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Systemic Coordination and Human Capital Development: Knowledge Flows in Malaysia’s MNC-Driven Electronics Clusters

Rajah Rasiah
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SYSTEMIC COORDINATION AND HUMAN CAPITAL DEVELOPMENT: KNOWLEDGE FLOWS IN MALAYSIA’S MNC-DRIVEN ELECTRONICS CLUSTERS

Rajah Rasiah
UNU/INTECH

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Abstract: Using two MNC dominated electronics clusters in Malaysia, this paper examines the development of human capital from two knowledge and skills acquisition modes – formal education and learning by performing - which were dominant in the successful evolution of industrial districts. Ineffective systemic coordination throughout the country from federal institutions has restricted the supply of high tech human capital from formal institutions of education and training. Hence, firms in Penang and Kelang Valley have faced growing demand-supply deficits. Restrictive immigration policies have hampered firms’ options of seeking high tech human capital from abroad. Differential systemic coordination at the regional level has produced different levels of network synergies in Penang and Kelang Valley. Stronger systemic coordination and network cohesion has stimulated greater differentiation and division of labor, engendering the movement of tacit and experiential knowledge embodied in human capital to support industrial dynamism in Penang. Weak systemic coordination and network cohesion has confined MNCs to largely truncated operations without significant levels of differentiation and division of labor in the Kelang Valley.

Keywords: Systemic coordination, Human Capital, Tacit knowledge, Experiential Knowledge, Electronics MNCs, Malaysia

1 Professor and Senior Research Fellow, UNU-INTECH, Maastricht. Constructive comments from Dieter Ernst and Hal Hill are gratefully acknowledged.
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1. INTRODUCTION

Economies achieving rapid industrialization and structural change have been driven strongly by significant transition in the supply of human capital. Two strategies have dominated human capital development in industrialization. The first relates to education policy where the focus has shifted from basic education to the supply of high tech human capital from formal institutions such as secondary and vocational schools, and universities (Lall, 1996; 2001). Demand-supply deficits in human capital – especially involving high tech – often led successful economies to complement local supply with immigration (e.g. Ireland, Singapore and the United States). The second strategy emphasizes the development of human capital from learning by performing (Arrow, 1962). Evolutionary and industrial economists have worked considerably on the pool of tacit and experiential knowledge embodied in human capital developed in firms (Penrose, 1959; Polanyi, 1997). This paper uses a framework that melds together both approaches with systemic coordination as the driver of knowledge accumulation.

The successful expansion of the Silicon Valley, re-emergence of Route 128 and the continued dynamism seen in Emilia Romagna are the product of both approaches working as one strategy (see Best, 2001; Sabel, 1995; Saxenian, 1994; 1999). Although the first is far more documented, the development of the second and mediation between the two has been instrumental in the development of human capital in Japan, Taiwan and South Korea, where local firms were the prime engines of economic growth. Ireland and Singapore are good examples of MNC-driven economies where the effective confluence of the two strategies drove the development and appropriation of knowledge embodied in human capital. While there are considerable accounts of the successful development of human capital, few examples actually detail differential experiences under the same polities. Malaysia is a good example of MNC-driven clusters where some aspects of systemic coordination succeeded while others failed.

Export-oriented MNCs began relocating on a large scale in Malaysia following the opening of Free Trade Zones and Licensed Manufacturing Warehouses since 1972. MNCs were targeted to generate investment and employment. Coming in the wake of an ethnic bloodshed in 1969, the government off-set the risks and uncertainty associated with generous tax holidays, tariff-free operations and controls on unionization (Rasiah, 1988). These efforts led to electric and electronics exports in manufactured exports to rise from 0.7 percent in 1968 to 71.0 percent in 1997 (Rasiah, 2002: Table 8).

The Malaysian electronics industry is a composite of three major regional agglomerations, and moribund operations in Sarawak and Sabah. Penang is the largest in terms of firm numbers,
employment and value added, followed by the Kelang Valley and Johor. Penang’s electronics industry employed over 90,000, followed by the Klang Valley with 85,000 in 1995 (MITI 1996: 38). Rapid expansion in Penang and the Kelang Valley extended the Northern cluster to Southern Kedah and Northern and Central Perak, and Melaka and Negeri Sembilan respectively. Johor’s growth hinged considerably on growth in Singapore. Sarawak and Sabah received significant assembly operations only from the 1990s.

This paper attempts to show that systemic links are critical in gluing together a coherent strategy for the development of human capital and make the participation of MNCs a complementary instrument for industrial clustering. It controls for industry, infrastructure, timing of inception and overall national policy, to show that strong institutional support and network cohesion will generate the production and appropriation of greater human resource synergies. More effective institutional and network coordination helped Penang produce greater skilled, technical and entrepreneurial synergies for differentiation and division of labor. Less effective institutional support and network cohesion produced less synergy for new firm creation in the Kelang Valley.
2. ANALYTIC FRAMEWORK

This paper uses a theoretical and methodical framework that fuses together two approaches to examine the development of human capital in the MNC-driven electronics industrial districts of Penang and Kelang Valley. The first refers to the supply of direct, technical and managerial knowledge through formal institutions. The second refers to tacit and experiential knowledge embodied in human capital acquired from learning by performing. The first channel is coordinated at the institutional level – by government, and private and intermediary organizations. The second is developed in firms, its spread and frequency are influenced by network density and cohesion.

