

PRODUCTION IN TRANSITION WITHIN THE SEMICONDUCTOR INDUSTRY AND ITS IMPACT ON PENANG

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Industri separa konduktor telah memainkan peranan penting di dalam ekonomi Pulau Pinang sejak pelancaran Zon Perdagangan Bebas pada tahun 1972. Namun, sehingga dekad 1980an, Pulau Pinang telah kekal sebagai salah satu 'tapak luaran' syarikat separa konduktor asing. Lantaran itu, apabila syarikat-syarikat separa konduktor mula mengautomasi barisan pengeluaran, spekulasi berleluasa bahawa cawangan-cawangan di Pulau Pinang akan ditempatkan balik di tapak-tapak induk. Bertentangan dengan tafsiran ini, penulis menunjukkan bagaimana peralihan pada dekad 1980an, khususnya sejak krisis seluruh-industri pertengahan tahun 1984 memperlihatkan Pulau Pinang sebagai salah satu tapak pemusatan tahap-tahap pengeluaran bawahan. Penulis juga membincangkan bagaimana peralihan ini telah mentransformasikan peranan industri separa konduktor di dalam ekonomi Pulau Pinang.

The semiconductor industry has featured prominently in Penang's economy with the introduction of Free Trade Zones in Penang in 1972. However, up until the 1980s, Penang had remained very much an off-shore enclave of foreign semiconductor firms. Consequently, when these firms began to automate their production lines, speculation was rife that they would be relocated back at their parent sites. Contrary to this belief, the author shows how changes in the 1980s, particularly since the mid-1984 industry-wide crisis point strongly to Penang becoming one of the major sites of agglomeration for the tail-end stages of production. In the light of such developments, the author also describes how these changes have transformed the role of the semiconductor industry in Penang's economy.

1 INTRODUCTION

This paper analyses the production changes within the semiconductor industry in the 1980s and their impact on the economy of Penang. An effort is then made to locate Malaysia in the current international division of labour vis-a-vis selected reference countries. The paper goes on to examine the impact of these changes on the industrialisation efforts, employment contribution, and the organisation of production in Penang.

The semiconductor industry was born in the United States' military establishment in the late 1940s (Marsh, 1981). Although the early development

of microelectronics was more associated with the military, the microelectronic 'revolution' is in itself the product of expansion in commercial markets (see OECD, 1985: 18). The latter was to provide the basis for the globalisation of semiconductor production. Underlying the thrust behind the nature of internationalisation is competition between individual firms. While the rivalry between the United States and Japan still holds centre stage, the emergence of semiconductor corporations from the newly industrialising countries (NICs), particularly South Korea, should no longer be treated lightly. Meanwhile, corporations from Western Europe have also been battling to gain ground on their grip on the global map.

The internationalisation of production by the United States' corporations and subsequently by their Japanese and European competitors into the Third World has been greeted with enthusiasm by most Third World nations. The NICs were among the first to take advantage of it. Aggressive export-oriented industrial policies were the order of the day. South Korea, for instance, embarked on a eight-year industrial master plan (MIDA: 1983: 43). Today, the NICs, especially South Korea and Taiwan, have taken a positive stride towards closing the yawning gap that used to separate them from the major semiconductor producing nations (see *Fortune*, 10/1984; South, 07/87: 9-17).

2 TRANSITION IN THE GLOBAL ASSEMBLY LINE

Fierce competition between the semiconductor corporations in the 1980s, particularly since the mid-1984 crash has radically affected the industry. The immediate effect has been falling chip prices. The E-PROM (Erasable, Programmable, Read Only Memory) chip, for instance, dropped from a price of US\$17 a chip to US\$4 a chip within ten months in 1985 (*Fortune*, 06/01/86: 21). Whilst the cost of producing chips have fallen (see Figure 2), American corporations who claimed that actual production cost could not dip below US\$6.85 a unit and, as a result, accused the Japanese of dumping (*Fortune*, 06/01/86: 21). The American government subsequently issued a statement claiming that the Japanese had in fact dumped chips in the U.S. market thereby justifying a raise in tariffs on Japanese chips to 188 percent (*Fortune*, 06/01/86: 21). The American government was also instrumental in forcing the appreciation of the Yen by Japan to protect its corporations. The immediate impact of these two developments on the Japanese corporations was an internationalisation of production facilities into the United States to circumvent tariffs. Hitachi, for instance, started a wafer fabrication plant in Texas (*Electronic Business*, 01/01/87: 64). There was also a floor price agreement for chips between the United States and Japan (*Electronic Business*, 01/01/87: 64-65).

Meanwhile, structural changes caused by the acceleration of product cycles, the incorporation of automation technologies, the Japanese Just-In-Time (JIT)¹

and Materials Requirement Planning (MRP)² infused a new dimension into the international division of labour within the semiconductor industry. With cut-rate competition between firms pushing prices down, firms are not only forced to come up with better chips but also to find ways to reduce production costs. In this regard, with the reorganisation of production through automation and the managerial techniques stated above, despite the rising scale of integration per chip that has risen exponentially with time (see Figure 3 & Figure 4), production costs have fallen sharply (see Figure 2).

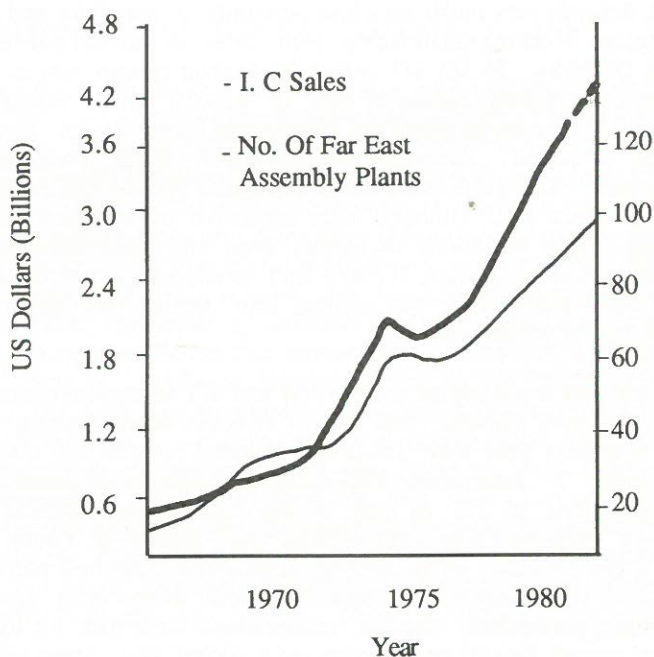
One of the most important features often drawn as instrumental in explaining the current structural changes occurring in the global semiconductor industry is the incorporation of newer management principles such as JIT and MRP. JIT (see Sayer, 1986: 51; Kaplinsky, 1985), born from the attempts of some Japanese car manufacturers, particularly Toyota to adapt Western practises to Japanese conditions, is being rapidly introduced in the production systems of the semiconductor corporations at Penang. JIT aims at reducing set-up times of machines, increasing the flexibility of production systems, eliminating buffers to zero, errors and rejects as well as to do away with idle time, surplus workers, excessive equipment capacity and insufficient preventive maintenance (Sugimori et al, 1977; cited in Sayer, 1986: 52). The success of this technique, however, depends very much on close proximity to suppliers and markets and a very close working relationship with them as pointed out by Hutchins (Fortune, 09/06/86: 56-58). JIT enlists the kanban system where instructions are communicated by means of tags or boards which markedly reduces planning, information-handling and supervision costs besides increasing the utilisation of capital. American semiconductor firms seem to prefer the computerised MRP production control systems (Ohno, 1982; cited in Sayer, 1986: 53). Since MRP although more expensive and complex handles more effectively bigger variations in output, even big Japanese corporations use it. Like increased automation, JIT also tends to encourage: one, a recomposition of work tasks and in that way setting into motion reskilling; and two, a centralisation of production.

