investments in high technology; its decision formed part of its long-term strategy for Asia. After this first step SGS/ATES invested S\$ 120m in the diffusion of integrated MOS for computers; these are pre-diffused gate array circuits.

Since that time a series of capital investments has strengthened the position of Singapore upstream of the micro-electronics industry.

Hewlett Packard has invested in the diffusion of gallium arsenide (GaAs) circuits (US\$ 23m in a first stage); American Telegraph and Telecom (ATT) has invested in a design unit (US\$ 20m) and in a telecommunications equipment unit (US\$ 35m). Unizon of Japan has invested US\$ 25m in a production line for discrete semiconductors and integrated circuits.

These investments are integrated within an inter-company logic, but this is not the case with the investment decided on by Chartered Inc. in December 1987. For some years now the Economic Development Board has tried to attract a "silicon foundry" to Singapore. After having experienced many set-backs the EDB was able to convince National Semiconductors to take a 9% interest with Sierra Semiconductors (17%) and the State company, Singapore Technology Corporation (74%) in a US\$ 40m unit for the manufacture of integrated CMOS circuits at a rate of 5000 6-inch wafers per month with a forecast turnover of US\$ 50m.

Half the production of Chartered Inc. will be taken up by the foreign partners in the project, NSC and Sierra, and so will benefit from the captive market of its promoters and will offer the possibilities for sub-contracting with design units. Singapore, which benefits from the GSP, will be able to export to Europe.

The most recent investments in the components sub-sector show that the companies concerned are involved in the manufacture of the most sophisticated components :

Fairchild and NSC, who have merged their plants, have invested in components for the defence and informatics industries (3800 jobs).

AMD and NEC have invested in the manufacture of VLSI memories (US\$ 45m).

The entire micro-electronics stream is present in Singapore with, in addition to the diffusion units :

- a local manufacturer of masks (Nanotek);
- a producer of lead frames;
- two aluminium and gold wire units.

3.1.3. Professional electronics

Professional electronics can be seen as the most dynamic sub-sector of the Singapore electronics industry. Exports from this sub-sector accounted for 46% of all exports in 1987.

Table 18 gives the breakdown of production and underlines the importance of the equipment related to data processing; according to Benn's statistics this equipment, coupled with office equipment, accounts for more than half of all the production.

The manufacture of data processing peripherals is the principal activity of this sub-sector.

The experience acquired in mass consumer electronics and in micro-engineering has contributed towards the major growth in these activities.

The major world manufacturers in computer peripherals are all present: Tandon, Syquest, Maxtor (3 plants), and Seagate (the world No.1 with 50% of the market, which has built six plants and is the leading employer with 7300 employees). This company has now been joined by the No.2, Unysis and by Control Data (S\$ 52m and 500 employees).

Singapore has become the leading country for the manufacture of disk readers. The complete range of these sub-assemblies, from simple floppy disk readers to 20 Gigabit systems, are manufactured in Singapore. In 1986 production reached S\$ 1.7b and exceeded S\$ 3b in 1987. Local supplies for this industry would account for S\$ 500m.

Amongst the other important sub-sectors are telecommunications. American Telegraph and Telecom (ATT) has invested US\$ 35m in a unit for telecommunications equipment.

Table 16
MASS CONSUMER ELECTRONIC PRODUCTS

	1984	1985	1986
<u>Production in US\$ millions</u>			
Video	301	316	351
Audio	562	499	515
Other	12	9	11
TV tubes	70	65	72
TOTAL	945	889	949

Production in thousands units

Colour televisions	1739	1970	2170
B&W televisions	255	165	160
Portable radios	3622	2334	1900

Source : Yearbook of electronics data, Benn Electronics, 1987

Table 17
PRODUCTION OF COMPONENTS

	1984	1985	1986
Discrete semiconductors	207	185	195
Integrated circuits	1060	1099	1409
Miscellaneous	3	3	3
<u>Sub-total, active components</u>	<u>1270</u>	<u>1287</u>	<u>1607</u>
Capacitors	53	50	53
Resistors	22	20	20
Printed circuits	474	566	632
Miscellaneous	134	132	136
<u>Sub-total, passive components</u>	<u>683</u>	<u>768</u>	<u>841</u>

Table 18
PROFESSIONAL ELECTRONICS in US\$ millions

	1984	1985	1986
Electronic data processing	879	801	977
Office equipment	174	161	131
Control and instrumentation	33	36	38
Medical and industrial	62	74	80
Communications and military	165	181	203
Telecommunications	560	515	506
TOTAL	1873	1768	1935

Source : Benn Electronics

Table 19
CAPITAL INVESTMENTS IN INDUSTRY (in S\$ millions)