Modern industrialization requires the employment of human capital with at least communication skills so that the conception, organization, coordination and execution of tasks are carried out effectively. From basic and secondary schooling, the demand for technical and professional skills rises as firms move up the technology trajectory. Primary and secondary schools offer the initial mass of labor for large scale but low skill mass production operations. Export-oriented MNCs seeking low cost literate labor to perform simple assembly operations relocated in economies that offered large reserves of literate (trainable) labor. American, Japanese and European MNCs relocated in Jamaica, Barbados, Malaysia (e.g. the export processing zones of Bayan Lepas, Sungai Way and Prai), Singapore, China Taipei (e.g. the export processing zone of Kaoshiung) and Korea (e.g. the export processing zones of Masan and Inchon) in the late 1960s and 1970s to access cheap literate labor (Scibberas, 1977; Lim, 1978; Rasiah, 1987, 1988). Political instability and restrictive policies discouraged similar relocations in China and India in the 1970s. China only became a major manufacturing target of MNCs from the late 1980s (World Bank Institute, 2001). MNCs did not figure strongly in the economies of Korea and China Taipei. Singapore and Malaysia relied strongly on MNCs to generate assembly-type low skill employment in the late 1960s and 1970s.

For networks of firms to operate at the technology frontier, the embedding regions require high tech infrastructure. A number of the necessary high tech institutions face collective action problems. Private agents are unlikely to participate in market-driven activities when the risks involved are not matched by commensurate returns. Arrow (1962) had argued that interventions in markets are necessary when social returns exceed private returns. Schumpeter (1934) had

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2 In fact the US customs items of 806.7 and 807 specifically offered generous exemptions to stimulate the relocation of low value added manufacturing activities to developing economies (see Scibberas, 1977).
argued that monopoly rents are necessary to motivate innovators. Abramovitz (1955) and Kaldor (1957) had contended that markets generate sub-optimal outcomes when involving investments that generate dynamic increasing returns.\(^3\) Interventions become necessary when involving public goods, whose consumption by one does not exclude its consumption by others and without being affected in value. Knowledge-related goods qualify as public goods. Hence, learning institutions such as universities and technical schools that generate high tech human capital and R&D institutions fall under the public goods category. In especially regions where the demand for innovations rises with growth, governments play a critical role to engender the conditions to step up the supply of high tech infrastructure. South Korea and Taiwan shortened the experience of the Western economies and Japan (see Gerschenkron, 1962). While innovating regions continue to upgrade their high tech infrastructure, demand-supply shortfalls are met by imports of high tech human capital from abroad. The United States, Israel, Ireland and Singapore relied extensively on human capital imports (Teubal, 1999; Rasiah, 2002; Best, 2001).

MNC-driven regions have typically managed to stimulate spillovers and industrial upgrading by matching demand conditions with the supply of technical, tertiary and scientific and engineering human capital. Both local firms and MNCs seek high tech human capital to introduce innovative activities. The demand for high tech human capital becomes most sophisticated when firms seek R&D operations. Systemic coordination is necessary to mediate demand-supply conditions effectively, and formal education and tacit and experiential knowledge to create a critical mass of high tech human capital to drive new firm creation. Penrose (1959) and Polanyi (1997) made distinctive contributions to the understanding and significance of experiential and tacit knowledge respectively – which are specific to individuals. Given its public goods characteristics, knowledge and learning - directly or indirectly - governments have participated strongly in the supply of high tech human capital domestically. Where the supply of human capital domestically has fallen behind demand as in Singapore, Ireland and United States, rapid growth and structural change have been sustained through substitution from abroad. Firms either relocated or imported human capital to overcome demand-supply deficits.

The second channel of human capital development occurs from performing – tacit and experiential. Schumpeter (1934) and Hirschman (1958) had discussed extensively the role of entrepreneurs in economic development. However, conventional economic theory tended to confine the term entrepreneurship to a black box. Given the tacit and spontaneous nature of a number of entrepreneurial actions, formal contracts can never be exhaustive and hence will

\(^3\) New growth economists such as Romer (1986) and Lucas (1988) demonstrated these ideas using elegant models. See Scherer (1992; 1999) for a lucid historical account.
always involve moral hazard problems. It is for these reasons trust has become a critical mode of governance to ensure that entrepreneurial synergies are expanded rather than contracted. Business theory has evolved significantly to define and differentiate entrepreneurs, with the focus largely on the evaluation and management of entrepreneurship. Management courses attempt to equip entrepreneurs with technical and professional knowledge so that they become better managers. Critical elements of the theory of entrepreneurship could be traced to Mills (1844), Marshal (1890), Penrose (1959) and Chandler (1962), albeit without specific definitions and methodological instruments for empirical inquiry. The application of theory to the creation and growth of entrepreneurs with a systemic focus became more dynamic with the works of Saxenian (1994; 1999) and Best (2001).

Tacit and experiential knowledge is best engendered in integrated cluster networks. The term clustering refers to a network of inter-connected firms, institutions and other organizations that enjoy systemic links from integrated coordination relationships. The amount of synergies generated and appropriated in industrial districts depends on the strength of clustering and the presence of dynamic institutions to create new spurts of growth. Agglomerations of firms enjoying strong network cohesion between them and institutions are likely to offer greater flexibility, and generate technological and market synergies than those defined by truncated operations of individual firms. Smith (1776; see also Young, 1928) had conceived the relationship between markets and the division of labor as one that is driven from both sides.

