

REGIONAL DYNAMICS AND PRODUCTION NETWORKS: THE DEVELOPMENT OF ELECTRONICS CLUSTERS IN MALAYSIA

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1 Introduction

The resurgence of the American economy especially since the second half of the 1990s, outperforming Japan, have been argued by some as being the result of weaknesses endemic to East Asian growth policies. While East Asia has been riddled with chronic problems of rapid long-term growth, too swift deregulation without the strengthening of legal instruments and inadequate adjustment measures, there is a growing body of literature that argues convincingly that American growth and competitiveness is, *inter alia*, also driven by a new model of industrial governance (see Best, 1999; Audretsch, 1999; Saxenian, 1996). American economic dynamism in the past had benefited from the advent of division of labor and time management advanced by Taylor at the turn of the 20th Century and later the conveyor belt system pioneered by Henry Ford with specialized R&D, production, training and marketing divisions that operated separately until Japanese organizational systems overtook American leadership in industrial management.

Toyota's invention of the multi-flow line using a single line with multiple products, co-ordinating cycle time with customization quantitatively and qualitatively and integrating R&D, production and marketing shifted industrial dynamism to Japan. Canon added rapid product development to Japanese competitiveness. American firms gradually accepted the challenge by incorporating Japanese organizational capabilities. A combination of the critical features of flexible specialization and rapid product development were subsequently deepened with features of open system networks that enable horizontal specialization and network synergies. The new model of systems integration that has evolved in the Silicon Valley and Route 128 has propelled American firms such as Intel, Motorola, Solectron and Dell to the forefront. Within electronics size is no more the critical variable as low levels of employment and high inter-firm division of labor has expanded performance and market opportunities. Firms embedded in open system networks such as in the Silicon Valley and Route 128 which also enjoy extensive firm diversity has stimulated synergies that assist firms to out-compete rivals located in other systems. Best (1999) calls this the New Industrial Innovation Paradigm.

The old industrial district argument that generated synergies from clusterization has resurfaced as a critical model of economic performance (see Sabel and Brusco, 1982; Sabel and Piore, 1986; Wilkinson and You, 1992; Smidt, 1994). Porter (1990) posited a model of competitive advantage developed from specialization along core competence, but with a division of labor where every participant operates at world class level. Saxenian (1994) showed how systems synergies can be raised through knowledge generation and diffusion involving people interacting in open system networks from the examples of the Silicon Valley firms. Best (1999), building on the past exponents, added Saxenian's critical elements of inter-firm diversity and open system networks, and Porter's cluster dynamics with the industrial innovation paradigm. The critical dynamics of the new innovation paradigm with its simultaneous interaction with cluster-based specialization, and horizontal integration and reintegration, technological variation and developmental enterprise constitute the new competition. The development of the Silicon Valley and Route 128 appears as the crystallization of these forces so that firms embedded in such high innovation, integrated and open networks with communal identity, have managed to maximize system synergies.

In developing economies, the networks growth nexus is often underdeveloped. Sometimes MNCs act as triggers for the quickening of clusterization, but only when effective domestic technology and education policies are in place. There is no evidence of MNCs on their own stimulating the development of horizontal specialization in host

sites, though the economic benefits generated by of FDI at host sites is mixed (see Lall, 1980; Rasiah, 1995).

Porter (1990) noted that the development of ancillary services and supporting industries that are tied to MNCs has traditionally been important in the advanced and industrialized countries. Porter's argument on MNCs and local firms' development is instructive on two grounds. First, MNCs offer room for the development of supplier networks. Second, the extent of deepening and technological sophistication that will take place in MNCs will *inter alia* depend on the availability of globally competitive suppliers and networks.

Regional growth becomes both a cause and a result of the clusterization processes of firms embedded in business networks that are open, and characterized by intense horizontal division of labor, flexible production organizations small enough to enable quick changes in demand and supplies, enjoying close coordination from support institutions and innovative agents assisting R&D and market development.

However, the capacity and direction of business networks to match high-performance industrial district models depends considerably on local structures. Since local structures are critical in understanding the development of strong inter-firm networks, efforts to manage its development would require sufficient cognizance of local and regional processes so that policies can endemic systemic failures. This paper looks at how four different local structures within the same federal political milieu have produced different forms of electronics clusters in Malaysia.

Using the foregoing framework, this paper examines the emergence of regional clusters in Malaysia's electronics industry, focusing on the four major locations in the country, i.e., Penang, Selangor, support states of Negeri Sembilan and Melaka, and Johor. The paper is divided into four sections. Section 2 reviews the different local structures that characterize the four locations of Penang, Selangor, Negeri Sembilan and Melaka, and Johor. Section 3 discusses the form and depth of firm-level development, inter-firm and network links in the three major electronics conurbations in Malaysia. Section 4 examines the implications for competitiveness of these clusters.

2. Regional Structures

It is important to detail the regional structures, which has impacted on the differential form and depth of production evolution in the three major locations in Malaysia. Malaysia's multiethnic social fabric is characterized by Malay political hegemony. The United Malays National Organization (UMNO) has controlled effectively the policy thrusts of the ruling Alliance and National Front governments, despite overtures to favor partner parties such as the Malaysian Chinese Association (MCA), Gerakan and Malaysian Indian Congress (MIC). The structural conditions of the three major electronics conurbations in the country, i.e. the Northern state of Penang, the central states of Selangor, Negeri Sembilan and Melaka, and the Southern state of Johor differed in that the local political leaderships were led by different ethnic parties. With a strong Chinese population, exceeding 60 percent and the relative dominance of the Chinese political party of Gerakan in the state assembly, the much suppressed Chinese business networks have been able to engender entrepreneurial policies within the national political milieu. Gerakan itself won its first election under opposition banners in 1969, switching to the ruling National Front in the early 1970s with bargains that allowed some local autonomy (see Rasiah, 1993). Because the Gerakan emerged as a middle class party, a wider range of businessmen were able to access state support than the MCA whose leadership at least initially were dominated by upper class Chinese. Hence, a greater sense of communal identity and business networks emerged in Penang.

The states of Selangor, Negeri Sembilan, Melaka and Johor were led by Malay dominated UMNO from independence. The MCA has traditionally remained docile to UMNO control, primarily because of its leaders being dependent on Malay voters to retain their seats. Except for the 1995 elections most MCA leaders depended heavily on Malay voters. While the very rich Chinese businessmen gained support from both the MCA and UMNO,

often along Ali-baba lines, middle class and newly emerging entrepreneurs lacked the coordination mechanisms as well as adequate information to access support and favorable treatment of their applications. The entrepreneurs that accessed support were primarily Malays and some who enjoyed connections with MCA officials. Because the Malays lacked learning experience from a short entrepreneurial past most Malay businesses tended to depend heavily on state created and captive rents. Proton's suppliers are examples. Hence, effective business networks hardly evolved in the states of Selangor, Negeri Sembilan, Melaka and Johor.

Government policy was instrumental in stimulating inflows of electronics firms into Malaysia. Endowed with good relative infrastructure, bureaucratic quickness when dealing with MNCs, political stability, muzzled labor organization and an English speaking labor force, Malaysia enjoyed tremendous advantages over other developing locations for electronics firms seeking sites for labor-intensive assembly activities. Three major waves of electronics MNCs can be traced in Malaysia, i.e., one, the period 1972-74 when American and Japanese firms relocated massive assembly operations, two, 1987-89 when the Plaza Accord of 1985 triggered the Yen-effect and the withdrawal of GSP from the Asian NIEs in February 1988 pressured labor-intensive consumer electronics firms to seek cheaper foreign sites, and three, 1990-94 when giant American disk drive and computer companies sought to locate in cheaper cost sites where supplier networks of key components such as micro-chips already existed.

While external events were important, the Malaysian government strengthened Malaysia's attractiveness with lucrative incentives. The government first launched its export-oriented industrialization policy following the Investment Incentives Act (IIA) in 1968. Electronics components multinationals only began relocating in Malaysia after the Free Trade Zone Act was enacted in 1971 and the subsequent opening of the FTZs and zones in 1972. National Semiconductor — the first semiconductor firm to commence operations in Malaysia — built its factory in Bayan Lepas in 1971 and started production in 1972. Clarion from Japan, which started operations in 1971, was the first foreign electronics firm in Penang. Government efforts to woo export-oriented manufacturing firms have been critical at least in four important ways:

- The federal government's free trade zone (FTZ) legislation offered financial benefits in the form of:
 - a. pioneer status — which gave tariff exemptions on imports and exports, and tax holidays over a period of five to ten-years. Firms were thus exempted from corporate income tax of 35 per cent and development tax of 5 per cent;
 - b. Upon expiry of the pioneer status, firms have often been granted investment tax credit (ITC)² which has given further tax exemptions for five to ten years. The exemptions have been equivalent to approved investment. Losses during the allowance period can be replaced after the period;
 - c. Where FTZs could not be established, licensed manufacturing warehouses (LMWs) have been established. LMWs enjoy similar privileges as firms located in FTZs;
- Amendments to the Employment Act of 1955 in the late 1960s and the Industrial Relations Act of 1967 imposed tighter controls on labor organization. The government did not allow unions in the electronics industry until 1989 when in-house unions were first allowed. Several firm managements still refuse to recognise some of these in-house unions;
- Government leaders offered unofficial guarantees to safeguard multinational corporate interests to ensure effective production coordination (e.g. for power supplies and customs regulation);
- The local state government offered subsidized land, water, electricity and other physical infrastructure.

A combination of political stability, good infrastructure, cordial approaches by the political leadership and lucrative incentives directed at firms generating large employment and investment levels, helped attract the world's leading electronics firms to Malaysia. The emphasis on investment and employment levels and labor-intensive production technologies associated with electronics assembly in the 1970s and early 1980s skewed the industry towards large firms (see Rasiah, 1993; 1996). The first wave of foreign electronics MNCs located in Penang and Selangor

in the period 1971-74. Local private initiatives were initially constrained by official policy directives under National Economic Policy (NEP), which with the promulgation of Industrial Coordination Act (ICA) in 1975, discriminated non-Bumiputera entrepreneurs. Firms with an employment size of 25 and above and a paid up capital of 250,000 were required to obtain licensing, often requiring compliance with national ethnic restructuring conditions. Also, local non-Bumiputera firms also hardly enjoyed access to incentives.