	Manufacturing	Electrical and electronics	Engineering
1976	303	142	
1977	396	120	
1978	812	292	
1979	943	253	
1980	1418	396	2
1981	1877	421	27
1982	1705	321	28
1983	1776	352	39
1984	1830	656	14
1985	1136	392	15
1986	1439	518	20
1987 (6 months)		458	

Source : Economic Development Board

Table 20
NATIONALITY OF COMPANIES IN THE ELECTRONICS INDUSTRY

Employees	under 100	100- 500	500- 1000	over 1000		Total
<u>Industrial electronics</u>						
Singapore	9	0	0	0	0	9
United States	3	5	0	3	0	11
Japan	0	0	0	1	0	1
EEC	0	1	0	0	0	1
Other	1	0	1	1	0	3
TOTAL	13	6	1	5	0	25
<u>Mass consumer electronics</u>						
Singapore	27	4	0	0	0	31
United States	2	0	1	2	0	5
Japan	6	6	5	4	0	21
EEC	4	0	0	3	0	7
Other	2	2	0	0	0	4
TOTAL	41	12	6	9	0	68
<u>Components</u>						
Singapore	28	11	3	2	0	44
United States	5	11	1	5	5	27
Japan	6	15	0	1	0	22
EEC	3	4	1	1	2	11
Other	2	2	0	0	0	4
TOTAL	44	43	5	9	7	108
<u>All sub-sectors</u>						
Singapore	64	15	3	2	0	84
United States	10	16	2	10	0	38
Japan	0	21	5	6	5	37
EEC	0	5	1	4	0	10
Other	5	4	1	1	2	13
TOTAL	98	61	12	23	7	201

3.1.4. The design of circuits and programs

The "Software Directory", published in 1987, lists 191 software companies: the great majority of these are very small companies which "embellish" well-known basic softwares and sell them to clients in Singapore or the ASEAN countries, a group formed from seven Singapore companies and Chinese companies EB 02 88.

This demonstrates the dynamism of this sector, and one can now see the arrival of the major groups. Bull has "Singaporised" its local branch, Data General Corp. has decided to invest S\$ 42m over the next five years in a software centre, and has obtained OHQ status (see below).

The design of integrated circuits is a rapidly developing activity. It is sometimes integrated into industry; this is the case with the SGS/ATES unit where a score of engineers develop "semi-customised" circuits using prediffused circuits: this example has been followed by Hewlett Packard and Fairchild. American Telegraph and Telecom has invested US\$ 20m in a design unit.

Chartered Electronics Industry is independent; here six engineers develop customised chips for the shareholding companies of the Sheng Li group. Austek (Australia) also has six engineers. The French Singaporean Institute is associated with Mentor in design work.

3.2. Organisation of the sector

3.2.1. Foreign investments

In no other ASEAN country do foreign companies play as important a role in the industry as in Singapore: they account for 60% of the jobs, 70% of the value added and 80% of the exports.

The EDB statistics (Table 19) show the flow of investment towards the electrical and electronics industry. It can be seen that these represent a considerable proportion of the capital investments made in the manufacturing industry; after a very noticeable slowing-down in 1982/83 the rate accelerated in 1986 and even more so in 1987.

The published information gives no indications as to the origin of these investments in electronics; in the whole of manufacturing these foreign investments currently represent more than 70% of total investments, and the proportion is undoubtedly higher in the case of electronics.

3.2.2. The place of Singaporean companies

In view of the lack of more pertinent statistics the data set out in Table 20 on the organisation of production have been derived from the Singapore Manufacturers and Products Directory, 1984 (published in 1987).

It can be seen that, out of the 199 companies listed, 117 are foreign, the majority (64) of the Singaporean companies having less than 100 employees whereas those companies with more than 500 employees are very often owned by foreign capital.

The breakdown of these companies by the principal sub-sectors of the electronics industry shows that the local companies are mainly in the components and mass consumer goods fields.

A more detailed analysis of the 42 companies producing components shows that they are mainly engaged in the production of discrete components and printed circuits, with 11 and 26 companies respectively being involved in these two activities.

3.2.3. Factor costs

The wages differentials between the industrialised countries and Singapore has been an important factor in attracting companies, but by itself it is not sufficient since wages in Singapore have always been very much higher than those found in the other ASEAN countries or in other New Industrialised Countries such as the Republic of Korea. (Table 21).

The levels of salaries of young engineers and technicians in Singapore are today a new and major comparative advantage (Table 22).

Amongst its other advantages which Singapore possesses, and which are very important for the electronics industry, are the excellent quality of the infrastructures, in particular the telecommunications and the moderate cost of the public services.