The systemic effects of cohesively integrated clusters have been important in the development of dynamic industrial districts. Inter-firm pecuniary relations through sales and purchases is only one channel of inter-firm interactions (Rasiah, 1995). Knowledge flows –rubbing off effects from the interaction between workers (Marshal, 1890), and the movement of tacit and experiential skills embodied in human capital - are more dynamic synergizers (Penrose, 1959). The ease of movement of tacit and experiential knowledge embodied in human capital from one firm to another, distinguishes dynamic industrial clusters from others. Saxenian (1994; 1999; 2000) documented the movement of tacit and experiential knowledge embodied in human capital, which helped support strong new firm creation capabilities in the Silicon Valley.

Porter (1990) contended that firms compete on the basis of four factors; viz., factor conditions, demand conditions of products, supporting industries and firm strategy, structure and rivalry. Network cohesion – relations between firms, government institutions and intermediary organizations – as a driver of systems efficiency was well documented from the experience of European and American industrial districts (Brusco, 1976; Wilkinson and You, 1992; Piore and Sabel, 1984; Sabel, 1995; Sengenberger and Pyke, 1988; Hirst and Zeitlin, 1991). Best (2001) went further by distinguishing systematically the key ingredients of systems integration, framing a model from the evolution of production historically, defining five critical features of
development that drive dynamic clusters. Best built a coherent theory that glued Smith’s (1776) features of differentiation and division of labor, and specialization (see also Young, 1928), open systems networks where skilled, technical and managerial human capital interact or move freely between firms (Marshall, 1890; Penrose, 1959; Saxenian, 1994; 1999; 2000), and firm-level process and product conditions that drive innovation and efficiency improvements. Innovations figure strongly as a critical driver of growth (see Schumpeter, 1934; 1941). The continuous supply of entrepreneurs for new firm creation is made possible by open firms where employees are easily transplanted to other firms.

Rasiah (2001) argued that entrepreneurs acquire and develop tacit and experiential skills from learning by performing in real business environments and in a systemic network – rather than in a vacuum or formal training institutions. Loose firm formations that encourage the entry and exit of human capital without compulsion are often critical for engendering the supply of entrepreneurs for new firm creation. New firms benefited from gaining managerial and technical personnel from older firms in the Silicon Valley irrespective of national ownership. For example, Japanese owned Sun Micro Systems reported in 1995 to have absorbed technical and managerial personnel from older firms in the Silicon Valley. The official even mentioned that the organizational framework they have introduced resembled the Silicon Valley with hardly any features of the typical Kaisha system in Japan. The open systems properties of the Silicon Valley – integrated around a myriad of developmental firms – helped condition Japanese firms’ employment practices so that typified the open systems properties of the region rather than the closed live-long employment practices of Japan. Mature firms gain new ideas and styles to ensure continuous organizational change as old employees are replaced with new ones, while new firms benefit from the entrepreneurial and technical – tacit and experiential – knowledge to ramp up and run firms instantly (Rasiah, 2001).

While the prime drivers of cluster dynamics in the successful industrial districts of Emelio Romagna and Silicon Valley are local firms, five important developments have made this approach applicable even to the MNC-driven clusters. Firstly, the strong emphasis by host governments to improve basic infrastructure and bureaucratic coordination helped resolve customs, security and labor problems (e.g. Singapore). Secondly, the growing tendency of MNCs to integrate and re-integrate production at host-sites to increase specialization, and hence

2. Best (2001) distinguished five critical features of dynamic clusters, viz., specialization and differentiation of capabilities, entrepreneurial and development firms, technological variation between firms, horizontal integration and reintegration processes and speciation capabilities.

5 Interviews in Santa Cruz (author, 1995).
6 Interviews in the Silicon Valley (author, 1995; 1999).
relocate close to supply and market chains (e.g. Ireland and Singapore). Thirdly, falling production and product cycle times has led MNCs to subcontract out dissimilar activities to effective suppliers. Fourthly, growing horizontal integration has increasingly driven synergies to several layers of firms (e.g. Israel and Singapore). Fifthly, MNCs have increasingly relied on host-site institutions to access scarce high tech human capital (e.g. software skills in India).

This discussion generated four critical dynamics for examining the production and distribution of knowledge in Malaysian electronics. First, effective systemic coordination and network cohesion is necessary to stimulate demand-supply conditions for the creation and appropriation of knowledge by humans both through formal educational institutions as well as firms. Second, regions that take advantage of tacit and experiential knowledge generated in firms benefit from the diffusion of synergies for new firm creation, differentiation and division of labor. High tech MNCs offer a new dynamics to the appropriation of tacit and experiential knowledge because of their participation in cutting edge activities. Third, high tech infrastructure is critical for substantial numbers of entrepreneurs in particular regions to participate in innovative activities such as R&D. Fourth, regions benefit from a open national framework so that human capital deficiencies can be overcome through imports as experienced by the United States, Singapore and Ireland.

Given the complex nature of the analytic framework, firm level interviews formed the prime vehicle for gathering empirical information. The empirical information is drawn from in-firm research in Monolithic Memories Incorporated (MMI)\(^7\) and Advanced Micro Devices (AMD) in 1986 and 1989-91 respectively, firm studies in 1993-95 and detailed interviews with 324 electronics, machine tool, plastic and other ancillary firms in 1999-2002. Interviews were also carried out with the training institutions, industry associations, State Economic Development Corporations (SEDCs) of Penang and Selangor and government departments in Penang and the Kelang Valley. Given the lack of information on unregistered firms, a snowballing research technique was used to trace firms – connections traced from firm-level interviews.