One should not misinterpret automation and JIT as synonymous. The latter may actually bring cheaper and more effective manufacturing with many simpler machines than with fewer sophisticated automated machinery (see Sayer, 1986: 51; Interviews, 1987). The centralisation of production implicit in the operations of JIT as well as the rapid move towards automation technology prompted Kaplinsky (1985), and Kamal & Young (1985) to forecast a centralisation of production at proximate sites near parent locations. This looked very likely in the 1984-85 period when most semiconductor corporations, particularly the US corporations were hard hit by a general downturn caused by stiff competition and a global glut. Some semiconductor corporations actually moved operations back to the United States. Micron Technology and Schlumberger for instance, moved from the Philippines and

Indonesia to Boise, Idaho and Portland, Maine respectively (The Asian Wall Street Journal, 20/08/85: 1,5). But this was not to be in other cases. Instead what has been appearing is the emergence of regional corners of centralisation rather than centralisation at any one particular site (see Rajah, 1987; 1988). Even Ernst (South, 07/1987: 9-17) has since noted this point.

The other significant structural change that has been occurring in Penang is the move towards automation. The level of integration attained by chips today is such that the use of automated computer controlled machinery is a must to work many of the tasks. For instance, the megabyte chip which has a million circuits is now inserted into a minimum line width that runs into submicrons (Ypsilanti, 1985: cited in Edquist & Jacobsson, 1987: 3; International Business Week, 10/06/85: 44-45). Besides, certain processes are no more feasible to perform by labour intensive methods. For example, viewing through computer aided machinery and the electron microscope is now considered essential, to perform many final test operations done on semiconductor products (Interview surveys, 1987).

Figure 1: Growth Trends in Worldwide Integrated Circuit Sales and Far East Assembly Plants, 1970-80



Source: Rosen Associates (1980); cited in Asian Exchange (1982/83: 43); reprinted in Kamal & Young (1985)

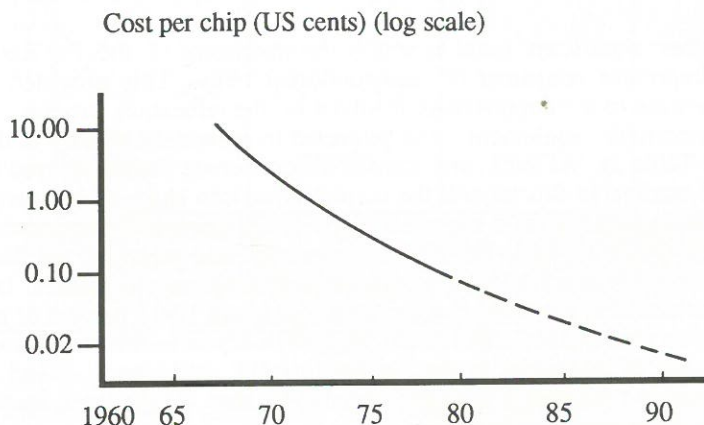
The consequent result of such a transformation is the gradual increase in the machine-man ratio. For instance, in early 1987, the machine-man ratio of the Japanese firm in Penang was 10 to 1 (Interview surveys, 1987). In the case of the most automated American firm, the machine-man ratio was 8:1. These ratios are expected to rise further.

TABLE 1
DEFINITION OF DEGREE OF INTEGRATION

Degree of Integration	Number of transistors per chip
Small-scale integration (SSI)	30-80
Medium-scale integration (MSI)	300-800
Large-scale integration (LSI)	3,000-8,000
Very-large scale integration (VLSI)	30,000-100,000
Ultra-large scale integration (ULSI)	About 1 million

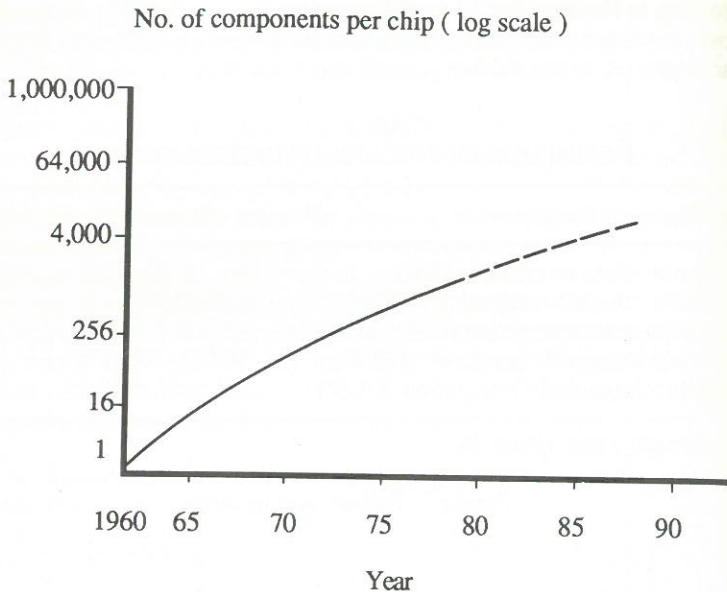
Source: Lalor (1986: 24)

Figure 2: Falling cost of chips



Source: Intel Corporation; cited in Lalor (1986: 25)

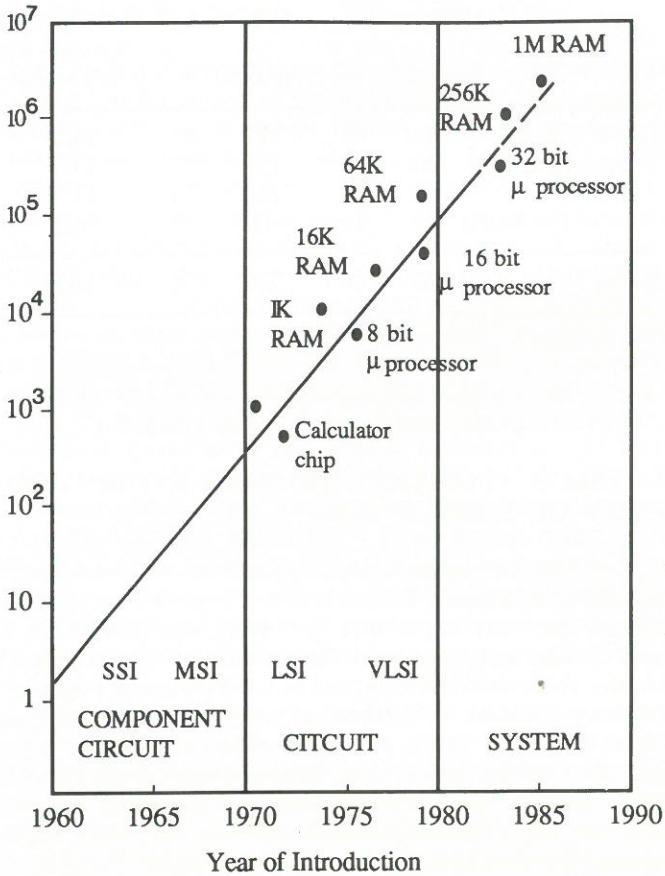
Figure 3: Increase in components per chip