In addition to the quality of these infrastructures the absence of "red tape" is one of the "comparative advantages" of the City State; others are, in the case of the electronics industry, the possibility of launching a new production line very rapidly. A manufacturer of computer peripherals was able to make its first despatches to the United States a mere three months after deciding to invest in Singapore. As the Managing Director of Aiwa pointed out to us "If we had had more time available we would have chosen Thailand but, caught short by the rise in the Yen, we chose to invest in Singapore".

Table 21
WAGES DIFFERENTIALS IN THE ELECTRONICS INDUSTRY

	1969	1975	1985	1985 in US\$
United States	100	100	100	8.50
SINGAPORE	9	12	19	1.58
Indonesia		5	4	.35
Republic of Korea	10	7	14	1.19
Malaysia		9	10	.84
Philippines		6	8	.63
China (Taipei)	8	7	16	1.36
Thailand		5	5	.43

Sources : The Global Factory, 1985
The semiconductor in South-East Asia, in
Regional Studies, Vol. 21.2, pp. 143-160, 1986.

Table 22
SALARY LEVELS ACCORDING TO DIPLOMAS, 1986

Mean monthly salary
Electronics engineers
Mechanical engineers

Source : National University of Singapore, Employment Survey.

* These are the net salaries received by newly-qualified graduates, and not total wage costs.

Table 23
INPUTS IMPORTED AND PURCHASED LOCALLY (in US\$m)

	Imported (N)	Local (L)	L/N+L as %
Mass consumer electronics	421	1275	33.0
Components	350	1961	17.8
Informatics and Office equipment	338	1038	37.4
Telecommunications	59	121	48.8

Source : Input Output, 1983

Table 24
CHANGES IN LEVELS OF SUPERVISORY STAFF

	1981			1985		
	men	women	total	men	women	total
Workers	7266 12.7%	50045 87.3%	57311 82.6%	7637 14.6%	44530 85.4%	52167 78.3%
Supervisors	7105 59.0%	4932 41.0%	12037 17.4%	8962 62.0%	5494 58.0%	14456 21.7%
TOTALS	14371 20.7%	54977 79.3%	69348	16599 24.9%	50024 75.1%	66623

Table 25
THE STRUCTURE OF EMPLOYMENT BY SUB-SECTORS (in 1985)

	workers	skilled workers	TOTAL
Professional electronics	11310 79.1%	2981 20.9%	14291
Telecommunications equipment	1513 71.4%	606 28.6%	2119
Mass consumer electronics	13763 77.3%	4049 22.7%	17812
Components	16495 77.5%	4798 22.5%	21293
TOTALS	43081	12434	55515

4. THE TRANSFER AND MASTERY OF TECHNOLOGIES

In the case of Singapore the transfer of technology cannot be dissociated from direct investment.

In order to measure the level of technological mastery we will study firstly the level of local integration (4.1), secondly the changes in skill levels (4.2) and finally research and development (4.3).

4.1. Local integration

Singapore, which may be regarded as an enclave of the world electronics industry or as a form of offshore site, is increasingly being seen as an "industrial pole" of electronics.

Local integration may be analysed at two levels, either macro-economically, using the 1983 Input-Output tables, or micro-economically.

4.1.1. The macro-economic approach

Analysis of the 1983 Input-Output data (Table 23) shows that the electronics sector imports 78% of its inputs, a very high figure; however it must be remembered that Singapore is a free-trade area and also that some of its imports are intra-company trading which in no way confirm the existence or non-existence of local competitive production.

The sub-sector which buys most from abroad is that of components, whilst the telecommunications sub-sector is the one which shows the highest level of integration of local sub-assemblies (32.7%).

4.1.2. The micro-economic approach

Two types of integration may be employed :

4.1.2.1. Integration by firms

In certain cases companies invest in Singapore in activities which support their principal activity. This was the case recently with Matsushita (25% of the world market for motors for audio equipment) which built its second small motors plant for audio and video products where it is now producing 5 million units. Japanese companies are investing in the mechanisms for cassette recorders and in the injection moulding of plastics.

Some foreign companies have helped certain sub-contractors to invest in equipment making it possible for them to manufacture sub-assemblies; this was the case with Hewlett Packard which in this way favoured the manufacture of the membranes used for the switches of computer control panels. The Local Industry Upgrading Programme (see under 5. below) is intended to promote this type of relationship between local firms and the major groups.

4.1.2.2. Purchasing from local sub-contractors

We have already indicated that it is possible to identify nearly 10,000 sub-contracting jobs related to the electronics industry: these are jobs in small-scale engineering and in the converting of plastics.