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\(^7\) MMI was acquired by AMD in 1987 (Rasiah, 1989).
3. EXPLICIT, TACIT AND EXPERIENTIAL KNOWLEDGE

This section examines the two channels of human capital development in the dominant electronics conurbation of Penang and Kelang Valley. The first examines the supply of basic and secondary schooling, tertiary and scientists and engineers. Since the formal institutions of learning throughout the country are governed by federal institutions situated in Kuala Lumpur, little coordination differences exist between Penang and Kelang Valley. The second refers to tacit and experiential knowledge embodied in human capital acquired from learning by performing. The differential strength of network coordination between the two clusters has produced significantly different results. Unlike Singapore, Israel and Ireland where complementary institutions of governance mediated both channels of human capital development, local state institutions in Penang lacked the authority to bypass federal institutions to coordinate educational institutions. Hence, while weak coordination characterized both channels of human capital development in the Kelang Valley, Penang faced similar coordination problems with only the first channel.

Selected features of systemic coordination differentiating Penang and Kelang Valley is shown in Box 1.

<table>
<thead>
<tr>
<th>Box 1: Selected Local Systemic Coordination Instruments, Malaysia, 2002</th>
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<tbody>
<tr>
<td><strong>STATE-LED COORDINATION</strong></td>
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<tr>
<td>Chambers of Commerce</td>
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<tr>
<td>Density of MNCs and institutions</td>
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<tr>
<td>Network cohesion</td>
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<tr>
<td>Skills development and training</td>
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<td>Matching of supplier firms with MNCs</td>
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<tr>
<td>Basic infrastructure support</td>
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<tr>
<td>Security problems</td>
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<tr>
<td>Meetings between state, MNCs and supplier firms</td>
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<tr>
<td>Formal Educational institutions</td>
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<tr>
<td>R&amp;D support institutions</td>
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<tr>
<td>Publication of documents on product and process technology of suppliers</td>
</tr>
<tr>
<td>Access to foreign High tech human capital</td>
</tr>
</tbody>
</table>

Source: Prepared by the author (2002)
3.1 Formal Institutions of Human Capital Supply

Formal education institutions in the country have been governed directly by the Federal Ministry of Education – general, vocational and technical education. Educational institutions in the Kelang Valley faced similar coordination problems (see Box 1). Little coordination efforts have taken place between schools, technical institutes and universities to orient education to meet changing structure of firms’ demand.

Both regions enjoy the most advanced basic infrastructure and educational institutions in Malaysia. Enrolment in primary schools has always been above the global mean (see Table 1). The index of primary school enrolment – measured as a relative share of the global mean (see notes below Table 1 for formula used) – remained slightly above 1 between the years 1970-95, falling slightly in 1995. Secondary school enrolment improved in the period 1970-75 to above the global mean but has subsequently fallen slightly to 0.9 (see Table 1). The slight decline was a result of improvements shown by other developing economies as primary school enrolment in Malaysia is near universal and the rates for secondary school enrolment has improved strongly. Between 1970 and 1990 when the unemployment rates fluctuated between 6.0-8.1 percent (Rasiah, 2002: Figure 6), labor reserves ensured that labor-intensive assembly MNCs continued to relocate in Malaysia. Political stability, good basic infrastructure, financial incentives and controls on unionization helped make Malaysia as one of the more attractive sites.

However, the demand structure of human capital in Malaysia’s manufacturing sector changed considerably in the 1990s following the exhaustion of labor reserves as unemployment rates fell from 6.1 percent in 1990 to 2.5 percent in 1997 (Rasiah, 2002: Figure 6). Rising wages and the emergence of low cost sites such as China, Thailand, Cambodia and Philippines with improvements to their infrastructure and political stability has severely undermined the capacity of Penang and Kelang Valley to retain such operations. With a similar primary and secondary schooling index but with a massive labor reserve China easily overtook other developing economies as the prime target for labor-intensive MNCs from the 1990s as the basic infrastructure improved and. government strategy became more focused. The Malaysian government sought a temporary alternative by seeking foreign labor imports – primarily from Indonesia and Bangladesh – which accounted for around 15-25 percent of the total national labor force in 1997.8 Foreign labor imports failed to stem the decline in FDI levels in GFCF in Malaysia, which fell from its peak of 24.8 percent in 1992 to 8.8 percent in 1999 (World Bank Institute, 2001).

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8 This figure has fallen significantly following the government’s aggressive efforts to deport illegal workers from 1998. Over 350,000 workers were deported in the period 2000-2001.
Despite the financial crisis and subsequent industry-wide downswing in the electronics industry, unemployment rates only rose to 3.1 percent in 1998 (Rasiah, 2002: Figure 6). Component firms began to experience production changes that required the utilization of high technology. However, the supply institutions failed to step up supply of engineers and technicians to match demand. Malaysia’s tertiary education enrolment was well below the global mean in the period 1975-95, though trend improvements have taken place (see Table 1). The situation became even worse as the share of science and engineering graduates in total tertiary educational enrolment fell from 41.3 percent in 1980 to 28.1 percent in 1995 (see Table 2). The government embarked on an aggressive strategy to step up the supply of vocational and technical training and graduates with the building of several schools.