Source: Intel Corporation; cited in Lalor (1986: 25)

Another significant point to note is the emergence of the Far East market as an important consumer of semiconductor chips. This provided an added dimension to the complexities involved in the relocation process. Production of electronic equipment was projected to grow most rapidly in the Far East (see Table 2). As such one cannot underestimate the role played by the Far East market. In this regard, the current American share of 10 percent in the Japanese chip market is expected to rise to 20 percent (International Business Week, 11/01/88: 61); The US government has also pressured the South Korean government to remove its huge trade surplus by opening its market. In 1987, one American firm was reported to have sold about 10-15 percent of its chips in the Far East market (Interviews, 1987). The Japanese firm sold between 34-35 percent of its output in the Far East. If JIT techniques blend well with proximate sites then, it is more economic to start a fully integrated production plant in the Asia-Pacific region.

Figure 4: Evolution in the Scale of Integration of Integrated Circuits Components/Chip



Source: Siemens. Reprinted in OECD (1985: 10)

If the US and Western European corporations are out to compete effectively with the Japanese and newly emerging corporations from the Far East in the Asia-Pacific region, it is wiser for them to erect plants within such a region. Such an effort would not only enable them to circumvent taxes but also realise the benefits of the JIT technique. Besides, there already exists a fully laid infrastructure, local government subsidy, linkages and operating plant in the case of many of the US and European corporations in the East (see Rajah, 1987; South, 07/87: 9-17). Penang is one such location which has strong potential for further development.

TABLE 2
WORLDWIDE PRODUCTION OF ELECTRONIC
EQUIPMENT (IN US\$ BILLIONS)

	1983		1988*		Average Annual Growth Rate 1983-1988
	Amount	%	Amount	%	
North America	163	45	317	41	14.2
Western Europe	68	19	131	17	13.9
Far East	80	22	230	29	23.7
Rest of the World	49	14	104	13	16.2
Total	360	100	782	100	16.8

* - Estimates

Source: Ghostic Concepts, reprinted in Electronics Weeks, 01/01/85, McGraw-Hill, USA, cited in MIDA/UNIDO (1985: 31)

3 MALAYSIA'S POSITION IN THE INTERNATIONAL DIVISION OF LABOUR (IDL)

In this section, I shall compare Malaysia's position vis-a-vis selected countries in the semiconductor industry. Generally three categories can be observed among them although one may argue that the form and dimension within such categories is diverse enough to merit further division. The criterion I have used is twofold: one, value added ranking; and two, the particular stages of production the corporations specialise in. To limit my analysis within manageable space, I have included the United States and Japan within the highest category although some might press for the inclusion of West Germany, France and Italy. I have placed South Korea, Taiwan, Hong Kong and Singapore in category two. Again some may argue that the presence of such big electronic corporations like Samsung, Daewoo, Goldstar and Hyundai might necessitate a different category for the South Koreans. The third category is occupied by countries such as Malaysia, the Philippines, Thailand, Indonesia and Barbados.

Between 1981 and 1982, based on either criteria stated above, Malaysia ranked last when compared with the four selected countries, the United States, Japan, South Korea and Singapore. Compared to the local average, remuneration in the United States was 8.53 times higher; Japanese employees enjoyed 5.26 times more; Singapore had a mean which was 2.38 times higher whilst South Korea's was 1.41 times bigger (see Table 3). Likewise, Malaysia also ranked last with regard to value-added per employee (VA/E). The VA/E of the United States was 5.28 times higher than that of Malaysia. Japan had a VA/E that was 4.6 times more. Singapore's VA/E was 1.5 times bigger. In the case of

South Korea, its VA/E was 1.1 times more. On paper, Singapore appears to rank higher than South Korea in the IDL which is not the case in reality. Singapore's VA/E seems higher because of the higher overall wage structure there. As is shown in the subsequent discussion, South Korea is indeed higher placed than Singapore in the IDL.

The internationalisation of production within the semiconductor industry was done by relocating specific stages of production. The highly capital-intensive stages of research and development (R&D), crystal growing and wafer fabrication was retained in the parent nations (see Rajah, 1987; 1988). Third World nations only recieved the stages of assembly and final test. Except for 'the four little tigers' of East Asia³ where there has been emerging a positive move towards upstream integration, the tail-end nations like Malaysia seem to be either vertically stagnant or look to be loosing their very position in the IDL that characterises the semiconductor industry. The NICs have since been classified as developed to the extent that their Generalised System of Preferences (GSP) were withdrawn in early 1988. The fact that Malaysia specialises in the stages of assembly and final test only is further proof of Malaysia's location vertically among the bottom rung countries in the IDL. Until the early 1980s when the Singapore government restructured its incentives, Malaysia only had assembling (see Kamal & Young, 1985). In terms of value-added and the extent of labour-intensiveness, assembling carries the least of the former and the most of the latter (see Rajah, 1987). Final testing comes second (see Rajah, 1987). The United States and Japan have the most advanced set-up of the first three stages of production and as a result occupy the apex of the IDL. South Korea and Taiwan too have all these stages of production. Samsung of South Korea, for example, has since 1985 been producing the 256K DRAM chips (see Edquist & Jacobsson, 1987: 28), whilst Gold Star also of South Korea has since 1983 been producing the 8 bit microprocessor under license from Zilog (Equist & Jacobsson, 1987: 29). However, with regard to R&D, as discussed in section 2.0, the rapid acceleration of product cycles still thwarts them from closing the gap. For instance, even the much vaunted South Korean semiconductor firms depend on other foreign firms such as AT & T, MICRON for the more sophisticated chip technology (see Edquist & Jacobsson, 1987: 28-29). Yet, the threat from these emerging industrial powers is monitored anxiously by the major electronic nations. Consequently, after a series of sanctions and raising of tariff walls on the goods of the NICs, the Organisation for Economic Cooperation and Development (OECD) nations succeeded in pushing up the the value of the former's currencies as well as have their GSP withdrawn (Rajah, 1988). Whilst the emergence of a horizontal division of labour between the OECD nations and the NICs seems apparent, the same cannot be said of Penang. Penang does not possess any local semiconductor firms. Neither are there any of the first three stages of production (see Rajah, 1987). Even the integration of some aspects of wafer fabrication in 1987 by National Semiconductor has hardly changed this picture. For the

backward processes relocated in Penang are only tail-end aspects of fabrication that are best sited close to where assembling is done (Interviews, 1987). Even the Malaysian Institute of Microelectronic Systems (MIMOS)⁴ was reported to have only knowledge of producing a limited number of Application Specific Integrated Circuits (ASICs). Thus, even with regard to the specific stages of production the firms specialize in, Penang with only the stages of assembly and final test, ranks among the bottom rung nations within the IDL.