According to the estimates of the Economic Development Board there has been little change in the number of these jobs since 1984. Sub-contracting firms in Singapore are in practice faced with very specific problems which are not encountered in other New Industrialised Countries. The "entry threshold" is very high for a sub-contracting company; it must be able to meet the quality standards of the largest multinationals. In countries such as Taiwan or Korea there is a much broader range of firms producing mass consumer electronics goods, and this facilitates a degree of apprenticeship.

It is in the field of disk readers that purchasing from local sub-contractors shows the highest level of dynamism. All the investors are attracted by the local sub-contracting possibilities, since they can buy more than half their inputs locally.

With overall production reaching S\$ 3 billion the value of the local supplies would be S\$ 500m.

As an example Maxtor, one of the world's largest manufacturers of 5¼" floppy disk readers and the owner of three plants in Singapore, buys 60% of its supplies locally.

Seagate purchases local components in Singapore to a value of US\$ 20m every month, representing 30% of all its purchases in Asia.

4.2. Technological level

4.2.1. The evolution of skills

Table 24 shows the breakdown of staff levels into workers and supervisory staff and also the breakdown by sex.

It is possible to see an increase, from 1% to 21%, in the levels of supervisory staff; in the Singapore statistics this classification covers engineers and technicians. This change is accompanied by a fall in the level of feminisation of the labour force.

It can be seen from Table 25 that engineers and technicians are, proportionately, more numerous in mass consumer electronics. The "high-tech" sectors, at least at the present time, employ relatively more workers.

4.2.2. The training institutions and their students

Since 1979 Singapore has put considerable effort into training; several technical training institutes have been established with the cooperation of foreign governments (for example the French Singaporean Institute for electronics) or foreign companies (as in the case of IBM which participates in the Institute of System Science).

4.3. Research and Development

4.3.1. A low level of R&D

Two surveys have been carried out to measure the level of R&D at national level.

The number of scientists is 20 per 10,000, whereas it is 22 in the Republic of Korea. R&D expenditure was 0.3% of the GNP in 1981, 0.6% in 1985 and should reach 1% in 1988.

This fairly low level is obviously a handicap for the development of the electronics industry: furthermore the foreign companies have, until very recently, invested very little in R&D in Singapore.

The State has played an important role in promotion: the Economic Development Board endeavours to attract "high-tech" companies. It has funds which enable it to play the role of venture capital. The EDB's offices abroad identify "start up" companies which they propose to internationalise, and can offer participation in the company capital. This initiative dates from 1985, and has made it possible to attract a manufacturer of disk readers and a company specialising in graphics cards for computers.

4.3.2. The Science Park

Singapore acquired its technopolis in 1979: the Singapore Science Park was conceived in the image of the Cambridge Science Park. Managed by the Jurong Town Corporation (JTC) it houses R&D activities but no industrial activities.

The SSP is situated in the neighbourhood of the University of Singapore and covers 115 hectares.

The first stage of its development is practically complete: it includes the Singapore Institute of Standards and Industrial Research (SISIR), the National Computer Board and 34 R&D establishments, including 29 private organisations, which occupy either "starter units" or, in the case of software activities, "Cintechs".

The SSP expects to double in size within three years, and to house about a hundred enterprises in ten years time.

Requests for admission are examined by the Singapore Science Council; the criteria employed relate to R&D expenditure, the scientific profile of the personnel and the service and research contracts to be offered by the enterprise.

Sectors to which priority are given are fine chemicals, biochemistry, polymers, fibre optics applications, medical laser applications, robotics, multipurpose units, biotechnologies, scientific instrumentation, informatics, circuit development and software.

Amongst the capital investments recently made in electronics R&D in Singapore are :

- Hewlett Packard for the development of systems informatics;
- Digital PABX telephone exchanges and software;
- Digital, for surface mounting technology;
- Micropolis, for high-capacity Winchester disk readers.

5. DEVELOPMENT PROSPECTS

Since 1985 the government has revised its industrial policy, and the reforms of 1985/86 made the economic environment more favourable for companies by revising the wages policy and public tariffs. Recently the British Copyright Law of 1911, which controlled patents, has been amended by more suitable legislation.

The rapid recovery of capital investments in electronics reflects the renewed attraction of Singapore.

In order to develop this sector the government is concerned with promoting sub-contracting and is trying to attract high-tech companies.

- The government has implemented a local programme, the Industries Upgrading Programme. In May 1988 41 local companies agreed to participate in this programme, including 12 multinationals. Each of them works with four or five sub-contractors and an EDB executive is responsible for following up their activities and for liaison with a foreign company.

The Small Industries Technical Assistance fund finances the technical aid which needs to be provided for the sub-contractor.

- Singapore owes its electronics vocation to the major companies. The EDB hopes to attract "start up" companies: since the end of 1985 a fund enables it to operate as "venture capital" once a company has been identified. It is then a matter of convincing the company to become internationalised.