Labor shortages in the 1990s also saw the government transform industrial strategy from one focused on employment generation to industrial deepening, clustering and the shift to higher value added activities. The Action Plan for Industrial Technology Development (APITD) of 1990 and the Second Industrial Master Plan (IMP2) of 1995 set the blueprints for the transformation. A series of institutions were created, which included the opening of the Human Resource Development (HRD) Council in 1993.9 The HRD fund required manufacturing firms with an employment size of 50 and more to contribute 1 percent of their payroll to the HRD council, which the firms could then reclaim with bills from approved training. The Private Universities Bill of 1995 opened the way for the introduction of private universities. To complement domestic human capabilities, the government offered exemptions for IT firms in the Multimedia Super Corridor (MSC) to import technical and professional human capital from abroad, which was launched in 1997.

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Table 1: Education Enrolment, 1970-95

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<tr>
<td>Rep Korea</td>
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<td>1.2</td>
<td>1.3</td>
<td>1.2</td>
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<tr>
<td>Singapore</td>
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<td>Hong Kong</td>
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<tr>
<td>Japan</td>
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<td>1.2</td>
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<td>na</td>
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<td>South Africa</td>
<td>0.9</td>
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<td>Na</td>
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<td>China</td>
<td>na</td>
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<td>Na</td>
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<td>Philippines</td>
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<td>Indonesia</td>
<td>na</td>
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<td>USA</td>
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<tr>
<td>Ireland</td>
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<td>1.1</td>
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<td>Thailand</td>
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<tr>
<td>Israel</td>
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<td>na</td>
<td>na</td>
</tr>
</tbody>
</table>

| **Gross Secondary** |      |      |      |      |      |      |
| Malaysia            | 1.1  | 1.2  | 0.9  | 1.0  | 1.0  | 0.9  |
| Republic of Korea   | 1.3  | 1.5  | 1.5  | 1.7  | 1.6  | 1.6  |
| Singapore           | 1.4  | 1.3  | 1.2  | 1.1  | 1.2  | 1.2  |
| Hong Kong           | 1.1  | 1.3  | 1.2  | 1.3  | 1.4  | 1.1  |
| Japan               | 2.7  | 2.4  | 1.8  | 1.7  | 1.7  | 1.6  |
| South Africa        | na   | na   | Na   | na   | 1.3  | 1.5  |
| China               | 0.8  | 1.2  | 0.9  | 0.7  | 0.8  | 1.0  |
| Philippines         | 1.4  | 1.4  | 1.2  | 1.2  | 1.3  | 1.2  |
| Indonesia           | 0.5  | 0.5  | 0.6  | 0.8  | 0.8  | 0.8  |
| USA                 | 2.6  | 2.2  | 1.8  | 1.8  | 1.6  | 1.5  |
| Ireland             | 2.3  | 2.3  | 1.7  | 1.8  | 1.7  | 1.8  |
| Thailand            | 0.5  | 0.7  | 0.6  | 0.6  | 0.5  | 0.9  |
| Israel              | 1.8  | 1.7  | 1.4  | 1.5  | 1.5  | 1.4  |

| **Gross Tertiary**  |      |      |      |      |      |      |
| Malaysia            | na   | na   | 0.3  | 0.4  | 0.4  | 0.5  |
| Republic of Korea   | 1.1  | 1.0  | 1.1  | 2.4  | 2.2  | 2.3  |
| Singapore           | 0.9  | 0.9  | 0.6  | 1.0  | 1.0  | 1.5  |
| Hong Kong           | 1.1  | 1.1  | 0.8  | Na   | na   | Na   |
| Japan               | 2.7  | 2.9  | 2.3  | 2.0  | 1.7  | Na   |
| South Africa        | 0.6  | na   | Na   | 0.7  | 0.8  | 0.8  |
| China               | na   | 0.1  | 0.1  | 0.2  | 0.2  | 0.2  |
| Philippines         | 2.6  | 1.8  | 1.8  | 1.8  | 1.6  | 1.3  |
| Indonesia           | 0.4  | 0.3  | 0.3  | Na   | 0.5  | 0.5  |
| USA                 | 7.2  | 6.0  | 4.2  | 4.3  | 4.2  | 3.6  |
| Ireland             | 1.8  | 1.8  | 1.4  | 1.6  | 1.6  | 1.8  |
| Thailand            | 0.5  | 0.4  | 1.1  | 1.3  | 0.0  | 0.9  |
| Israel              | 2.8  | 2.6  | 2.2  | 2.3  | 1.9  | 1.8  |

Note: Figures calculated using the formula \( x_i / (\sum(x_i - \bar{x})^2/n) \) where \( x_i \) refers to the % of enrolment of country \( i \) and \( n \) the number of countries reporting data.