However, Penang remains one of the major off-shore production sites for transnational firms in the Asia-Pacific region. Actually the reorganisation of production at proximate sites that ensued with the incorporation of the JIT technique initially triggered an agglomeration of the bottom end stages of assembly and final test - for those firms that had subsidiaries in Penang. The relocation of these two stages of production from Barbados and Puerto Rico to Penang by one American semiconductor firm was part of such reorganisation. Plans were underway to relocate the plant from the Philippines as well. So was the case with plants in Indonesia and within Malaysia, from Malacca, Kulim and Seremban. Two firms had planned to relocate their plants from Penang to Bangkok some time between 1985 and 1986 when their pioneer status expired. One of the firms had in fact, built its factory premises whilst the other had begun building it. However, such plans were temporarily shelved when the Malaysian government extended to them investment tax credit (ITC) of 100 percent.⁵ However, with firms fearing political turmoil in Malaysia, particularly since 1987, Bangkok as an alternative site has become important again. Even plans of an American firm to relocate a plant that specializes in the assembly and test of memory chips from Manila to Penang have been abandoned. Two Managing Directors (Interview surveys, 1987) stated that,

The political situation in Southeast Asia is very unstable. Malaysia used to be quite an exception. Now, whether it is Malaysia, Thailand or the Philippines, the political environment is somewhat similar. Thus, our current strategy is to scatter our productive capacity over a few alternative places.⁶ If any government becomes hostile to us, we'll remove and expand production in the remaining sites. In the case of our firm, this danger is very serious since all our assembly and final test is now done in this part of the world. The other important reason is the possibility of the Malaysian government not extending lucrative tax benefits once the ITC and the accelerated depreciation allowance that we enjoy now, expires in 1991. Without incentives, we'll obviously look upon other sites. That is the reason why we are gradually developing the Bangkok plant. Otherwise, Penang is our most strategic location for the tail-end stages of production.

In the case of the Japanese firm in Penang, the re-emergence of alternative sites in the Southeast was mainly triggered by efforts to relocate production out of Japan so as to enable it to circumvent taxes and evade the 'yen effect' (Rajah, 1988). Hence, the sub-heirarchy within the IDL that existed below Penang in Southeast Asia, which was on the verge of disappearing when the mid-1984 industry-wide crisis struck the semiconductor industry, is now becoming important again. A clear implication that can be drawn from here is the fact that there is no definite long term pattern of IDL emerging within the semiconductor industry.

All the eight semiconductor firms in Penang reported that their Penang plants are the most important for assembling and final testing. In addition, the firms also noted that there are plans for further expansion at Penang. Thus, as long as tax incentives and political stability remain, there is no indication that these firms would leave Penang.

In 1986, Malaysia accounted for 8-10 percent of world-wide semiconductor production, as the world's third largest exporter of semiconductors (Star, 17/07/86: 8). While the relative volume of production puts Malaysia in good stead, its growth is far from satisfactory. To date Malaysia can only boast of having the stages of assembly and final test. The lack of both forward and backward integration leaves Malaysia entrenched as one of the low value-added sites of semiconductor manufacture.

4 IMPACT ON PENANG

4.1 LOCAL INDUSTRIALISATION EFFORTS

The Malaysian state embarked on an aggressive policy to attain the optimistic goals it had set in the NEP. The Investment Incentives Act of 1968 (Malaysia, 1971) gave various benefits for import substitution oriented industries which can be seen as the starting point of incentive packages to stimulate industrial development. Penang was suffering from net emigration in the late 1960s which was worsened by the revocation of its free port status in 1969 (see Kamal & Young, 1985:1). At a time when the foreign firms were increasingly relocating labour-intensive stages of production in the Third World countries, Malaysia went on an aggressive promotional drive to woo these firms. To bolster such efforts, a string of attractive incentives were offered to potential investors (The Asian Wall Street Journal, 20/09/73; cited in Linda Lim, 1978: 91). The states of Penang and Selangor were in the forefront of such a drive. In the case of Penang, the political leadership under Dr. Lim Chong Eu saw it as the best possible way of bulwarking its industrial growth. Then, the introduction of the Free Trade Zone (FTZ) Act of 1971 left Penang as one of the major areas of conurbation for transnational corporations into Malaysia (see Ismail, 1981). Table 4 shows the projects approved along with their

TABLE 3
COMPARISON OF LABOUR COSTS AND VALUE-ADDED
PER EMPLOYEE (IN M\$) SEMICONDUCTOR/ELECTRONIC
COMPONENTS FOR MALAYSIA AND SELECTED REFERENCE
COUNTRIES

	Annual Remuneration Per Employee	Value-added per Employee (VA/E)
Malaysia (1981) Semiconductors, Other Electronic Components & Communications Equipment and Apparatus	4,688	15,250
Republic of Korea (1982) Electronic Tubes and Other Electronic Parts and Components	6,600	16,390
Singapore (1982) Semiconductor Devices	11,164	23,241
Japan (1982) Electronics and Communications Apparatus and Components	24,680	63,430
United States (1982) Semiconductor Devices	40,001	83,597 ^a

a - Estimate

Source: Departments/Bureaus of Countries Concerned; Extract from MIDA (1985: 17).

potential investment and employment between 1971-81. Penang received 68 projects in 1972 and another 48 in 1975 (MIDA, 1975:129). In 1984, Penang had eight industrial estates (MIDA, 1984:38). Till late 1974, Penang was classified as an underdeveloped area (MIDA, 1975:116). As a result, besides the pioneer status, investment tax credits, labour utilisation benefit and accelerated depreciation allowance Penang also enjoyed the locational benefit. In 1975, the rezoning of Penang as a developed state led to the abrogation of the locational benefit (MIDA, 1975:116).

Between 1982-83 when the 10 year pioneer status of most semiconductor firms were coming to an end, the Malaysian government was pressing for upstream integration as a condition for offering other benefits (see New Straits Times, 18/08/84: 3; Interview surveys, 1986). At this juncture, the semiconductor firms world-wide were recording their best business performance ever so much so that increased automation was offset by excessive demand thereby pushing upwards employment figures. As a result, the exhaustion of pioneer status, which is a tax benefit that exempts corporations from all corporate taxes including development tax (PDC, 1984), did not appear to bother the firms in the period 1982-83. In any case the full impact of the absence of the pioneer status was not felt because of the fact that the firms still enjoyed the accelerated depreciation allowance. Six firms had exhausted their pioneer status by 1982 (Interview survey, 1987). Two other firms had exhausted it in 1983 (Interview survey, 1987). Until late 1985, the only benefit that was of importance to these firms was the Accelerated Depreciation Benefit (Interview survey, 1987).