Given the lack of production experience in electronics components making prior to the 1970s, local initiatives in the industry only began to emerge from the 1970s. With the exception of showpiece industries and other scattered small-scale efforts, local involvement in electronics component manufacture did not grow much until the late 1980s. Being small and largely owned by local Chinese capital, electronics component firms generally enjoyed little state support. Smaller local owned electronics firms only received strong impetus only following its classification among the promoted industries in the Industrial Master Plan of 1986. Being complementary to the operations of the strategic industries such as electronics, the industry enjoyed similar incentives, though, the extent of foreign direct investment was extremely small. The Promotion of Investment Act of 1986 offered the industry equal duty exemptions if located in free trade zones (FTZs) or licensed manufacturing warehouses (LMWs) and export incentives such as the double tax deduction on exports and export credit refinancing.

Under such circumstances, domestic policy tended to be biased toward large industries and foreign MNCs. The global glut in 1984-86 forced several small electronics firms to close, especially local ones. Penang Electronics and Penang Printed Circuit Boards were a few of them. The only foreign casualty of that period, Mostek which assembled Dynamic Random Access Memories (DRAM), was sold to Thomson CSF which later sold it to International Device Technology.

Thus, federal policy instruments generally discouraged the growth of small and medium electronics firms in Malaysia. Against this general trend nationally, changes in production organization especially from the mid-1980s began to change the structure of electronics firms in Malaysia. With considerable assembly and test upgrading, as well as, aspects of redesigning taking place in Malaysia, local state initiatives began to stimulate the development of institutional networks to enable greater deepening in Malaysia. Penang state was arguably the most advanced in pursuing such opportunities. Government-business initiatives led to the formation of the Penang Skills development Center (PSDC) in 1989. Several other aspects of infrastructure were strengthened so that firms could externalize substantial aspects of production, which was internalized in the past due to the uncertainties associated with the local structure. Such production segments were dissimilar but complementary to the operations of the main electronics component firms in Malaysia. The lack of similar strong networks in the Selangor and Johor discouraged strong development of electronics production networks. Singapore's strong institutional network enabled the relocation of labor-intensive firms in Johor to service firms located across the causeway.

With the exception of Penang, local electronics firms – especially SMIs - in the rest of Malaysia generally faced constraints accessing government support. Under such circumstances, suppliers that have had a long entrepreneurial experience and show potential linkage development effects - dominated by ethnic Chinese ownership - have enjoyed little state support. Chinese owned small and medium electronics component suppliers faced considerable problems in their efforts to supplier multinationals in locations outside Penang. The lack of state support has left them facing severe market failure problems - though ethnic congruence with the generally ethnic Chinese purchasing officers in the multinationals have encouraged some amount of local sourcing. Not only are electronics component multinationals badly positioned to identify small and medium scale firms' potential capabilities as it would require detailed scrutiny and monitoring, they themselves have received little encouragement to participate in such developments, which can be risky and uncertain. Hence, outside Penang, little links were forged between foreign multinationals and local and indigenous firms in the electronics industry. They not only face finance problems - including accessing subsidized loans and technical assistance from the credit guarantee schemes and the industrial technical assistance fund (ITAF) - but are also hardly prominent to attract the attention of potential multinational clients. Indeed, interviews show that the list of small and medium scale firms promoted

by the government include relatively few machine tool firms operating in the Selangor. Where it has involved active state promotion, such as those by the *Bumiputera* venture trust, Permodalan Usahawan Nasional Berhad (PUNB) stringent ethnic-based conditions apply.

The lack of political dynamism has restricted the establishment and strengthening of sourcing relationships between electronics MNCs and local firms in Selangor, Negeri Sembilan, Melaka and Johor. The intermediary coordination role played by the PDC in Penang has been missing in the Selangor, Negeri Sembilan, Melaka and Johor. Lacking state efforts through institutionalization of risks and other support services, electronics MNCs in Selangor, Negeri Sembilan and Johor reported lacking motivation to develop local suppliers. Unlike in Penang where a proactive state leadership has played a critical role in stimulating links between local firms and MNCs, state leadership in other parts of West Malaysia has generally avoided such a role (see Rasiah, 1998a). Since the federal state, *de facto* has generally been the active governance agent in the rest of West Malaysia, national considerations embedded in the NEP and its successor, the national development plan, have dictated the promotion of local firms. *Inter alia*, ethno-class differences restricted the effectiveness of the nationally coordinated SEP and VDP programs. Their success in stimulating subcontract relations between ethnic Chinese firms and electronics multinationals have been modest even after the enactment of the 30 per cent local sourcing condition in 1991 for firms applying to enjoy financial incentives. Yet 2763 firms had registered under the SEP by 1993 (Malaysia, 1994: 260).

The federal state has only been slightly more successful than SEP in its promotion of the VDP involving the electric/electronics industry. Anchor companies began to support small and medium firms with an equity of not less than RM100 thousand that show *Bumiputera* participation in equity and employment of 70 per cent and 55 per cent, however, respectively. Participation in this program within the electronics industry has so far largely involved consumer and industrial electronics firms. Few of them, however, have established links with electronics MNCs. Sapura and Sharp were the initial anchor firms. This program has helped create *Bumiputera* controlled suppliers from scratch within a short time in the electronics industry. The government planned to create 80 new vendors over the sixth and seventh Malaysia plans (Vijaya Letchumy, 1993: 14). Subsidized loans and technical assistance offered through ITAF and venture companies such as PUNB have been critical in their development. Nevertheless, some large Chinese controlled local firms have managed to expand operations outside Penang. Carsem, Unisem in Perak, Malaysian Electric Company (MEC) and OYL in Selangor and Setron in Johor are examples.

Negeri Sembilan and Melaka benefited from industrial congestion in Selangor. In fact Selangor's SEDC actively promoted these states as locations for labor-intensive operations from the early 1980s. Kulim in Kedah attracted labor-intensive assemblies for firms seeking cheaper costs sites outside Penang from the early 1980s. From 1990, the Kulim High Tech park, enjoying strong incentives for high tech and strategic industries, managed to attract wafer fabrication and other redesigning projects, primarily as government directed (as with Silterra which is being built to produce 0.5 and 0.18 micron wafers from next year) spillovers from Penang. However, Kedah still lacks the network and inter-firm dynamics of Penang. Perak figured strongly only from the late 1980s through promotions by the states SEDC as well as deflections from Selangor and Penang. Johor gained from Singapore's efforts to shift incentives away from labor-intensive operations following severe labor shortages from 1979. Proximity also helped attract firms to Johor seeking to supply to higher value added operations in Singapore. The growth of Johor also attracted suppliers from Melaka and Negeri Sembilan to link with Johor firms. However, unlike Penang, firms in these states operate largely truncatedly with little inter-firms and business network synergies. Japanese, Taiwanese and South Korean firms have created supplier networks, but limited to first-tier suppliers with key inputs coming from foreign firms located in Malaysia or from abroad.

Both Sabah and Sarawak are late starters in the electronics industry. The earliest firms came in the 1990s following efforts by the government to encourage through PS and ITA incentives labor-intensive firms facing rising labor and land costs to move out operations to the Eastern corridor and East Malaysia. Most of the electronics establishments that have set up operations in Sabah and Sarawak are labor-intensive. Komag of USA has set up its

plant in Sama Jaya FIZ Kuching, Sarawak. Komag's suppliers who are already in operation in Malaysia, especially Penang, are expected to set up their factories in either Sarawak or Sabah. The latest development is the setting up of the first wafer fabrication plant at Sama Jaya FIZ in Sarawak by 1st Silicon. The company, in joint venture with the State government of Sarawak and the Khazanah, is expected to use the latest technology to fabricate wafers.

Weak business networks in Kedah, Perak, Selangor, Negeri Sembilan, Melaka and Johor has restricted the development of complementary institutions to support the growth of local and indigenous electronics firms and greater links involving MNCs. Electronics assembly in Sarawak and Sabah is still very new. With weak inter-ethnic relations at the small and medium scale level, the Chinese business community involved in metal, tooling, foundry, rubber and later electronics and plastic works enjoyed little support to grow. Federal financial incentives associated with support for SMIs too failed to stimulate the growth of significant numbers of small and medium local electronics firms comparable to Penang. Hence, foreign MNCs in Selangor, Negeri Sembilan, Melaka and Johor tend to source more from foreign suppliers located in Malaysia.

Penang's political structure and business networks have helped support greater dynamism and development of local electronics firms and inter-firm links than other locations in Malaysia. The lack of effective political support, weak business relationships has restricted the development of local business networks in locations outside Penang in the Western corridor states of Malaysia. MNCs still dominate electronics assembly in Malaysia. Foreign capital accounted for 92 percent of fixed capital ownership in 1994, and forms the building blocks of electronics production dynamics in Malaysia.

3. Emergence of Regional Manufacturing Dynamics

Three major regional dynamics has evolved in the electronics industry in Malaysia. While locally based foreign MNCs continue to expand, the local and indigenous sector has evolved differently in the three main regions studied. MNCs in Penang tend to enjoy greater linkages with local and indigenous firms and better co-ordination with support institutions. A number of the MNCs and local firms have moved to attain critical aspects of Toyota's multi-flow dynamism. MNCs in Selangor have tended to evolve truncatedly (e.g. Texas Instruments and Motorola), some substituting supplier requirements with own subsidiaries (e.g. Chungwa Picture Tubes). MNCs in Johor tend to have evolved as offshoots of higher operations in Singapore, or use the proximity to Singapore as a gateway to export markets. Successful local and indigenous firms in Penang enjoy strong links with MNCs in the state. Successful local and indigenous firms in Selangor and Johor do not enjoy strong production links with MNCs. MNCs in Negeri Sembilan and Melaka show patterns similar to Selangor. Apart from flexible production systems used in assembly and test operations, MNCs and local firms in Selangor, Negeri Sembilan, Melaka and Johor demonstrate largely TM2 operations.

The above discussion however does not take into account the fact that the electronics industry in Malaysia shows three major structurally different clusters. Malaysian electronics industry is a composite of three micro regional clusters of roughly the same size in employment, namely, Penang, the Klang Valley and Johor. Other areas such as Melaka, Negeri and Sembilan have developed later as spillover effects took place in Penang and the Klang Valley. East Malaysia is a region that is just developing its electronics industry.