Source: Computed from World Bank (2001)
Table 2: Tertiary Enrolment in Science and Engineering, 1970-95 (%)

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Source: Computed from World Bank (2001)

However, despite massive emphasis on the development of infrastructure, the supply of high tech human capital has remained limited. Anandakrishnan, Rasiah and Selvaratnam (1995) had projected severe widening of the demand-supply gaps as well as a structural mismatch caused by coordination problems. Rasiah and Osman (1996) also reported a serious mismatch in skills between supply and demand in the manufacturing sector. Malaysia’s relative (to the global mean) R&D scientists and engineers index of 0.1 in 1995 was extremely low (see Table 3). The weak R&D human capital endowments has severely restricted firms capacity to drive innovations, which becomes increasingly necessary as a critical mass of firms in rapidly industrializing economies reach the technology frontier. It is little wonder that few electronics firms in Malaysia – whether foreign or local – undertake R&D activities in Malaysia (see Rasiah, 1996). Ineffective coordination has also offered little incentive for thousands of Malaysian scientists and engineers qualified abroad to return. The Republic of Korea and Singapore successfully raised their R&D scientists and engineers index from 0.4 and 0.3 respectively in 1981 to 1.5 and 1.6 respectively in 1995 (see Table 3). Singapore, Ireland and Israel managed to keep strong high tech human capital endowments by both increased emphasis on higher education domestically, as well as selective immigration policies. Ireland and Singapore continue to enjoy strong FDI levels in GFCF, while the much smaller share in Israel has risen in the 1990s (see World Bank Institute, 2001). The United States has off-set its gradual decline in the relative human capital supply from domestic institutions by attracting them from abroad.
Table 3: R&D Scientists and Engineers per Million people, 1981-97

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Note: Figures calculated using the formula $x_i \left[ \sum (x_1..x_n) \right]^{-1} n$ where $x_i$ refers to R&D scientists and engineers per million people in country $i$ and $n$ the number of countries reporting data.

Source: Computed from World Bank (2001)

Hence, the formal institutions of human capital development have generally only managed to supply basic primary and secondary education, which was instrumental in attracting large scale MNC operations in export-oriented labor-intensive manufacturing activities from the early 1970s until 1992. However, when labor reserves was exhausted by the early 1990s the lack of high tech human capital restricted firms transition to higher value added activities. Despite aggressive government efforts, both Penang and the Kelang Valley failed to enjoy sufficient supplies of high tech human capital. Federal governance institutions neither produced sufficient numbers of high tech human capital nor coordinated supply and demand conditions effectively. Immigration policies also restricted electronics firms – both MNCs and local firms - from accessing high tech human capital developed from abroad to overcome the growing deficits.

3.2 Development and Transfer of Tacit and Experiential Knowledge

Political stability and excellent basic infrastructure with good bureaucratic coordination continues to retain Penang and the Kelang Valley as off shore assembly bases for MNCs. Penang’s and Kelang Valley’s production platform is superior to many competing sites, though the emergence of China, Thailand and the Philippines has eroded this strength. Hence, while a saturated labor market will discourage future waves of labor-intensive relocations, Penang and Kelang Valley are likely to retain considerable electronics manufacturing operations.

Both Penang and Kelang Valley enjoy strong MNC operations in electronics manufacturing since the early 1970s. Foreign ownership accounted for 83.0 percent of fixed assets in the
electronics industry in 1998 (Rasiah, 2002: Table 6). In addition, Penang has developed network cohesion and institutional coordination to support flexibility and technological interface between firms. However, the Kelang Valley suffers from truncated operations without much network cohesion. This difference has explains why Penang has enjoyed dynamic industrial clustering, while Kelang Valley has not, with ramifications for the development and movement of human capital for increasing differentiation and division of labor.

MNCs in Penang tend to enjoy greater linkages with local firms and better co-ordination with support institutions. MNCs and several local firms have moved to attain critical aspects of flexible and mass production capabilities. Penang’s production linkages have spread to Kedah, and Perak. Successful local firms in Penang enjoy strong linkages with MNCs in the state.

MNCs in the Klang Valley have tended to evolve truncatedly, some substituting supplier requirements with own subsidiaries (e.g. Chungwa Picture Tubes). Local firms in the Kelang Valley do not enjoy strong production links with MNCs. A number of MNCs have flexible and mass production capabilities in-house, but their systemic potential has been low because of weak network cohesion. Large local firms in Kelang Valley demonstrate mainly single-product mass production operations without significant inter-firm links.

**Penang: Strong Systemic Synergies**

The Penang government established the Penang Development Corporation (PDC) in 1969 to “undertake and promote socio-economic development of Penang” (PDC 1994: 4), which worked extensively to attract export-oriented MNCs in the manufacturing sector. MNCs helped raise Penang’s manufacturing share in GDP from 13 percent in 1971 to 46 percent in 2000 (Rasiah, 2001). Penang has developed the resemblance of an industrial cluster, but without significant participation in new product development. Strong inter-firm relations and systemic coordination effects have helped the cluster generate and appropriate considerable economic synergies. Fairly integrated business networks with PDC’s pivotal intermediary role fuelling cohesion has helped movement of tacit and experiential knowledge embodied in human capital for new firm creation, differentiation and division of labor.

**Differentiation and Division of Labor**

The Penang region has built high volume production capability in electronic components, consumer appliances, hard disk drives and PC components (DCT, 1998). Many of these parts and components are elements in global production networks coordinated from MNCs’ parent plants. Changes in the dynamics of production that was accompanied by improvements in systemic coordination stimulated the introduction of strong inter-firm links that transformed Penang as a regional supply base since the late 1980s. Complementary but dissimilar product
lines were relocated as new firm creation expanded. Entrepreneurs, and professional, technical and skilled human capital developed in MNCs moved to run many of these firms. Intel established Globetronics, Shinca, Shintel and Unico, while Motorola started BCM. Eng Technology, Metfab, Prodelcon and Choong Engineering grew strongly from technological diffusion from Intel. Wong Engineering very much grew with support from Motorola. The founder of Loshta – opened in 1978 and sold in the mid-1990s, gained his tacit and experiential knowledge working in Motorola. Polytool and Rapid Synergy absorbed considerable precision engineering technology from Intel and AMD. This has been accompanied by the emergence of a locally owned supplier base with increasing differentiation.