When the downturn which began in mid-1984 threatened to undermine the foundations of these corporations, a series of meetings with state representatives particularly from the Finance Ministry and Malaysian Industrial Development Authority (MIDA) were called upon (see Rajah, 1987). Some firms threatened to move operations to Thailand and Western Europe. AMD had actually built a factory in Bangkok whilst MMI was contemplating to start one there in 1985 (Electronics, 06/1985: 224-242; Rajah, 1987). Another firm was considering Ireland and Scotland (Interviews, 1986). Retrenchments were then mounting. Following widespread picketting in Penang, the government extended Investment Tax Credit (ITC) of 100 percent over a period of five years (see Rajah, 1987). Plans for upstream integration suddenly took a back seat. In fact, Penang's efforts to integrate the backward stages of production were shelved temporarily. The subsequent integration of some tail-end processes of wafer fabrication came mainly as a result of efforts by one American firm to rationalise production along the principles of JIT (Interview surveys, 1988). The only concrete thing to emerge from earlier promotional efforts was the creation of MIMOS which comes under the Prime Minister's department and is responsible for research on electronic components and the possibility of starting local electronic firms (see Rajah, 1987; Nun, 1988).

It is clear that Penang's industrialisation efforts vis-a-vis semiconductor transnational capital has been one of what I would call 'accomodative growth'. With the absence of competitive local semiconductor firms, relations between the local state and foreign capital has very much remained skewed towards the latter. Thus, Penang has always been forced to accomodate various demands by transnational capital that were caused by structural adjustments forced upon by the international economy. This was obvious even when the 'invitation

TABLE 4
APPROVED PROJECTS, PROPOSED INVESTMENT &
POTENTIAL EMPLOYMENT, ELECTRONIC INDUSTRY,
MALAYSIA, 1971-1981

Year	No. of Projects	Proposed Investment (M\$ '000)	Potential Investment
1971	10	20,610	5,773
1972	33	77,183	17,139
1973	31	78,183	11,848
1974	36	107,866	13,477
1975	8	8,163	691
1977	22	30,174	3,897
1978	23	67,257	4,894
1979	40	180,954	17,917
1980	29	199,707	13,045
1981	22	110,486	7,131
Total	267	888,626	98,186

Source: MIDA (1983: 5)

model' of growth was adopted as can be seen from the relaxation of labour laws (see Linda Lim, 1978: 91). Nevertheless, with the growing importance of the Asia Pacific market and the need to centralize production to harness the benefits of JIT, there has been a significant transfer of technology and development of the plants in Penang (see subsequent sections).

Contrary to the operations of semiconductor corporations in the 1970s when Penang remained very much an off-shore enclave, since the mid 1980s, changes in the international economy has necessitated adjustments within the firms that has led to the development of local ancillary firms (see Section 4.4). Thus, Penang's industrialisation strategy vis-a-vis the semiconductor corporations has now taken a dynamic change. Instead of leaving the foreign corporations' operations virtually untouched, as was the case in the 1970s, the emphasis is now on developing a section of the local industrial base around these corporations. Hence, the Penang Development Corporation (PDC) itself has been at the forefront encouraging local investors to venture into ancillary businesses (Interview surveys, 1987). In 1985, Penang had 22 local supporting firms that were linked to the semiconductor industry (PDC, 1985a; 1985b). These ancillary firms specialize in metal, plastic and packaging services. Some have developed so much that one even exports semi-automated die-attach machines to the foreign market (Interview surveys, 1988). With the withdrawal of the GSP status and the appreciation of the currencies of the

NICs vis-a-vis the Malaysian dollar, transnational corporations in Penang, including the semiconductor firms, are increasingly looking forward to sourcing their ancillary support locally. Penang's planners should be shrewd enough to encourage those industries into which capable local entrepreneurs can venture. They do not even have to levy taxes (a path Taiwan took⁷) on these products and services as the currency differential and the GSP has already given a significant advantage to Penang. However, the state will have to scrutinize carefully foreign firms investing in ancillary services so that local infant firms can be protected.

The PDC officials have already gone a long way to develop the ancillary base of industries in Penang. Meetings between local supporting firms, managing directors of the semiconductor and other transnational firms, PDC officials and selected scholars⁸ in the field have been arranged by PDC officials to strengthen local linkages. But since the semiconductor firms are heavily prone to the vagaries of the foreign market, local firms linked to them must be diversified to cater to other industries as well. Otherwise, falling demand will destroy the local firms as exemplified by the closure of Equatorial in 1985 (see Rajah, 1987).

In view of the rapid acceleration of product cycles as well as falling prices of products in the semiconductor industry, Penang's industrialisation strategy at this juncture should not aim towards starting local semiconductor firms as the technological gap is too wide. Penang should instead stimulate the emergence of consumer electronic firms. With a weaker dollar coupled by its GSP protection, it may succeed in carving out a sizable foreign market to bolster local industrialisation plans. This however, depends very much on the ability of the national planners and administrators in retaining the relatively cheaper Malaysian dollar and its GSP status.

A more pressing problem is the threat from Thailand as an alternative site to Penang. As was explained earlier, so long as the national government can guarantee the semiconductor firms political stability and the extension of tax benefits, the firms have indicated positively their intentions to remain in Penang (Interview surveys, 1987-88).

4.2 EMPLOYMENT AND RETRENCHMENT

The semiconductor industry employed 2,655 employees in 1972 (see Table 6). There were two significant peaks in the emergence of foreign firms in Malaysia: one, the period 1972-74 which was caused by massive promotional efforts; two, the period 1979-80 as a result of the relocation of labour-intensive industries from Singapore (MIDA, 1983: 4). A good many of these firms were semiconductor firms that located subsidiaries in Penang. In fact, in the period 1979-1982, eight firms moved final test to Penang (Rajah, 1987 &

Interview surveys, 1987). Four actually started separate test plants while the remaining four started final test within their existing premises (see Rajah, 1987). Hence, the effects of the global oil crises of 1973-74 and 1979-80 did not really have a serious impact on the employment performance of the semiconductor firms although total employment actually fell in the period 1979-80 as is shown in Table 6. Employment reached an all time high of 20,498 in 1982 although the semiconductor industry actually peaked in 1983. This was because of a rush to gather workers for the test plants moved from Singapore (Interview surveys, 1986).

Except for the recessionary years of 1973-74, 1979-80 and 1984-86, employment trends in Penang was one of gradual growth. Employment figures in the semiconductor industry for the years 1973-74 is not available. But Kamal & Young (1985b) mentioned an actual drop in that period. The earlier two crises were random bottoms mainly created from a standstill in the developed nations that were heavily dependent on Arab oil. In 1973, the accident was the October Arab-Israel War, which interacted with the basic market conditions to set off the first oil shock where the price of oil shot four times high whilst the Iranian embargo caused the second oil shock of 1979 where the price of oil rose by another two and a half times (Yergin & Hillenbrand, 1982: 3). Employment actually fell from 13,581 to 11,162 in 1979 increasing by only 617 in 1980 (see Table 6). The mid-1984 crash was caused by a global cyclical downturn which can be explained using the 3-4 year Kitchin cycle (see Hopkins & Wallerstein, 1982:106) as well as structural changes resulting from the incorporation of automation technologies and JIT techniques of production in the semiconductor industry. The latter two was already moving into Penang rapidly since 1980. This explains why, despite extraordinary sales in the period 1982-83, employment although increased gradually, such an increase was not commensurate with the good performance of the firms. However, mid-1984 was one of the blackest moments for semiconductor workers. The global glut coupled with economic recession sent shock waves, crippling many of the corporations. Retrenchments were widespread from mid-1984 to 1986 (see Rajah, 1987). One firm which was acquired by a new buyer, in three exercises layed off 1,212 workers in 1987, retaining only 335 workers (Rajah, 1987: 193). This firm has since sold the plant to another American firm to move all its operations to Johore (Interview surveys, 1988). This firm which depended heavily on the 64K RAM (Random Access Memory) chip was shattered since the mid-1984 crash as the Japanese firms took monopoly of the market (see Rajah, 1987). The biggest employer that had employed 4,187 workers in 1983 shrunk its workforce to 3,162 in 1986 so much so that the current biggest employer is AMD (Interview surveys, 1987). This firm was expected to trim another 500 workers by the end of 1987 (Interview surveys, 1987). Four other firms reported to have drastically reduced their workforce by reducing replacement for labour turnover (Rajah, 1987). One significant method of labour shedding employed by these firms is induced