Penang has the largest concentration with over 90,000 employed, followed by the Klang Valley with 85,000 and Johor with nearly 80,000.³ While all three districts are variants of the Singapore model, in that they are driven by MNCs, the linkages to corporate headquarters follow different patterns and consequently, the regional dynamics within and across firms are different as well. A look at the different regions describes the situation. This section assesses the evolution of Malaysian electronics in the three major locations using the four major elements of Best's (1999) New Innovation Paradigm and Cluster Dynamics.

Penang

Penang became the top manufacturer of electronics products in Malaysia since the early 1970s. It has built up a high reputation in the assembly and testing of semiconductors and components, computers and peripherals, machine tool support, as well as consumer electronics. The first phase of Penang's industrialisation process (1970-1986) was largely based on the abundant pool of cheap and trainable labor as well as the availability of pioneer status incentives. However, from the late 1990s, utilisation of robotics and automation increased. The 1990s saw the emergence of computers and peripherals manufacturing in Penang.

Penang's electronics industry has also created spillover effects for Kedah and Perak. The establishment of Kulim Hi-Tech Park (KHTP) in Kedah which is expected to house corporate, academic, and government tenants specialising in R&D activities related to electronics, is an example. Pioneering tenants at the KHTP include Intel Products (US), Akashic Kubota Technology (recently acquired by Stormedia), Empak, AIC, Maxmedia, Fuji Electric, MEMC Electronics Materials (US-Germany), and Hitachi (Japan). While Penang is evolving as an integrated cluster, Kedah and Perak still appear as uncoordinated supplier states – both labor and inputs despite government efforts to promote the Kulim High Tech Park in Kedah as the Northern center for high tech electronics manufacturing. For these reasons, this section discusses Penang only.

As one of the earliest regions involved in the electronics industry, Penang has the critical mass of firms for clusterization. The State Government of Penang and the Penang Development Corporation has successfully developed networks that encourage horizontal information sharing and considerable inter-firm employee interactions. Public and private partnership in skill formation and monitoring through the Penang Development Corporation is also evident. There are also signs of entrepreneurial firms emerging in Penang, utilising its skill base for maximum effect.

Differentiation and Division of Labor

While the Penang region has built a high volume production capability in electronic components which spread to hard disk drives and, more recently, to a wide range of elements of the PC chain (DCT, 1998). While many of these parts and components are elements in global production networks which are co-ordinated at the headquarters of MNCs and do not cross penetrate, the 1990s has witnessed a transition to a regional supply base with a growing degree of local horizontal integration. In Penang, Globetronics, UNICO, Shinca and Trans Capital supply MNCs. MNCs such as Intel have created spin offs of their own, including Globetronics, UNICO, Shinca, Shintel and Samatech. Wong Engineering, Prodelcon, Metfab, Rapid Synergies and SEM owe much to MNC support. Intel has also assisted the establishment of Altera and AIC, while Motorola has done the same for BCM, which has been accompanied by the emergence of a locally owned supplier base with increasing capabilities in technology management.

A number of studies attest to the superior performance of the Penang region amongst the three regional concentrations of electronics and electrical products in Malaysia. For example, Rasiah (1993; 1995; 1996; 1998; 1999) and Narayanan and Lai (1997) show that most supplier firms in Penang have passed through the third and fourth stages of technology absorption and diffusion.⁴

The high level of technology diffusion in Penang compared to other states in Malaysia is due to a much higher proportion of local outsourcing by MNCs and local firms. Local supporting firms in Penang sourced 46 percent of their inputs locally (see Narayanan, 1997: 23). Rasiah (1994) using a detailed study of linkages between seven electronics component MNCs and nine local machine tool firms in Penang showed that the latter fostered the growth of second and third tier suppliers (see also Rasiah, 1997: 25).

The first-tier vendors (those who had the first links with the electronics sector firms) have, in time, chosen to specialise in certain functions, and passed on some of their previous tasks to second-tier machine tool firms whom they now nurture. These second-tier firms have gone on to spawn their own third-tier subcontracting firms, giving them simply tasks like parts fabrications which are no longer profitable for the former. In this way, not only has the number of machine tool firms increased but there has been a greater degree of specialisation among them. These findings suggest a wider diffusion of technology through the agency of first-tier firms to smaller firms servicing them.

With totally truncated operations in which all production inputs and output arrived from and went out from the country, MNC operations in the early 1970s enjoyed no local supplies. In fact the FTZ legislation until the mid-1980s required exports and imports exceeding 80 percent of inputs and output respectively. Despite the lack of supplier companies and capabilities to support the needs of the MNCs, using the PDC as an intermediary organization and relying strongly on old boy networks in business chambers, some MNCs spawned local suppliers. Intel managed to support the modernisation of companies such as LKT, Metfab, Prodelcon, Rapid Synergy, SEM and Eng Teknologi and its staff founded Shintel, Samatech, Unico, Globetronics and Shinca. Motorola was instrumental in the modernisation of Wong Engineering.

Penang's electronics benefited from considerable growth in local suppliers. Local sourcing in the electronics industry in Penang totaled RM1.9 billion in 1997,⁵ rising from RM1.8 billion in 1995 (Malaysia, 1999: Chapter 4). The share of local sourcing in purchases rose from 56.1 percent in 1995 to 57.9 percent in 1997. A study involving 10 major MNCs in Penang showed that local content in component, consumer, communication equipment, and PCs and peripherals were 4-50 percent, 40-50 percent 20-40 percent and 13-60 percent respectively in 1998 (PDC, 1999). The value added of ancillary and supporting firms of the electronics industry rose from RM258 million in 1990 to RM736 million in 1996. The value added per input of ancillary and supporting firms rose from 56 percent in 1990 to 103 percent in 1996 (PDC, 1999). The nominal value added per worker of the ancillary and supporting industries rose from RM24,142 in 1990 to RM39,102 in 1996.

While MNCs have claimed that they would like to increase their local sourcing but are unable to find suitable local suppliers that meet their requirements, some of the major components with a high share in the production cost are simply not available locally. Examples of such components include wafers, TFT-LCD, STN-TFT, aluminium and lead frames.

Entrepreneurial and Developmental Firms

PDC sought the world's leading electronics firms by wooing them through both formal and informal visits to the Silicon Valley in the early 1970s. Many of these firms fit what Intel's Andy Grove describes as the 'new horizontal computer industry.'⁶ Interestingly Grove himself was approached by PDC officials and made a visit to Penang before deciding on relocating there. Other leading examples include Motorola and AMD. Dell relocated in the early 1990s.

Penang's electronics industry have advanced with the development of these companies. Intel's progressive moves from assembly to incremental change generating capabilities made it possible for its headquarters to transfer technology to Penang and for the local plant to move to more complex higher value-added activities such as testing and later redesigning of mature product technologies.⁷

Motorola telecommunication equipment firm has also evolved considerably.⁸ Its R&D center, which carries out customization and product design had 125 engineers in 1995. Motorola Penang reported in 1995 to be the leading telecommunications design center in Asia for the CT2 cordless telephone. The Centre does new product design, product-process interfacing and advanced manufacturing processing see Rasiah, 1996; Hobday, 1999). Motorola's

emphasis on designing has offered Malaysia tremendous opportunities for stimulating learning in R&D activities.

The evolution of production capabilities, including rapid ramp up has ensured that Penang moved beyond the first stage of absorption in the genealogy of technology transfer. It is at the moment at the stage of adapting and redesigning mature technologies. The learning experience from working in MNCs and network support has assisted the movement of local capabilities in Penang up to the redesigning stage. This stage has to be passed before a critical mass of firms begin inventing at the frontier.

Human capital deepening in local divisions of MNCs fostering technology transfer, particularly via skilled personnel have been instrumental in the birth and growth of several local firms. Unisem, Carsem, Globetronics, UNICO and Shinca are just a few who have benefited from absorbing staff who gained their experience from MNCs. Trans Capital's Director worked previously at AT&T in Singapore. Meanwhile new batches of MNCs such Quantum, Komag, Conner Peripherals (bought by Seagate), Read-rite, Dell and Seagate also benefited tremendously from absorbing staff from older MNCs in the 1990s. Rasiah (1998: 10) reported that:

Intel, AMD, National Semiconductor, Siemens, Hewlett Packard, Micro Components Technology and Motorola Malaysia reported that former personnel...had started up new firms, and have offered substantial technical support to local firms.⁹

This is not surprising as these companies are developmental firms in the United States and have long spin-off histories. Fairchild's (previously known as National Semiconductor) subsidiary plants in Penang, Dynacraft and Micro Components Technology (sold later to Towam), trained many of the region's key personnel in precision engineering and metal working which now run successful local firms, including Prodelcon, Metfab and Rapid Synergy. Motorola encouraged its engineers and managers to join BCM during its initial development stage. Two of Intel's personnel left for AMD's NVD design centre in Penang. Two of Motorola's staff also joined the R&D division of Sapura in Ulu Kelang.

The development of supplier firms in metal working, machining and tooling, and plastics is critical to maintaining the competitive advantage of electronics in Penang. But, at the same time, the number of Malaysian-owned entrepreneurial firms (firms with design and new product development capabilities) in electronics is limited. Outstanding examples in Penang are Eng Teknologi, UNICO, Prodelcon, Rapid Synergy, SEM, LKT, Metfab, Polytool, Wong Engineering and Globetronics¹⁰ (see Appendix 2, 7, and 8 for further discussion).

Intel and Motorola are exceptional in the commitment to local innovation and opportunities for driving cluster dynamics. They are developmental firms within the Penang context, which are enhancing the skills base of the region (technical and managerial skills), a prerequisite to making the transition to integrated manufacturing.

Technological Variation

MNCs undertake redesigning of mature products rather than state-of-the-art product design and new product development in Penang. The early stages of technological variation can be seen in the region. The earlier developments of precision engineering and machining are examples of new sub-sectors to the region that enhance the potential for technological diversity. Penang already has local firms manufacturing robotics products, plating, computer monitors, disk drive components such as actuators, and flexi-boards and other surface-mount technology products.