Increased differentiation and division of labor helped deepen and widen the movement of tacit and experiential knowledge embodied in employees. Most supplier firms in Penang have passed through the third and fourth stages of technology absorption and diffusion (Rajah 1994; 1996; 1999). In the first stage, suppliers carried out simple grinding, machining, welding and stamping operations to supply trolleys, components and parts to MNCs, using imported machinery and designs and drawings supplied by the MNCs. This stage characterized the local machine tool firms in the 1970s. In the second stage, supplier firms upgraded to assemble semi-automated machinery and precision tools using imported machinery and designs and drawings from MNCs. In the third stage, supplier firms began adapting and reverse engineering imported machinery for their own use, and high precision foreign components and machinery for sale to MNCs in Malaysia and subsidiaries abroad. In the fourth stage, suppliers developed their own original equipment manufacturing capabilities to supply MNCs in Malaysia and export using machinery manufactured in-house and imported. In the fifth stage, suppliers managed to introduce their own designs, though much of production is oriented towards subcontract demand operations.

The first-tier firms have evolved from simple backyard workshops to separate factories, to modern plants, to multi-divisional firms and some to MNCs with production operations spread to China, Philippines, Thailand and Indonesia. Eng Technology has subsidiaries in China, Philippines, Malaysia and Thailand, while Atlan has subsidiaries in Malaysia and Indonesia. The network of suppliers in Penang shows generally a vertical division of labor with firms confined to all the five stages of technology utilization. Nevertheless, a handful of firms (e.g. Eng technology, BCM, Unico and SEM) show strong potential for horizontal integration. Strong technological interface between MNCs and these suppliers have resulted in the two-way flow of information and development of dissimilar technologies in the latter.

The development of MNC-driven strong supplier networks and institutional coordination to support their growth has increased localization of inputs by MNCs. Local supporting firms in Penang sourced 46 percent of their inputs locally in 1996 (Narayanan 1997: 23). Further
differentiation by supplier firms intensified the opportunities for expanding further the development of tacit and experiential knowledge in the Penang cluster. The economic advantages of introducing flexible production systems encouraged lead suppliers to actively further differentiate and intensify the division of labor below them. Rasiah (1994) traced three tiers of suppliers in 1990, which by 2002 had spread to five tiers.10

The first-tier vendors (those who had the first links with the electronics sector firms) have, in time, chosen to specialize 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 were no longer sufficiently profitable for the former (Rasiah 1994).

Species New to the Region
Systemic coordination was also instrumental in the relocation of industrial species new to Penang. New industrial species helped sustain rapid growth and extended the platform for furthering human capital development in firms. Personal approaches by the Penang government and PDC starting in the early 1970s attracted giant electronics MNCs from the Silicon Valley and Japan. Generous financial incentives from the federal government helped offset the risks associated with initial relocation. While Penang Electronics was the first to start operations in Penang in 1970, it was started primarily for symbolic reasons. Japanese controlled Clarion was the first electronics MNC to relocate operations in Penang in 1971, followed by American controlled National Semiconductor. Among these firms were some of the world’s most entrepreneurial firms that Intel’s Grove (1996: 42) described as the ‘new horizontal computer industry.’11 Leading examples include Intel, Fairchild, Motorola, Hewlett Packard, AMD and Dell. These firms operate using quick turnaround JIT and rapid ramp up capabilities. Products are assembled, tested and shipped out, and production can be stepped up and down quickly to meet demand fluctuations.

While lacking the capacity to create new industrial species of its own, Penang’s state leaders and the PDC actively sought new species to sustain rapid growth in the region. Effective systemic coordination and network cohesion saw Penang’s government leaders acquiring the knowledge necessary to attract industrial species from locations abroad. From the late 1980s, the Penang government and PDC improved their monitoring mechanism to seek new industrial species – especially from the Silicon Valley, Japan and Taiwan. From semiconductors and components in the early 1970s, consumer electronics became important from the late 1970s, but

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10 Interviews by author (2002).
11 Also known as systems integration (see Best, 2001).
particularly since the late 1980s. Disk drive companies were actively wooed from 1989, followed by computer companies. In addition to product transitions in old subsidiaries such as Komag and Osram, the Penang government sought new opto-electronics firms from the Silicon Valley in 2000-2001.

The development of synergies from MNC operations drew the early computer and peripherals assembly firms of Dell, Maxtor, Conner Peripherals, read-rite, Komag, Quantum and Seagate to Penang. Dell reported its relocation in Penang as having been primarily driven by the need to integrate around its product chain as well as strategically customize product development for the Asia Pacific market. The movement of computer assemblers to Penang attracted disk drive makers such as Seagate, Quantum and Komag, and other peripheral contract manufacturers such as Solectron. Intel, AMD, Motorola and Fairchild increasingly subcontracted out a number of their production lines to contract manufacturers such as Solectron, Globetronics, Unisem and Carsem in Malaysia. The early developments involving precision engineering and machining and later to disk drives and computers are examples of new sub-sectors attracted to the region, which has expanded network synergies. From semiconductors in the early 1970s, the sub-industries added from abroad include telecommunication component and equipment, audio, video equipment from the mid and late 1970s, integration of semiconductor testing from late 1970s and early 1980s, and disk drives and computer assemblies from the early 1990s. Opto-electronics is looking to become Penang’s latest sub-specie.