retrenchment where a token sum of payment is given to voluntary job-leavers (Rajah, 1987). Since the current strategy used by the firms allow for the employment of voluntary job-leavers by other firms with the threat that forced job-leavers would not be re-absorbed by the other firms, many seem to have chosen to resign whenever there arises a threat of retrenchment (Rajah, 1987). While the current employment situation has somewhat stabilized, continuing structural changes forced upon by automation technologies and JIT point to a relative employee shrinkage as suggested by Ernst (South, 07/87:11). However, with the coming of a few more American firms such as International Device Technology and Control Data, overall employment is expected to rise slightly (Interview surveys, 1988).

The sex ratio within Penang's semiconductor industry was more than 4 women (84.3%) to one man (15.7%) from a total workforce of 2,655 in 1972 (see Table 6). This gender breakdown conforms to the kind of labour the semiconductor corporations were seeking in the early 1970s. Whilst the 'nimble fingered' women were preferred (see Edgren, 1984) the other important advantage women had was that it was relatively cheaper to employ them. In 1986, the sex ratio was three women (78.1 percent) to one man (21.1 percent). The incorporation of automation technology and the subsequent fall in demand for the dexterity provided by the women may explain the slight change in the sex ratio. The two most important reasons given to explain why women still dominate line tasks in the semiconductor industry of Penang are: one, the firms for a start had a large proportion of women; and two, they are relatively cheaper and easier to manage (Interview surveys, 1987).

With regard to the racial breakdown, Malays comprised 52.2 percent of the workforce in the semiconductor industry of Penang as compared to 47.8 percent non-Malays in 1986 (Rajah, 1987). The figure for foreign employees was only 8 which did not amount to even 1 percent (Rajah, 1987). In contrast, only about 9 percent of the professional jobs in the semiconductor industry in 1986 were held by the Malays (Interview surveys, 1987). Viewed from the perspective of the government, the overall racial breakdown may be satisfactory as it somewhat reflects the overall breakdown of the national population. However, the fact that most of the Malays are found in the lower segment of the workforce continues to worry the national government.⁹

In short, it is obvious that with regard to employment, Penang did actually benefit from the semiconductor corporations since the firms began operations there. But, because of the vulnerability of semiconductor firms to the amplitudes of the business waves, crises have often brought tremendous pressure on these firms that have very often been transferred to Penang and its workers. This can be seen when the industry-wide crisis struck in mid-1984. Now with the move toward capital-intensive production, Penang's semiconductor workers have

TABLE 6
EMPLOYMENT IN THE SEMICONDUCTOR INDUSTRY,
PENANG, 1972, 1977-86

Year	Male	Female	Employment
1972	416	2,239	2,655
1977	1,924	9,241	11,165
1978	2,355	11,226	13,581
1979	2,202	8,960	11,162
1980	2,308	9,471	11,779
1981	4,339	16,159	20,498
1982	3,913	14,153	18,066
1983	4,094	14,982	19,076
1984	3,900	14,326	18,226
1985	3,181	11,966	15,147
1986	2,764	10,334	13,098

Source: Extract from Rajah (1987)

experienced an improvement in their welfare (see Rajah, 1987) but at the expense of numbers (see next section).

4.3 MOVE TOWARDS CAPITAL-INTENSIVE PRODUCTION

Automation is increasingly diminishing the cheap labour attribute of Third World countries. Corporations are resorting to labour-saving automated machinery to increase the productivity of labour. Table 7 shows that the capital-labour ratio of one American firm had risen from M\$1,439 in 1972 to M\$38,066 in 1986. The overall workforce of this firm has been falling except for 1984 when a booming 1983 necessitated such an increase. Another firm showed increasing investment on employee training which was reported as mainly to equip them to handle new machinery (see Table 8). This medium-sized American firm slashed training expenditure in the years 1984-85 as part of its measures to withstand the global recession. Except for the processes in 2nd optical in assembling and final visual cosmetic test within final test, scopework has virtually disappeared in the semiconductor industries at Penang. Some firms however, still retain manual production lines for the assembly of hermetic products such as flatpacks and cerpacks (Interview surveys, 1986-88). In addition, stress tests done using acids are also done manually (Participant observation, 1986).

Mobile units consisting of innovative technicians work on modifying existing machinery to improve efficiency (Participant observation, 1986; Interview surveys, 1987). The introduction of laser marking has also boosted

efficiency tremendously (Participant observation, 1986; Interview surveys, 1987). Some of these developments such as the automation of die attachment and bonding (see Section 2.0) may be welcomed with great relief by those who showed concern over scopework which was not only arduous but also bad for the eyesight. The recomposition of work tasks with the rise in multiplexing which amounts to reskilling is seen as the answer to acute alienation that characterised the highly decomposed work tasks in assembly line production (Palloix, 1978: 46-67). Some may argue that automation by displacing workers actually would cause deskilling. But whatever the merits of this counter opinion, the fact that the individual worker does enjoy a relatively larger work task including access to quality control information as well as the execution of it is sufficient to suggest that there is occurring reskilling (see Sayer, 1986). Workers now also need some knowledge of statistical process control and basic programming (Interview surveys, 1988). On the employment front however, union officials may argue that labour-saving machinery of this kind will lead to continuing structural unemployment. Since this is a global phenomenon which the semiconductor corporations must adopt to survive in a highly competitive atmosphere, it will be pointless for the local state to expect a compromise. Instead, the local state should except this reality and plan effectively its labour and manpower policies to accommodate the move toward capital-intensive production. However, since the technical workforce in Penang is considered to be highly skilled and at the same time flexible, the changing dimensions in automation has so far worked towards the benefit of Penang (see Rajah, 1987). In this regard, unlike the parent locations where strong unions protect worker's as well as other employees' opposition to retraining, Penang's employees have been known to accept retraining without any opposition (Interview surveys, 1986-88). Thus, in the light of rapid changes in technology as discussed in Section 2.0, rigorous retraining can be carried out in Penang easily. This is inexorably one of the major reasons why despite the move toward labour-saving capital-intensive technology, Penang's position within the IDL has become even stronger.