The emergence of Altera, the first design studio, signals a new, critically important development in Penang's transition (Malaysia, 1999). The skills needed for "front-end" operations like chip design, systems integration, and applications engineering are in short supply in Penang. Some firms have second-order R&D facilities. Intel's Design Centre offers designing capabilities that can become part of the wider cluster of capabilities for Penang to

make the transition to a more powerful cluster dynamics. The PDC helped start the Penang Design Center, which accounts for 3 phases in the development of design capabilities and tools across the following disciplines: mechanical engineering, electrical engineering, software engineering, media and communications, industrial design, and manufacturing.¹¹ Nineteen different software tools are involved; the Penang Design Centre has at least one trainer for each tool. The PSDC reported developing training modules that assist design engineers so that a larger supply of R&D engineers can be trained. The expansion of such centers could assist the movement of Penang firms up the technology trajectory.

Horizontal Integration and Reintegration

Companies such as Intel, Motorola, and HP have attracted world-class first-tier suppliers including contract manufacturers such as Solectron and disk drive makers such as Seagate, Komag and Quantum, which, in turn, have filled in the PC supplier base making the region attractive to innovative PC assemblers such as Dell. Dell's strategy of combining the Toyota production system with the internet distribution channel has revolutionised the PC industry; a second feature of Dell's strategy, simultaneous product launches world-wide has created pressures in the Penang supplier base to operate at the frontier of production capabilities with first generation technologies (Lim, 1997).

Penang offers capabilities for state-of-the-art manufacturing and rapid ramp-up to high performance standards to market-led or design-led companies from anywhere in the world. Xircom, for example, is a fast growing telecoms company that "started the mobile computing revolution" with small, inexpensive, adapters that make it possible for notebook PC users to access their corporate networks (Lim, 1997; Best, 1999). The Xircom adapter turns notebooks into desktop PCs in terms of connectivity to local area networks but without sacrificing the mobility of the notebook. Xircom's products are made in Penang only. The local managing director was chosen because of his contacts in Penang. He was able to build a management team; assemble the operations personnel; identify, set-up and equip a plant; and get it running to high performance in a short time span. Making the plant operational has involved ongoing interaction with Automated Technology, a process automation supplier literally across the street. Automated Technology personnel work inside Xircom's plant.

Selangor, Negeri Sembilan and Melaka

Selangor was better endowed than Penang when the first exodus of electronics MNCs relocated in Malaysia in the early 1970s. The administrative capital, the promotional agency of MIDA and federal support was strongest for Selangor. Negeri Sembilan and Melaka benefited from the spillover effects from expansion in Selangor. A number of MNCs seeking sites with cheaper land and lower wage costs from the late 1970s and early 1980s relocated in Negeri Sembilan and Melaka.¹² Hence, Selangor, Negeri Sembilan and Melaka have become highly industrialized, albeit their share of electronics production is not comparable to Penang.

Selangor received the first electric/electronics firm in Malaysia, i.e., Matsushita Electric which started operations in 1965. As with Penang the first big exodus of electronics MNC relocated in Selangor from the early 1970s. Companies equally as illustrious and large as Penang also relocated in Selangor. Melaka and Negeri Sembilan received electronics investment from the late 1970s and early 1980s. Unlike Penang, however, Selangor, Negeri Sembilan and Melaka did not receive tangible investment on computer and related assemblies.

Selangor, Negeri Sembilan and Melaka also enjoy a relatively strong skills base, but limited largely to entry-point qualifications. Firms do engage in internal training and horizontal information sharing. Motorola in Seremban fabricates transistors. Siemens in Melaka manufactures 4 megabit and 16 megabit chips. However, public and private partnerships in skills formation and monitoring through development agencies are weakly developed. Support systems, both formal and invisible are evident in this region, but they lack coordination.

Selangor, Negeri Sembilan and Melaka could become a very important area for the electronics industry in Malaysia. The Bukit Jalil High Tech Park, the Multimedia Super Corridor (MSC), and Cyberjaya have been attracting high-tech and R&D based IT and electronics companies.

Higher Intra-firm and Low Inter-firm Division of Labor

Selangor, Negeri Sembilan and Melaka region have built high volume production capability in consumer electronics, which spread to television sets, video and audio equipment and, more recently, to picture tubes and other components. However, many of these parts and components have remained as elements in global production networks which are co-ordinated at the headquarters of MNCs and do not cross penetrate. Unlike Penang, local and indigenous firms such as Sapura and OYL electronics have not been able to penetrate significantly intermediate MNC markets in Selangor, Negeri Sembilan and Melaka.

MNCs have supplanted supply requirements by attracting either foreign suppliers or their own subsidiaries. For example, Taiwanese owned Chungwa Picture Tubes has a range of suppliers of its own in Shah Alam. Similarly, Samsung in Negeri Sembilan also sources considerably from its own plants.

A limited number of local and indigenous suppliers in the same region supply MNCs, but all confined to non-core components. Procurement officers in four Japanese firms involved in the assembly for videos, CTVs and car air-conditioners in Bangi reported sourcing core components from either other Japanese suppliers or from their own sister subsidiaries.¹³ Capannelli reports a similar finding:

Although the strategy of intra-group sourcing varied among the assemblers, as a general rule, the parts involving core technologies were often procured from sister companies of the same group. In contrast, the lower end technology parts were mainly supplied by “Malaysian” firms. In several cases these input makers were joint ventures with third country firms from Singapore and Taiwan.... Finally another category of suppliers consisted of firms whose ownership was entirely non-Malaysian ... Such firms included American, European, South Korean and Taiwanese...¹⁴

Capannelli's¹⁵ research also showed that only about a-fourth of Japanese consumer electronics firms sourcing in Kuala Lumpur and Johor were from Malaysian firms. Japanese suppliers accounted for 60 percent of the supplies.

Rasiah (1995; 1996; 1998; 1999) and Narayanan and Lai (1997) reported weaker linkages between MNCs and local and indigenous firms in Selangor, Negeri Sembilan and Melaka.¹⁶ Supplier firms in these areas have hardly passed the first stage of transfer. Hence, local and indigenous supplier firms in these states have not progressed to the second stage of absorption. Instead of local firms creating synergies from an extensive division of labor – both horizontally and vertically – as in Penang, MNCs source minimally and directly from end-suppliers. The lack of micro-diversity among supplier firms in this region has restricted the development of world class suppliers.

American and European firms source far less locally in Selangor, Melaka and Negeri Sembilan. Unlike Japanese, Taiwanese and South Korean firms who source most of their supplies from firms of their own nationalities, similar national suppliers are sparse in the central region. Given the weak technological capabilities of local and indigenous suppliers, American and European firms either source directly from the foreign East Asian firms, including Singaporean, or import their inputs. Some firms, including Motorola Sungai Way and Intersil reported sourcing higher value added supplies from local firms located in Penang.¹⁷

The lower level of technology diffusion in Selangor, Negeri Sembilan and Melaka is linked to a much lower proportion of local outsourcing by local firms. Local supporting firms in Selangor accounted for less than 13% of

MNC purchases.¹⁸ In a detailed study of the linkages between four electronics companies and four local and indigenous suppliers in Selangor found that the latter has evolved little over the years.¹⁹

The first-tier local vendors (those who had the first links with the electronics sector firms) still perform low end activities out sourced by MNCs. Few second tier firms exist. When they exist, the first-tier firms are either owned by Japanese firms, or both the first and second tiers are owned by Taiwanese, Singaporean or South Korean firms. Hence the division of labor between firms is very low, while within firms high.²⁰

JVC, Toshiba, Sony, NEC, Fujitsu and Hitachi reported attempting to increase local sourcing following promotional efforts by the government under the subcontract exchange program (SEP) and the vendor development program (VDP) from the late 1980s. Each MNC has attempted to use three to four suppliers for low end inputs, including plastic injection molding. As with the general pattern in the central states, local and indigenous firms enjoying supply relationships with MNCs do not have a production division of labor vertically below them. Suppliers reported obtaining low margins due to competition created between them by the MNC clients. MNCs reported that local firms were undermining their competitiveness because of high costs and poor quality supplies offered by them. Such cut throat business strategies has undermined strong integration potential. The conflicting responses between MNCs and suppliers suggests the lack of strong inter-firm cooperation and trust.

Unlike in Penang, no state corporations in other states have estimated local sourcing achieved in the electronics industry. Interviews with 16 firms in the central states in 1999 suggest that MNC electronics component firms source between 2-10% of their inputs locally. The commensurate figures for MNC consumer, and MNC computer peripherals firms ranged between 40-60% and 20-70% respectively. These figures included supplies from foreign suppliers operating in Malaysia.

Entrepreneurial and Developmental Firms

Developmental firms such as Motorola has its biggest Malaysia operations in Sungai Way, but unlike Penang, the synergies generated in the central states has not been directed effectively to develop local and indigenous entrepreneurial firms. Intermediary organisations such as the state development corporations of the three related states hardly play a proactive role to gather and disseminate information, build bridges between firms and appraise economic performance in such detailed areas as technology and skills development, R&D, linkages and clusterisation. The PDC has been instrumental in developing and co-ordinating these activities in Penang.

While a number of development firms in Selangor, Negeri Sembilan and Melaka have incorporated incremental engineering capabilities in-house, weak supplier support and requisite firm-level skills development and technical professionals has restricted headquarters ability to transfer sophisticated technologies to the central states. Where such transfers has occurred, it is confined largely to in-house developments as with Motorola (Seremban) and Matsushita Air-conditioners. Nevertheless, the emphasis on redesigning older technologies in Selangor firms does demonstrate the potential for higher technological synergies in the central states.

Human capital deepening in local divisions of MNCs fostering technology transfer, particularly via skilled personnel moving to local firms has occurred across the Western corridor states, supporting a growing body of literature that shows MNCs as critical training grounds for local labor (see Rasiah, 1995). Rasiah notes from interviews conducted in 1999 that:

Motorola, Texas Instruments, Intersil, Hitachi, Sony ...and Matsushita Electric reported that former personnel were hired by local firms such as Unisem, Carsem and OYL Electronics.²¹

However, the extent of inter-firm support involving MNC assistance to local firms have been quite limited. Where it exists, much of it comes through the support of business councils representing the different foreign countries.

Examples include JETRO, JACTIM and American Business Council.

Japanese participation in the development of supplier firms involved in moulds, tools, dies, jigs and fixtures in Selangor have been important. However, much of the support has involved low end supplier activities. Much of the higher end supplies are sourced from Japanese suppliers located in Malaysia and abroad.

MNCs in Selangor, Negeri Sembilan and Melaka concentrate more on process developments. R&D is confined primarily to adaptations and minor extensions, but a few MNC exceptions include the development of split level air-conditioners developed by Matsushita Air-conditioners in Shah Alam (Rasiah, 1996). The latter emerged from a well-defined R&D department that focuses on product adaptation and development. Matsushita operates using a flexible production model, approximating the Toyota multi-flow system. Its involvement on R&D is still generally underdeveloped. The Malaysian executive director of the firm reported that its product enhancement activities will be strongly magnified if more qualified R&D personnel is made available in the country.

Weakly Connected Technological Variation

While considerable technological and product diversity has emerged in the central states, most firms do not show strong levels of connections between each other. The operations of firms depict more of uncoordinated variation, which has seriously restricted the establishment of integrated clusters. The bigger successful local and indigenous firms such as MEC, OYL and Sapura tend to operate without production links with MNCs. The emergence of Sapura and OYL Electronics benefited little directly from MNCs in Selangor. Sapura and OYL have R&D capabilities, show extensive exports in telecommunication products and air-conditioners respectively. Their only tangible support from MNCs came from staff transfers.

Yet 8 MNCs interviewed in Selangor, Negeri Sembilan and Melaka contend that their operations will be enhanced if local suppliers develop to substitute imports. As the Managing Director of Motorola noted in 1995:

We are for greater sourcing as that would raise our productive flexibility and lower costs. .. Our official contacts with government bodies has always been with MIDA and MITI. These two bodies only encourage local sourcing through formal investment guidelines but do not actively participate in building relationships.²²

The statement by the Motorola chief reflects the general opinion of MNCs in Selangor, Negeri Sembilan and Melaka. Driven by similar production capabilities and market structures as with the semiconductor and consumer electronics MNCs in Penang, MNCs in Selangor, Melaka and Negeri Sembilan reported having interest in assisting the development of local suppliers if the requisite co-ordinating framework is put in place. In fact it is the development of these synergies that drew the early computer and peripherals assembly firms of Dell, Maxtor (sold to Japanese capital), Conner Peripherals (bought by Seagate), Read-rite, Komag, Quantum and Seagate to Penang. Only Acer reported looking for low wages as an important stimulant for locating in Penang.

Little Integration

Companies such as Texas Instruments, Intersil, Matsushita, Sony and Toshiba have not attracted world-class first-tier suppliers including contract manufacturers, which has seriously affected effective clusterisation. Most MNCs use JIT, MRP2 and TQM practices in-house, but continue to retain in-house a number of even dissimilar activities such as machine tool support. Where specialised components are needed, such as microchips and lead frames, they are primarily bought from firms in Penang, Singapore, Taiwan, South Korea and Japan. The lack of a developed computer and peripherals sub-sector in these states has restricted the purchases of microchips from semiconductor firms. The latter's sales in Malaysia primarily go to Penang firms. The limited needs of Selangor, Negeri Sembilan and Melaka are primarily purchased from Singapore. Meanwhile in addition to purchasing major machinery from

abroad, Texas Instruments sources its machinery supplies from its subsidiary in Singapore.

Despite these limitations, Selangor firms offer capabilities for state-of-the-art manufacturing and rapid ramp-up to high performance standards. However, unlike Penang and with the exception of Matsushita, firms in Selangor do not offer strong market-led or design-led start up opportunities. Unisem, a chip assembly located in Perak was started in record time of less than a year after its construction following the hiring of personnel from existing MNCs. As with most of the areas located outside Penang, it does not have design and market prospecting capabilities.

A number of Japanese and Taiwanese firms act as anchor firms, creating a range of supplier links. In Selangor, anchor firms include Matsushita group of air-conditioner companies, Sony Group of TV/Video companies, Motorola, Tamura Electronics, Chunghwa Picture Tube Component, Formosa Prosonic Technics and Quality Technologies Opto.²³ Examples of local-entrepreneur-led anchors in the Klang Valley include Sapura, OYL, MEC, M-SMM Electronics and Jasa Kita. They usually license their technology from the market. These firms have been largely started by entrepreneurs with state support. The anchors offer markets and technological support for foreign and some local firms. However, interviews show that most local and indigenous suppliers are limited to low value added non-core activities. Hence, the extensive localization of air-conditioner, television, video and refrigerator component supplies has largely been confined to low value added activities. Key technologies such as LCD is still imported from Japan, South Korea and Taiwan. All development work on audio and video equipment, including Discman and Internet music players is done at headquarters abroad.²⁴ OYL, MEC and Sapura are exceptions in that they have R&D operations. Firms such as MEC have also entered production by building their knowledge of the domestic consumer market.

Johor

Johor did not figure when the first early exodus of electronics MNCs relocated in Malaysia in the early 1970s. Johor attracted more textile firms in the 1960s and 1970s. Johor enjoyed proximity with Singapore, but the Island country absorbed even labor-intensive firms in the early 1970s. The prime motivation for relocating in Johor was driven by the need to shift out labor-intensive production stages out of Singapore from the late 1970s. MNCs seeking sites with cheaper land and lower wage costs from the late 1970s and early 1980s relocated in Johor (see Rasiah, 1993).²⁵ The move was further supported followed official initiatives to strengthen the SIJORI growth triangle.

The electronics industry forms an important component of Johor's industrial investment sector although its strengths are more obvious in the shipbuilding and petrochemical industries. Most of the electronics establishments in Johor fall under the electrical sector. Electronics factories have become important particularly since the late 1980s. US based Seagate Technology has recently set up its printed circuit boards (PCB) plant in Senai. Hitachi, Matsushita and Solectron have also started operations in the 1990s.

Johor has the benefit of obtaining spillover firms from the Klang Valley as well as Singapore. However, electronics firms in Johor are still largely small in size and enjoy a weak skills base. Few are entrepreneurial firms, and enjoy little public and private partnerships. Entrepreneurial and developmental firms such as Seagate and Solectron relocated operations only a few years ago, and are engaged in the assembly of peripherals. Wearne Electronics has operated for many years in Pontian, but is still functions as a feeder plant for its parent in Singapore. A significant amount of PCB assemblies service Singaporean and foreign MNC contractors located in Singapore. The Singapore, Johor and Riau (SIJORI) growth triangle seems to have put Johor as low end and ECM supplier base for regional MNC operations in Singapore, in terms of value added being only higher than Batam in Riau.

Specialisation in Supplier and Low End Activities

While the Johor region has built a high volume production capability in particularly computer peripheral and consumer electronics assemblies, which spread to PCBs, disk drives, television sets, video and audio equipment and, more recently, to capacitors, resistors and other components. Many of these parts and components have remained as elements in global production networks which are co-ordinated regionally from Singapore. Suppliers unrelated directly to purchasers equity holders, have also located strongly in Johor.

MNCs and suppliers operate primarily as suppliers or ECM facilities for MNCs located in Singapore. For example, Wearne Electronics, Solectron, PNE, Aiwa and Asahi send much of their output to MNCs located in Singapore. Exceptions include SGS Thomson, which both export to Singapore for regional markets as well as export to the major markets.

A limited number of local and indigenous suppliers in the same region supply MNCs, but all confined to non-core components. Six foreign PCB assemblers reported sourcing only non-core components from local and indigenous firms.²⁶ However, over 90 percent of their inputs come from MNCs in Malaysia and Singapore. One Managing Director reported that:

Most PCB assemblies in Johor cater for firms located in Singapore. Our inputs come primarily from Singapore, Penang and Selangor from a wide range of MNCs. A few of us use OEM facilities to supply PCBs. Most of us assemble PCBs using specifications given by our clients.....It is difficult to compete with Singapore as it has much better facilities and government support for computer assemblies and regional design.²⁷

Johor's Japanese consumer electronics assemblies also figured in Capannelli's²⁸ findings which along with Selangor showed that MNCs only source 25 percent from local and indigenous firms.

As with the central states, supplier firms in Johor have hardly passed the first stage of transfer. Hence, local and indigenous supplier firms in these states have not progressed to the second stage of absorption. Instead of local firms creating synergies from an extensive division of labor – both horizontally and vertically, MNCs source minimally and directly from end-suppliers. The lack of micro-diversity among supplier firms in Johor has restricted the development of world class local and indigenous suppliers. The world class supplier firms such as Solectron (ECM) and Asahi are foreign owned. The former assembles computer components for Dell in Penang, but its activities in Johor so far is limited to PCB and component assemblies for MNCs in Singapore.

Sourcing patterns of American and European firms in Johor are similar to those in the central states. Unlike Japanese, Taiwanese and South Korean firms who source most of their supplies from firms of their own nationalities, similar national suppliers are sparse in the central region. Given the weak technological capabilities of local and indigenous suppliers, American and European firms either source directly from the foreign East Asian firms, including Singaporean, or import their inputs.

The lower level of technology diffusion in Johor is linked to a much lower proportion of local outsourcing by local firms. Interviews with 6 local supporting firms showed that less than 15 percent of MNC purchases in Johor came from local and indigenous firms.²⁹ As with the central states, the extent of differentiation and division of labor between local suppliers have remained low. Rasiah notes the following:

The 6 local suppliers interviewed showed that they were horizontally unlinked in the production chain with other local firms. None showed more than one tier supply links. These firms either exported directly to firms in Singapore, or supplied foreign suppliers operating in Johor. The latter than mainly export to firms

in Singapore. The lack of division of labor between supplier firms in Johor has stunted the capacity of firms to specialise horizontally.

PNE, Wearne Electronic, Fujitsu, Aiwa Electronics, Sharp Manufacturing, Pioneer Technology and Hitachi reported attempting to increase local sourcing following promotional efforts by the government under the subcontract exchange program (SEP) and the vendor development program (VDP) source from the late 1980s. However, unlike Selangor, MNCs have not done much to use local suppliers for low end inputs. Most MNCs have their own suppliers in Johor. As with the general pattern in the central states, local and indigenous firms enjoying supply relationships with MNCs do not have a division of labor vertically below them. Solectron's ECM facilities, however, use large amount of inputs from MNCs operating in Malaysia.