4.4 REORGANISATION OF PRODUCTION

JIT has helped minimize inventory including those in work-in-process and the various resources used in production. Owing to the nature with which the book-to-bill ratios change, work-in-process are made as flexible as possible. The fact that most of the products produced by the semiconductor firms of Penang are semicustomized, the production line is arranged in such a way that the front line processes are the common ones. In Penang, marking and tests come last (Participant observation, 1986; Interview surveys, 1987). With such flexibility, workers are often reshuffled to areas where they are needed so much so that most workers have a working knowledge of all the line tasks.

TABLE 7
WORKFORCE AND CAPITAL-LABOUR RATIO OF A
SELECTED SEMICONDUCTOR FIRM, PENANG

Year	Workforce	Capital-labour ratio
1972	740	1,439
1976	1,300	2,954
1980	1,556	9,162
1981	1,240	13,063
1982	1,165	15,200
1983	873	22,509
1984	922	24,133
1985	764	33,331
1986	720	38,066

Source: Rajah (1987)

In the case of the semiconductor companies in Penang (Participation observation, 1986; Interview surveys, 1987), there is appearing a 'smoothed output' derived as a result of fixed work-cycle tasks. This changing dimension seems to be reducing moments of zero productivity effectively. Since the success of JIT also depends very much on the overall set-up of the corporation itself, firms in Penang have also taken drastic steps to reduce downtime, overheads that do not directly relate to production and other expenses deemed a waste (Participant observation, 1986; Interview surveys, 1987). Three firms reported to have introduced the four-shift system that reduced sharply shift-change time. The working-day has been made flexible ranging from 4-7 days by atleast four firms. At times of high demand, the working week is extended with overtime. The shortening of the work week during periods of low orders is to enable the firms to save overhead costs such as power supplies. The usage of flexible workforce allows effective rotation between tasks which is essential for JIT where work is only done when needed, in the necessary quantity at the necessary time (see Sayer, 1986: 53).

The incorporation of JIT is another feature which strongly suggests that reskilling is occurring. As Sayers (1986: 66) explains, flexibility actually implies multi-skilling and the elimination of demarcation, and reduction or abolition of job descriptions. Eight firms reported that most of their workers have a working knowledge of almost all the line tasks as well as the nature of quality control in their firms (Interview surveys, 1987). Seven firms reported to be using computerised production control systems known as MRP (Interview surveys, 1987). Although the basic operations of the kanban system is demonstrated to the general foremen, production superintendents, quality controllers, engineers, technicians and supervisors from time to time, MRP is

TABLE 8
TRAINING EXPENDITURE OF A SELECTED AMERICAN
SEMICONDUCTOR FIRM, PENANG (IN M\$)

Year	Training Expenditure
1977	20,683
1978	64,299
1979	55,404
1980	60,369
1981	95,127
1982	140,309
1983	159,142
1984	115,870
1985	78,832
1986	160,000
Total	950,026

Source: Rajah (1987)

preferred because of its ability to cope with wider output variations (Interview surveys, 1987). As a result, the semicustomised products manufactured by the semiconductor firms of Penang which are highly susceptible to irregular market responses can be adjusted more effectively.

With the JIT organisation of production, firms prefer having more permanent workers than the temporary ones of the 1970s (Interview surveys, 1987). Talented workers who display a profound knowledge of at least three line tasks are promoted to the post of super operator who earn as high as M\$800 monthly. The tight rules on discipline that characterized the labour process in the 1970s has now been relaxed (Participant observation, 1986). One manager (Interview surveys, 1986) stated that,

In the 1970s such controls were necessary. But with the current technology, such stringent rules are no more necessary. In fact, by removing some of these rules, we have managed to reduce boredom and monotony, thereby increasing productivity.

It is pertinent to emphasize here that the introduction of automation and JIT in Penang, and consequently an improvement in the welfare of workers came, not from the efforts of the local state or the emergence of a strong working class but by an industry-wide crisis (see discussion in Section 2.0) in the international economy that forced responses from the firms.

5 CONCLUSION

It is obvious that transition in the international economy and the subsequent adjustments within the firms has left Penang as one of the major points of assembly and final test in the semiconductor industry on the globe. In this regard, the emergence of the Asia-Pacific market, as well as introduction of automation and JIT point to an agglomeration of the tail-end stages of production at Penang. This has been further boosted by the existence of a highly skilled yet docile and flexible labourforce in Penang.

Unlike the 1970s, the semiconductor industry in the 1980s can no longer be considered a labour-intensive industry. Although the employment contribution of the semiconductor industry has subsequently shrunk, structural adjustments within firms forced upon by changing conditions in the international economy has led to the multiskilling of workers and consequently making them more permanent.

Semiconductor firms have since mid-1984 featured prominently in the efforts of the Penang state to develop local ancillary industries. This has come about not only because of the need for reliable proximate vendors to realise the benefits of JIT, but also because of rising currencies of the NICs and the withdrawal of the GSP status from them. Thus, unlike the 1970s, Penang has now embarked actively on strengthening the local ancillary base. As to the question of whether Penang should begin producing semiconductor chips, apart from the research done by MIMOS, at this juncture it really should not do so. Not only have the technology developed too far, but the tremendous rate of acceleration of the product cycles makes it difficult for beginners to succeed. Such efforts should instead come in the form of consumer electronic industries where Penang could initially begin producing simple consumer items at cheap cost for the foreign market. Only after its industries have established themselves should they integrate backwards to produce chips. This is the path the NICs including South Korea took (see Edquist & Jacobsson, 1987).

NOTES

¹ Sayer (1986: 51), strictly speaking, refers JIT narrowly to a way of organising the immediate manufacturing labour process and buyer-supplier relationships between firms, but explains that it is normally surrounded and supported by a wider set of practises regarding skills, management-labour relations and labour market conditions.

² MRP are American computer controlled systems that are used to plan and monitor the flow of materials within production lines.

³ Hamilton (1983: 36) uses this expression to refer to South Korea, Taiwan, Hong Kong and Singapore.

⁴ This information was gathered from a discussion with the director of MIMOS.

⁵ The Malaysian government issued an ITC of a 100 percent which was introduced in late 1986 when some of the firms threatened to migrate after their pioneer status expired. With this tax benefit, all profits of firms that do not supersede their investments are not taxable over a period of five years. Losses incurred in any of these five years can be deducted from profits earned after the five years (Electronic, 06/1986: 224-242; Interview surveys, 1987).

⁶ Linda Lim (1978) noted that semiconductor companies in the 1970s practised such a spatial decentralisation of production to overcome the threat of political instability.

⁷ Taiwan imposed a 20 percent tax on imported machine tools and components. However, tariffs were generally levied only on products that were equivalent in price and quality with those produced locally (see Fransman, 1986: 1388).

⁸ The author has been one of the members in these meetings.

⁹ The author noted this fact in interview surveys with various companies and the PDC. For details, see Rajah (1987: Chapter 4).

REFERENCES

Primary Sources

Interview surveys (1987) This is an on-going research on the Electronic Industry at Penang which was initially used for gathering data for my master's thesis (see Rajah, 1987).

Participant observation (1986) I did two months participant observation in one semiconductor company at Penang (see Rajah, 1987a). Information not cited in my master's degree are cited under such a section.

Secondary Sources

Edgren, G. (1984) "Spearheads of Industrialisation or Sweatshops in the Sun", in *Export Processing Zones and Industrial Employment in Asia*, Eddy Lee (ed.), pp 27-52.