Unlike in Penang, the Johor state development corporation has not estimated local sourcing achieved in the electronics industry. Interviews with 1 semiconductor firm, 9 PCB assemblers and 8 consumer electronics firms in Johor in 1999 suggest that MNC electronics component firms source between 2-5 percent of their inputs locally. The commensurate figures for MNC consumer and MNC computer peripherals range between 40-50 percent and 40-90 percent respectively. These figures included supplies from foreign suppliers operating in Malaysia.

Entrepreneurial and Developmental Firms

Most electronics firms located in Johor appear to be fairly closed in their networking relationships with other firms located in the state. Interviews did not generate the presence of strong developmental firms in Johor. Not much seems to have been done to tap the synergies generated from Singapore to develop local and indigenous entrepreneurial firms. Intermediary organisations such as the state development corporation hardly play a proactive role to gather and disseminate information, build bridges between firms and appraise economic performance in such detailed areas as technology and skills development, R&D, linkages and clusterisation. The exemplar role of the PDC is hardly seen in Johor. An official from the Johor state development corporation reported:

We rely considerably on Singapore's promotional efforts. Singapore spends heavily on promotion, while we absorb some of the synergies because of our close location and to the division of labor that has emerged in the industry... Our activities do not stretch to co-ordinating firms' activities. We only do that when we have equity participation in the firms. As for others, we see it as getting too involved in activities outside our area. If firms establish strong linkages in Johor, that is good for us. But it should come from firms' own initiatives.³⁰

Consumer firms such as Sharp-Roxy, demonstrate stronger local supplier links. Most firms, however, do not operate as development firms in Johor due to the confinement of supply chains within subsidiaries and the lack of institutional support facilities to stimulate innovative activities in local firms. SGS Thomson is a slight exception as it emphasises improvements in cycle time, quality and efficiency and therefore has hired more than 60 percent of its 3,700 staff from engineering and technical background. The firm also has a process R&D department. Also, weak supplier support and requisite firm-level skills development and technical professionals have restricted headquarters ability to transfer sophisticated technologies to the central states. Where such transfers has occurred, it is confined largely to start-ups of low value added supplier activities.

Johor seems to show a lower professional staff turnover to support the opening of new dynamic local firms. Broad-based and continuous human capital deepening in local divisions of MNCs is very important only in some firms such as SGS Thomson and Solectron.³¹ Others also reported emphasis on training to sustain production competitiveness.

Japanese participation in the development of supplier firms involved in moulds, tools, dies, jigs and fixtures in

Johor have been important. However, much of the support has involved low end supplier activities. Much of the higher end supplies are sourced from Japanese suppliers located in Malaysia and abroad.

MNCs in Johor concentrate more on process developments. None of the firms interviewed engaged in formal product R&D activities. Minor adaptations and process improvements were reported as the most sophisticated activities. Firms show largely Ford's conveyor belt structure and some aspects of Toyota's multi-product line due to the use of flexible production methods. However, Johor firms hardly involve in integrating customisation activities with flexible production methods.

Weakly Connected Technological Variation

Johor firms are largely confined to computer peripherals, and consumer electronics assemblies. Interviews show that Johor has only one microchip firm and no computer assemblies. While considerable technological and product diversity has emerged in the central states, most firms do not show strong levels of connections between each other. The operations of firms depict more of uncoordinated variation, which has seriously restricted the establishment of integrated clusters. The bigger successful local and indigenous firms tend to operate without production links with MNCs.

Unlike Penang and Selangor, in Johor, local and indigenous electronics firms do not have developed R&D and OBM facilities. MNCs and suppliers in Johor operate as supply organizations in a conduit where most regional innovations, marketing and development is handled in Singapore.

Little Integration

Companies in Johor such as Hitachi, Matsushita and Asahi have not attracted world-class first-tier suppliers including contract manufacturers, which has seriously affected effective clusterisation. World class contract manufacturers such as Solectron and intermediate industries such as Seagate located in Johor to supply Singapore firms. It is the MNCs in Singapore that have attracted these companies to locate in Johor. Yet, most MNCs in Johor use JIT, MRP2 and TQM practices in-house. Where specialised components are needed, such as microchips and lead frames, they are primarily bought from firms in Penang, Singapore, Taiwan, South Korea and Japan. The lack of a developed computer and peripherals sub-sector in these states has restricted the purchases of microchips from semiconductor firms. The vast number of PCB assembly firms cater for Singapore's computer assemblers.

Anchor companies – involving their local own suppliers – has also evolved in Johor, though the incidence is relatively low. The anchors for Johor firms are largely located in Singapore. Dai Hwa Electronics, Flextronics, MMI Industries, Hokuden and Wearnes Electronic are some of foreign MNCs that function as anchor firms in Johor. Local firms, such as Setron, which supports anchor activities, is a rare example in Johor. Local entrepreneurs performing supplier activities include Akijaya, Strong Tex and Multi-Unify. The audio equipment supply network is virtually domesticated, though the core components are supplied by foreign suppliers located in Johor, Melaka and Negeri Sembilan.

Johor's capacity to use state-of-the-art manufacturing and rapid ramp-up activities is largely possible because of the human capital capabilities it draws from Penang, Singapore and Selangor. For example, Solectron is managed by its employee from its subsidiary in Penang, who made his name working for Intel Penang. The lack of generation of substantial local capabilities in the state, and the hopping effect to Singapore, has constrained the capacity of firms in Johor to not engage in market-led or design-led start up opportunities. If firms look to locate such operations in Johor, unless these gaps are overcome, the human resource capabilities required will have to come from Penang, and to a less extent, Selangor.

As with Selangor, Negeri Sembilan and Melaka firms, firms in Johor also lack intermediary support from institutions.

The Johor Development Corporation does not produce a list of suppliers, to match them with MNCs, and coordinate its Skills Development Center to reflect industry needs effectively. Interviews show that the corporation does not perform *ex post* appraisal activities to improve its support services. The lack of such co-ordination efforts has prevented the establishment of information and co-ordination networks between firms and institutions. Hence, the extent of network synergy generated in Johor is significantly short of Penang. For firms in Johor to make the transition to the new competition, the PDC's role should be replicated taking cognizance of local conditions. The right policy framework can create the conditions necessary to attract MNCs from Singapore and local firms to emerge alongside so that the core in the cluster can be extended to Johor. Johor's land space, water resources, power supply and population access can assist the state to compete effectively with Singapore.

4. Implications for Clusterization and Innovation Dynamics

A number of implications can be drawn from the foregoing discussion. On the positive note, Malaysian electronics has come a long way from its virtual non-existence before 1970. 25-35 years of production experience has facilitated the development of a labor force that excels in manufacturing activities, including starting and rapid ramp up capabilities. The major locations of Penang, central states and Johor have also attracted large numbers of MNCs from abroad. MNCs that are entrepreneurial and development firms such as Intel, Motorola, Dell and Solectron have operations in Malaysia.

With their superior infrastructure, political stability, bureaucratic efficiency involving MNCs and a trained labor force, Malaysia has managed to become one of the major centers for labor-intensive and low value added activities. Despite the lack of inter-firm links and business networks *a la* Penang, Selangor and Johor have a range of audio, video, computer peripherals and related firms that can form the basis for the development of strong clusters. Penang, Selangor, Negeri Sembilan and Johor in particular are unlikely to lose their plants for several more years.

However, three decades of growth in these states have not transformed the depth of production operations much. Only firms in Penang are attempting a significant move up from labor-intensive operations to higher value added activities such as redesigning activities. Enjoying superior inter-firm links and business networks and an inspirational role by PDC, Penang enjoys the potential to make the transition. However, even Penang cannot do it if the requisite human capital, innovative potential capabilities and market development capabilities are not developed – all of which involve collective action problems that the government must address in an active industrial policy. The critical problems facing electronics firms in Malaysia are:

- Malaysian electronics is still dominated by MNCs. Malaysia's competitive advantage is still based on low cost labor engaged in low value added activities. Local and indigenous firms are generally ill-equipped to take up the new high-tech challenge because of the limited development of indigenous capabilities; including technology absorption capacity, and local inter and intra-industry linkages.
- Imports still dominate production activities. Imports accounted for 74.2 percent of exports in 1998 because of the limited development of local companies and high imports of intermediate and capital goods.
- The inter-firm division of labor in Malaysian electronics is still low. The number of efficient SMIs are still too few to establish strong integrated production in Malaysia.
- Malaysian electronics is continuing to face growing innovation deficits. Electronics firms in Malaysia are disadvantaged by the lack of innovation in the country. Institutional support mechanisms do not match the capabilities of even Singapore, Taiwan, South Korea and Japan, let alone Route 128 and the Silicon Valley.
- Malaysian electronics is facing growing shortfalls in human capital supply. Whatever the status of technology, the requisite manpower must be developed to drive technology development and competitiveness.

- Electronics firms in locations outside Penang suffer from serious gaps in inter-firm links and business networks. The PDC has stimulated its strengthening in Penang.
- Local and indigenous firms have not developed their market prospecting and development capabilities. MNCs are unlikely to involve too deeply in market R&D other than regional customization due to their facilities in parent locations.

The value-added share of electronics firms in Malaysia has grown slower than inputs and the factors of production. The total factor productivity growth (TFPG) of all four five digit industries in the electric and electronics sector have faced a fall in the period 1988-96. Much of the growth in valued-added is linked to extensive accumulation or growth in inputs, labor and capital instead of gains in disembodied technological capabilities. This, in turn, reflects a worrying reality: manufacturing capability is increasingly becoming like a commodity. With the build up in volume-production capabilities throughout East Asia, manufacturing plants are in excess supply. China's emerging capabilities in this area will only intensify the tendency of mass production manufacturing to be commodified.

Malaysia is faced with a general trend of falling rates of TFPG growth in the industry. Examined by firm size by employment, with the exception of electrical and electronics industrial machinery, in which firms with employment size 1000-1999 and 2000 and more enjoyed TFPG rates of 0.5 and 9.1 percent respectively, the rest experienced declines (Malaysia, 1999: Tables 4.7-4.10). In others, the industry's value-added has been driven largely by inputs of labor and capital. Disembodied technical progress has declined relative to other factors. Although TFPG was worst for employment size categories of less than 100 for electric and electronics industrial industry and less than 30 for electronics components, the sensitivity tests did not reveal significance of TFPG by size. Hence, neither scale nor smaller size differentiate performance, suggesting that the average level of disembodied technical change has been low. Put simply, value added in Malaysia's electronics industry has grown far less than inputs and factors of production.

From this perspective, Penang's institutional, physical and skill formation infrastructures orchestrated by the Penang Development Corporation were highly successful in guiding the transition to a high-volume manufacturing cluster. But a new transition is called for and will require an entirely different set of institutional and skill formation capabilities. Four major drawbacks in governance mechanisms in the country need addressing if Malaysian electronics is to make the transition low value added activities to higher value added activities, *viz.*,

- Growing Skills and Technical Manpower Deficits
- Weaknesses in Inter-firm and Network Links
- Weak Innovation Capabilities
- Market-development

Growing Skills, Technical and R&D Manpower Deficits

The most crucial shortfall is in the skill formation required to foster entrepreneurial firms and industrial innovation. There are no short-cuts: innovation in electronics is engineering intensive. Penang's limited innovation related skills, given the considerable manufacturing capabilities, illustrates the limits of an electronics infrastructure that does not include strong skill formation capabilities in areas such as design engineering, computer science, systems analysis, and information technology generally.

The scale of the problem is presented in Table 1. While the projections made in 1995 are somewhat dated, Malaysia faced a demand-supply gap of 15,000 shortfall of R&D scientists and technologists by the year 2000, requiring an additional annual average increase of 3,000. The commensurate shortfalls for engineers, skilled and semiskilled personnel were 36,000, 24,700 and 402,500. The commensurate additional annual average growth

figures required for engineers, skilled and semiskilled personnel were 7,200, 50,000 and 80,500. While efforts were made to overcome the shortfalls, including expansions in student enrolment in local universities, interviews suggest that the supply institutions were seriously short of meeting the numbers.

Table 1: Technology Manpower Projections, 1995-2000

Occupation	Stock	Gross Demand		Gross Supply	Demand-Supply Gap	Additional
Annual Average Increase	1995	2000	2000	1995-2000	1995-2000	
R&D Scientist & Technologist	7000	22000	7000	15000	3000	
Engineers	39000	110000	74000	36000	7200	
Skilled*	303500	550000	368000	247000	50000	
Semi-skilled**	1047500	1650000	1247500	402500	80500	

Note: * Diploma holders (from polytechnics etc.); ** Certificate holders (from vocational schools and MLVK etc).

Source: World Bank/UNDP/MOSTE (1995).

Given the shortage of engineers and scientists in Penang, finding over 800 quality lecturers with the requisite capabilities and experience will be difficult. The major pool of candidates would likely be from within the MNC companies and Malaysians working overseas. To attract lecturers will require considerable attention to quality of life issues. But it would also involve considerable attention to a curriculum appropriate to building on the strengths and strategic opportunities for Malaysian electronics.

The benefits from building up university education programs in engineering are not only in skill formation of engineers. The development of both the Route 128 and Silicon Valley electronics clusters involved the simultaneous development of university departments, research institutes and curricula, on the one hand, and rapidly growing entrepreneurial enterprises, on the other. This dynamic is the hot-house environment that has nurtured techno-entrepreneurs, important drivers of cluster dynamics.³²

The industry and state government has a history in Penang of responsive collaboration in skill formation at the technical skill level. Each year the PSDC offers courses to over 8000 students (Malaysia, 1999). The collaboration has contributed to the targeting of curriculum and upgrading of shop-floor skills appropriate to high-volume manufacturing production.³³ Presently, the PSDC is moving into information technology with a series of pilot projects that, if scaled up, could make a big contribution to upgrading the IT capabilities of the manufacturing labor force. An Indian software training company in Bangalore has been contracted to teach computer-programming skills.

It takes not months but years for the training of engineers, software engineers, and developers. The training period for qualifications for teachers is much higher. In the case of technician and manufacturing skills, companies themselves run related training programs and could quickly upgrade the quality of teaching staff.

Other states in Malaysia lack effective industry and firm level training support *a la* the PSDC in Penang. Similar centres were created in Selangor, Johor, Kedah and Negeri Sembilan, but poor co-ordination has undermined seriously their roles.

Overcoming the human capital shortfalls will require institution building which will, in turn, require a large commitment of government funding, local political leadership, and industry/education institution partnerships to develop the skills required to make the transition. The range of incentives that attracted MNCs to Penang were successful but they are not adequate to make the transition to the new competition. Effective industrial policy is more about education and training policy, technology and marketing policy than about tax incentives. Lacking strong business networks and inter-firm links, Selangor, Negeri Sembilan, Melaka and Johor face a more difficult path to move of the technology trajectory.

Gaps in Inter-Firm Links and Business Networks

It was noted in Section 1 that the Silicon Valley and Route 128 enjoy the conditions for systems integration so that firms specialise horizontally with strong network support and inter-firm linkages. Central to network dynamics is the fact that the competitiveness of individual firms is not just powered by intra-firm capabilities, but more so by the network synergies produced from links involving individuals, firms and institutions. Effective co-ordination between firms, individuals and institutions have generated substantial synergies that enables firms located in such networks to out-compete firms located elsewhere. Hence, firms such as Intel, Dell, Solectron and Motorola achieve tremendous competitiveness in the Silicon Valley.

Penang firms enjoy the conditions to nourish an integrated cluster of inter-firm links and business networks. Firms in the central states and Johor are too loosely bonded and unconnected to capture enough of the network synergies to make the competitive transition. Local firms and others in the value chain have to also build the innovative capabilities to enable equal and two-way interfacing. Only then can the division of labor can be intensified and effective horizontal specialisation take place.

The PDC offers a unique base to formulate strategies to make firms in Penang move up the technology trajectory, and its reproduction in the central states and Johor to stimulate firms similar movement. PDC's efforts to build inter-firm links, actively matching buyer-supplier links, assisting SMEs overcome problems, opening channels for inter-firm employee interactions, taking the lead to initiate programs to solve collective action problems is laudable. The PSDC was one of the prime results of the key intermediary role that PDC has played. This role should be expanded to include the promotion to networks linking individuals, universities and all firms and institutions – both systemic and pecuniary – so that the entire system functions as a whole. This way, effective interfacing between individuals, firms and institutions will enable the development of all so that horizontal specialisation to levels of world class competitiveness can emerge.

The central states and Johor must replicate integrating local specificities to create effective networks. Although both networks currently function with minimal links, the right policy framework can initiate and help build such networks to stimulate the transition of firms up the technology ladder.

Growing Innovation Deficits

Section 1 established the key role played by Silicon Valley's and Route 128's open system networks in generating rapid innovation. The electronics industry in Malaysia lacks the capacity to generate rapid innovations. MNCs on their own would hardly perform state of the art R&D activities in host-countries. The focus on R&D should then be largely on local and indigenous firms, though its promotional activities need not impose ownership conditions. The demand for R&D in local and indigenous firms has been emerging, but its supply has widened.

The lack of funding organisations to underwrite risks associated with innovative activities has stifled the growth of innovations. Innovators hardly have the requisite collateral to borrow from commercial banks. Some firms have managed to overcome this problem by accessing capitalisation from MTDC; e.g., Globetronics. Others like Sapura

obtained a RM70 million loan from Sumitomo and Marubeni with government backing.³⁴

The government provides a range of financial assistance to companies that fall under the official SMI definition. The incentives include the Industrial Technical Assistance Fund (ITAF); Soft Loan Scheme for Modernisation and Automation; Soft Loan Scheme for Quality Enhancement of SMIs; and the newly established Financial Package for SMIs (soft loan for Project Financing and Working Capital Finance). However, local and indigenous firms reported considerable problems accessing such loans.

The lack of designing and research capabilities has restricted local and indigenous vendors' capacity to break out from their dependence on MNCs to provide the necessary specifications and manufacturing requirements. As such, local and indigenous firms enjoy fewer options and remain far from the technology frontier. The need to do R&D becomes more pronounced as these companies plan to progress from vendors to OEM and ODM. They will need to do their own prototyping, design, and product innovation to ensure a continuous stream of updated products and improvements in product performance.

Many of them like UNICO (concluded four joint ventures with overseas partners during the years 1994-1996) and Trans Capital rely on overseas partnerships to perform this service. However, if the products are eventually going to be built here, they will need further modifications before they can be produced in high volume. Therefore, some level of local R&D is needed even for firms still performing supplier and ECM activities. In the long-term, a greater push in R&D is central for firms to move from OEM to ODM, and OBM activities locally along a higher technology and value-added chain within rapidly evolving product cycles.

To be competitive globally, there is a need for the indigenous electronics companies to upgrade their technological capabilities. These companies should aim to automate the production processes. Sapura and OYL are product innovative but not process innovative. The majority of the indigenous electronics firms are still at the lower end of the technology chain. Many of these companies are still using machinery and equipment that are considered obsolete by foreign MNCs and large local firms. Only a few of the indigenous firms are using CAD-CAM (computer aided design, computer aided machining) and CNC (compute numeric control) machines.

Although most local firms are not highly advanced along the value-added chain some local companies in Malaysia have developed into entrepreneurial firms. The three examples in Penang are Globetronics, UNICO and Trans Capital. Sapura, MEC and OY, and Setron perform product R&D in Selangor and Johor respectively. However, the Selangor and Johor firms do not have integrated state-of-the art process R&D facilities. Sapura and MEC still rely considerably on government support. MEC targets sales primarily to the domestic market. These case studies show that indigenous electronics companies can succeed well even in an environment of high-tech and highly connected MNCs given good planning, an initial market niche, innovative management, and good business and government relationships.

The tie-ups some local and indigenous have used to upgrade their manufacturing activities – have helped them enhance their R&D capabilities. Firms such as Globetronics, and Trans Capital currently provide products and components to MNCs and also export. Sapura and OYL enjoy licensing and joint-venture access to foreign technologies. These firms have enhanced their technology capability through tie-ups rather than attempting to reinvent the wheel. However, most local and indigenous electronics firms have not established such links.