Edquist, C. & Jacobsson, S. (1987) "The integrated circuit industries of India and South Korea in a techno-economic context", in *Industry and Development*. United Nations Industrial Development Organisation (UNIDO), (21): 1-62.

Electronic (06/1986) "Investment incentives revamped to speed export growth - focus on Malaysia", pp 224-242.

Electronic Business (10/12/86) "Fujitsu plus Fairchild: hope for profits and more ASICs", p 17.

_____ (01/01/87) "An uncertain future for the U.S. chip makers", pp 64-65.

Ernst, D. (1982/83) "Review:restructuring world industry and the new information technology", in *Asian Exchange*, Dis-Mar, pp 51-59.

_____ (1983)*Global Race in Microelectronics*, Campus Verlag, Frankfurt.

_____ (1985) "Automation and the Worldwide Restructuring of the Electronic Industry: Strategic Implications for Developing Countries", *World Development Journal*, Special Issue, No. 3, Mar. pp 333-352.

Fortune (15/10/84) "The Microelectronic Industry in Taiwan", pp 158-159.

_____ (06/01/86) "Who will survive the microchip shakeout", pp 20-29.

_____ (12/05/86) "A respite in the chip price war", pp 87-88.

_____ (09/06/86) "Having a hard time with Just-In-Time", pp 56-58.

Fransman, M. (1986) "International Competitiveness, Technical Change and the State: The Machine Tool Industry in Taiwan and Japan", in *World Development Journal*, December, 14(12): 1375-1396.

Frobel, F. Heinrich, J. & Kreye, O. (1980) *The New International Division of Labour*, Cambridge.

Frobel, F. (1983) "Economic Policy in the Crisis: Some Observations from the Perspective of the Industrialized Countries", Paper presented on *Internationalisation and Industrialization of the Periphery*, Oaxtepec, Mexico.

Hamilton, C. (1983) "Capitalist Industrialisation in East Asia's Four Little tigers", *Journal of Contemporary Asia*, Vol. 13, No. 1, pp 35-73

Henderson, J. et al (1985) "The New International Division of Labour and Urban Development in the Contemporary World System", in Drakakis Smith, *Urbanisation in the Developing World*, Croom Helm, London.

Hopkins, T. & Wallerstein, I. (1982) *World-Systems Analysis - Theory and Methodology*, Sage.

International Business Week (10/06/85) "Superchips: the new frontier", *International Business Week*, pp 40-43.

_____ (10/06/85) "Making submicron chips: only computers are up to the job", *ibid*, pp 45-45.

_____ (25/05/87) "An Italian chipmaker shows the way", *op cit*, pp 89-90.

Ismail, H. (1981) "Export incentives available under the Free Trade Zone Act, 1971", Paper presented on Export Incentives in Malaysia, Kuala Lumpur, Oct. 1-2

Kamal S. & Young M.L. (1985) "Penang's industrialization: where do we go from here?", Paper presented at the convention: *Future of Penang*, Malaysian Economic Association, 6-8 May.

Kaplinsky, R. (1980) "Micro-electronics and the Third World", *Radical Science Journal*, Third World Issue, 10, pp. 37-51.

_____ (1985) "Electronic-based Automation technologies and the onset of systemofature: implications for Third World Industrialisation", *World Development Journal*, Special Issue, pp 423-440.

Lalor, S.E. (1986) "Overview of the micro-electronics industry in selected developing countries", in *Industry and Development*, United Nations Industrial Development Organisation, No. 16, pp 23-58.

Linda Lim, Y.C. (1978) *Multinational Firms and Manufacturing for Export in Less Developed Countries: The Case of the Electronics Industry in Malaysia and Singapore*, Phd. Thesis (in microfilm), University of Michigan.

Malaysia (1971) *First Malaysia Plan*, Kuala Lumpur.

Marsh, P. (1981) *The Silicon Chip Book*, Sphere Books, G. Britain.

Maxwell, S. & Moffat, S. (1985) *Electronics and Development*, Scotland and Malaysia in the Electronic Industry, Scottish Education and Action for Development (SEAD), Edinburg.

MIDA (1975) *Annual Report*, Malaysian Industrial Development Authority, Kuala Lumpur.

_____ (1981) *Annual Report*, Malaysian Industrial development Authority, Kuala Lumpur.

_____ (1983) *"Review of the Electronics Industry in Malaysia and Policy recommendations for its development"*, Electrical and Electronic Industries Division, Malaysia Industrial Development Authority, Malaysia, Aug.

_____ (1984) *Annual Report*, Malaysian Industrial Development Authority, Kuala Lumpur.

MIDA/UNIDO (1985) "Electronics and Electric Industry", Medium and Long Term Industrial Master Plan, Malaysia, 1986-1995, Vol II, part 8, Aug.

Morris-Suzuki, T. (1984) "Japan's role in the New International division of Labour - a reassessment", *Journal of Contemporary Asia*, No. 4.

New Straits Times (18/08/84) "Boost local electronics skill - Dr. Lim", p 3.

_____ (18/08/84) "'Jolt' for electronic firms from Razaleigh", p 3.

New Straits Times (18/08/84) "Set up high tech research centre' call to Penang", p 3.

Nun, A. (1988) "Entrepreneurship, Innovation and Technology for a Competitive Malaysian Electronics Industry", Paper presented at the seminar *Changing Dimensions in the Electronic Industry in Malaysia*, Penang, January 14-15.

Ocampo, C. (1980) *The Semiconductor Industry: A Critique of Neo-Smithian Marxism*, M.A. Dissertation, School of Development Studies, University of East Anglia.

OECD(1985) *The semi-conductor industry - trade related issues*, Organisation for Economic Co-operation and Development.

Palloix, C. (1978) "The Labour Process: from Fordism to neo-Fordism", in *The Labour Process & Class Strategies*, Conference of Socialist Economists Pamphlets, pp 46-67.

PDC (1974) *Annual Report*, Penang Development Corporation (PDC).

_____ (1980) *Annual Report*, Penang Development Corporation (PDC).

(1984) *Penang Investment Incentives*, Penang Development Corporation (PDC), Penang.

(1985) *Annual Report*, Penang Development Corporation (PDC).

Rajah, R. (1987) *Pengantarabangsaan Pengeluaran dan Pembahagian Buruh Antarabangsa: Kajian Kes Industri Separa Konduktor di Pulau Pinang*. M.Soc.Sc., Universiti Sains Malaysia, Penang.

(1988) "The Assembly Line in Transition: Implications and New Directions for the Electronic Industry in Penang", Paper presented at the seminar *Changing Dimensions in the Electronic Industry in Malaysia*, Penang, 14-15 January.

Sayer, A. (1986) "New developments in manufacturing: the just-in-time system", in *Journal of Capital and Class*, No. 30, Winter, pp 43-72.

South (07/1987) "The computer tangle", pp 9-17.

Star (17/07/86) "Doubts over expansion plans", *The Star*, p. 8.

The Asian Wall Street Journal (20/08/85) "Chip automation is hitting jobs in Asia", pp 1, 5.

Yergin, D. & Hillenbrand, M. (1983) *Global Insecurity*, Penguin Books.