Recognizing the importance of local and indigenous electronics establishments in contributing to the national economy, it is important to assist these companies, especially the export-oriented, and those that are providing supporting and ancillary services to the MNCs and other export-oriented industries. More important, the government, through the various ministries and agencies like MITI, MIDA, and SMIDEC could provide adequate funding and convert all incentives specifically for the SMIs to local and indigenous industries that are export-oriented or provide supporting and ancillary services to the export market. However, because of their special status, SMIs

should enjoy special access. It is important to note that finance should not be equated with incentives as the former is necessary all the time for any economic activity, while the latter is often only necessary to initiate innovative activities with no long-term need to continue. Efforts to reduce the emphasis on incentives based on ownership will also assist Malaysian electronics meet the requirements of WTO, which forbids differential treatment of investments based on ownership.

Slow Growth in Market Development

Indigenous firms also face problems in exporting their products. These include difficulty in finding export markets. In addition to this, indigenous firms that export their products have to face increasing competition from other exporting countries and the need to develop new products quickly in the light of rapidly changing product life cycles. Moreover, the current economic crisis and depreciation of the Ringgit have also resulted in increased prices of raw materials.

Indigenous firms lack marketing skills. Firms such as Sapura are still dependent on their connections with the government and foreign companies in order to develop their overseas market.³⁵ MEC sells largely in the domestic market, capitalizing strongly on a “buy Malaysian” advertising strategy. The lack of marketing skills is evident in the location of distribution centres of many of the locally-based foreign MNCs in Singapore rather than near their manufacturing locations in Penang and Selangor.

As the market for electronic and electric products becomes more competitive there is a growing need to develop local marketing expertise. Marketing skills are essential in order to understand consumer needs and identify areas for continued growth and development. Unfortunately the majority of Malaysian SMIs still view marketing as ‘selling’ and follow a production rather than a marketing orientation.³⁶ For Malaysian firms to move up the value-added spectrum requires the development of a significant base of marketing expertise. A customer or marketing orientation will provide a better understanding of the key activities that adds value from the customer’s perspective. Market prospecting and market development are hardly emphasized by local firms.

There is an urgent need to promote export-oriented industrialisation among indigenous entrepreneurs. Taiwan provides PCB Net, a system that matches PCB manufacturers with firms that require PCB. The government and Matrade could place more emphasis on the indigenous electronics industry by providing a similar match-making program, with MNC buyers locally as well as with those from overseas. Although the indigenous electronics companies have been included in overseas investment missions, this exercise could be extended to more of these companies. To further enhance the competitiveness of indigenous companies, companies that have already invested overseas could be encouraged to assist the smaller ones to invest overseas to take advantage of lower labor costs. Some Penang-based manufacturing companies that have become ‘Malaysian MNCs’ abroad. Eng Teknologi, Trans Capital and Globetronics have production operations supplying foreign markets in the Philippines, China, Thailand, United States and Virgin Island.

The use of JIT in the local and indigenous electronics firms has been constrained by their excessive reliance for raw materials suppliers from overseas and as such, the uncertainties in lead-time and delivery schedules often require companies to keep expensive stocks. Yet many MNCs with local suppliers are already insisting that the suppliers deliver parts on a JIT mode. This means multiple daily deliveries and deliveries upon demand. To cope with this, many suppliers end up keeping high stocks in their finished goods inventory or keeping stock in warehouses close to their consumers. If the suppliers are not careful, they can end up increasing their logistic costs and inventory carrying costs. At the end of the day, the cost is merely transferred from the purchaser to the vendor who in turn cannot pass on to their suppliers because they are located overseas. Marketing strategies in local and indigenous firms hence should include effective inventory management.

Information dissemination in Malaysia in general is lacking and many of the local and indigenous firms are

disadvantaged by their inexperience. Effective marketing cannot be achieved if firms are unaware of the products and services they and others offer. As such, they are discouraged from approaching either MIDA or SMIDEC for assistance. Product and demand information dissemination is critical in the electronics industry, where trends and fads require changes in the production line. Firms such as Matsushita that have an overseas parent company can easily obtain information on such issues. Other firms have to rely on their marketing and supply network. Firms such as Intel and Motorola have close co-ordination in both areas.

5. Conclusions

This paper used the Industrial Innovation Paradigm and Cluster Dynamics Approach to examine the dynamics of electronics manufacturing in Malaysia, focusing on the three major conurbations of operations, i.e., Penang, the Central states and Johor. Three different regional structures within a national polity has produced distinctly different results, though, only Penang stands out. All three major sites have firms, especially MNCs with world class manufacturing capabilities, the local staff having gained production experience of between over 20 to 35 years. The electronics industry is still heavily dependent on MNCs in the whole country. Considerable value added leakage involve the country so that it remains very much a platform for OEM assembly and test of imported inputs for export markets. With the exception of a handful of firms, SMIs and suppliers – particularly involving local and indigenous capabilities – have hardly developed. MNCs and local firms still largely specialize in low value added activities.

Nevertheless, firms in Penang have established stronger linkages and with the inspirational role of PDC, have established good co-ordination relationships between firms and institutions. A number of collective action problems, such as the use of PSDC for industry-oriented skills development, have been stimulated by its intermediary role. The emerging cluster in Penang is fairly open with a diverse range of firms across the industry. However, for firms to make the transition to TM4 and TM5, Penang needs substantial development of human capital, R&D and market prospecting and research especially involving local and indigenous firms. Only a handful for local and indigenous firms have successfully broken out from OEM facilities to ECM and ODM facilities. While the potential for expansion exists, a more potent policy is necessary to generate the systems capabilities required to bridge the deficits involving human capital, innovations and market research and market prospecting.

MNCs in the central states of Selangor, Negeri Sembilan and Melaka enjoy world class manufacturing capabilities, but in addition to the weaknesses afflicting Penang firms, also suffer from weak inter-firm links and network development. Negeri Sembilan and Melaka firms tend to service Selangor firms, but a few also service Johor firms. Institutions hardly play effective intermediary roles to strengthen inter-firm links in these states. As with Penang, efforts to develop inter-firm links and business networks must be open. The Central states have much to learn from the role played by PDC, but the dynamism achieved in Penang require adapting to meet the specificities of the Central states. These problems need to be ironed out, and deficits in human capital, innovations and market prospecting and research bridged for firms in the central states to make the transition to the new competition.

Electronics firms in Johor operate primarily as suppliers of labor-intensive and low value added services for firms operating in Singapore. Many have achieved world class manufacturing capabilities. Most firms in Johor assemble PCBs, audio and video equipment and peripherals and other components. As with the central states, Johor firms also operate without significant inter-firm and network relationships, seriously restricting the potential for appropriating synergies. The Johor SEDC also does not play an intermediary role to build inter-firm links and business networks. As with the other states, Johor has much to learn from PDC to achieve the network dynamics achieved in Penang. The different local conditions in Joho requires the adaptation of the PDC model to suit Johor. Along with efforts to overcome the deficits involving human capital, innovations and market research, inter-firm links and business networks should be developed to assist firms to gain world class competitiveness. Such efforts will also help Johor attract much of the higher value added in Singapore.

In the absence of effective technology management, inter-firm links and business networks are likely to face continued leakage and dissipation of network synergies. Policy efforts must go beyond incentives to achieve the above goals. While incentives can be useful to start activities, especially risky and uncertain ventures, the success of a comprehensive policy for building long-term competitiveness requires emphasis on technology development and education. The focus should be on generating the requisite human capital, R&D and market prospecting and development. At the firm level, the Toyota model incorporated all three for effective R&D, production and customisation. The whole industrial district must be tapped and be involved to create a system of continuous human resource development, innovation and market prospecting and development.

References

¹ Discussions with Michael Best has benefited my understanding of the Industrial Innovation Paradigm considerably. Discussions with Paul Lubeck in 1993 also helped my understanding of the political dimensions of the electronics industry in Penang. I am also grateful to Colin Chang for supplying me case studies of five electronics firms in Selangor and Johor. All errors that remain are mine.

² This allowance was renamed the Investment Tax Allowance following the Promotion of Investment Act of 1986.

³Malaysia (1995), *Second Industrial Master Plan*, 38.

⁴ See Rasiah (1994) for an elaboration of vertical and horizontal differentiation within supplier networks.

⁵Based on 32 electronics companies that responded to the PDC Industrial Surveys for three consecutive years.

⁶ Andrew Grove (1996), p. 42; Also known as TM 5, a business model associated with horizontal integration, collective learning, and community institutions.

⁷ Lim (1991)

⁸ see Ngoh (1994)

⁹ Rasiah (1998) p. 10

¹⁰ Each has been profiled by Lim Kah Hooi (1997).

¹¹ The Penang Design Center seeks to develop state-of-the-art design and manufacturing capabilities to transform product concepts into viable products. Advances in software, and modularization, have driven down the design cycle time. The design process has five phases: product definition, functional design, logic design, circuit design, and layout design.

¹² Interviews by Rasiah, Rajah in 1995 and 1999.

¹³ This finding is corroborated by Capannelli (1999)

¹⁴ Capannelli (1999: 213)

¹⁵ Capannelli (1999:213).

¹⁶ Rasiah (1996; 1999); Narayanan (1997)

¹⁷ See also Rasiah, Rajah (1996)

¹⁸ Narayanan, Suresh (1997), p. 23

¹⁹ Rasiah (1999)

²⁰ Interviews conducted in 1999.

²¹ Interviews, Rasiah and Chang (1999)

²² Rasiah, Rajah (1999), p. 14.

²³ Interviews by Chang and Rasiah (1999)

²⁴ Interviews by Chang (1999)

²⁵ Interviews by Rasiah, Rajah in 1995 and 1999.

²⁶ This finding is corroborated by Capannelli (1999)

²⁷ Interviews with a Singapore owned PCB assembly firm conducted by Rasiah in 1999.

²⁸ Capannelli (1999: 213).

²⁹Interviews, (1999)

³⁰ Interviews in 1999.

³¹ Soletron might be one of the exceptions due to the experience its MD gained while working for Intel.

³² The best Asian model for the development of techno-entrepreneurs is Taiwan.

³³ Lim (1997) documents both the areas of strength and the missing areas.

³⁴ Alavi, Rokiah (1999), p. 331.

³⁵ Alavi, Rokiah (1999). Rents, Technological Innovation and Firm Competitiveness in a *Bumiputera* Malaysian Firm. In *Industrial Technology Development in Malaysia. Industry and Firm Studies*. Jomo, K. S., Felker, Greg, and Rasiah, Rajah (Eds.), Routledge: UK.

³⁶ See De Run, Ernest; Kilgour, Mark; and Jais, Mohamad (1999).