Hence, while the Silicon Valley has managed to create species of industries that are new to the universe, Penang has successfully drawn species of industries from other locations. Speciating capabilities have helped the region sustain growth, and offer the building blocks for accelerating inter-firm links. This “invitation” strategy has worked well for Penang as the demands for science and engineering capital have not been high for assembly, test and redesigning activities.

Sub-species of industries – not new to the universe – have also evolved domestically to stimulate differentiation and diversity in Penang. Machine tool and plastic molding species evolved from technological constraints emerging in the production dynamics of MNCs operating in Penang. The development of several tiers of firms in these industries has enabled the workforce to expand further knowledge development and movement in the Penang cluster.

However, the lack of high tech human capital has restricted Penang’s capacity to attract high value added activities. For Penang to sustain this strategy, a pro-active strategy to develop high

12 Osram was renamed from Siemens Litronix.
13 Author’s (2001) interview with Penang’s Chief Minister.
14 Read-rite, Conner Peripherals and Maxtor have since sold their operations.
15 Interviews by author (2001).
tech human capital with complementing imports from abroad is necessary. China has already emerged as the biggest single threat to labor-intensive industries in Penang. In fact, four MNCs reported shifting operations from Penang to China in 2001.16

Training Ground
Industrial expansion and upgrading in MNCs has stimulated greater widening and deepening of tacit and experiential knowledge embodied in human capital in Penang. Intel’s progressive moves from assembly to continuous improvement capabilities made it possible for its parent plant to transfer technology to Penang, which helped the local plant to move to more complex higher value-added activities (Rasiah, 1987; Lim 1991). The dynamics of flexibility in process technology in Penang’s Intel operation has been managed completely by Malaysians from 1980. JIT and the shift towards flexible production systems took place from late 1984 (Rasiah 1987). It is this flexibility that enabled semiconductor firms in Penang to avoid massive capacity restructuring whenever a downswing struck. New firm creation has helped MNCs to function as flexible market-driven assembly and test lines with primarily process engineering to enable organizational efficiency improvements. Redesigning activities in MNCs in Penang are confined to adapting older technologies. AMD and Hitachi are also engaged in these activities. Penang does not have a critical mass of high tech human capital and R&D labs to support rapid product innovation, and institutional support to outsource these activities.

Motorola Penang was completely run by Malaysians from the late 1980s. Motorola’s R&D center, which started with four engineers in the 1980s, had nearly 120 in 1998 (Ngoh, 1994). Motorola Penang enjoys design leadership in Asia for the CT2 cordless telephone. The Center does new product design, product-process interface and advanced manufacturing processes (Rasiah 1996). However, Penang’s short supply of R&D scientists and engineers made similar expansion by other MNCs difficult.

Dell targeted Penang as its Asian headquarters, where it has developed a mass customization system. Dell is attempting to reproduce in Penang its “produce to order” model that combines the Toyota production system (cellular manufacturing, JIT, Kanban, quick changeover, continuous improvement, self-directed work teams) with internet to integrate production and distribution into a single high-throughput process. Dell’s factory is being geared to respond directly to the final customer so that all intermediary distribution links are eliminated. Its Managing Director reported that Penang stood out not only because of the smooth coordinating approach of the state government and PDC, but also because of its cultural mix that offered regional customization potential for much of Asia (Rasiah 1995). Dell’s unique fusion of design, process flow and final demand facilitated by the internet has offered production and

16 Interviews by the author (2001).
marketing flexibility. However, Dell does not yet have the high tech human capital to drive rapid product innovation and systems integration capabilities in Penang. These limitations may constrain its efforts to achieve integrated manufacturing operations linking customers to production.

Fairchild’s subsidiaries in Penang, Dynacraft and Micro Components Technology, trained many of the region’s engineers in precision engineering and metal working who now run successful local firms, including Prodelcon, Metfab and Rapid Synergy. The founders of these three firms also acquired their tacit and experiential knowledge from working in Micro Machining, which was a subsidiary of National Semiconductor until 1989. Motorola encouraged its managers to join BCM during its initial development stage.

R&D facilities were introduced in a handful of MNCs from the late 1980s to support process technology development and redesigning of old product technologies. Intel, Motorola, AMD, Hewlett Packard and Hitachi introduced specifically defined R&D activities in Penang whose prime focus did not include new product development. From the early 1990s, electronics MNCs began expanding R&D activities to some aspects of product design. Intel, AMD, Hitachi introduced re-engineering activities to widen the use of maturing products. Participation in R&D activities – albeit narrowly – that offered human capital development opportunities for raising tacit and experiential knowledge in Penang. Motorola’s designing center developed the CT cordless phone in Penang.

Malaysian employees subjected to learning by doing in dynamic MNCs have gained critical tacit and experiential knowledge – professional, technical and skilled personnel and entrepreneurs - for new firm creation. A number of electronics MNCs have played a major role as training grounds for the hiring and nurturing of entrepreneurs who have stepped up the creation of new firms in Penang. The development of entrepreneurial skills in MNCs has created a large pool of potentially successful managers who could easily start new firms to stimulate further differentiation and horizontal integration in Penang. Globetronics, Shinca, Sanmatech, Unico, Prodelcon, Metfab and Rapid Synergy were started by local entrepreneurs who gained their experience working in MNCs in Penang. MNCs that relocated in Penang in the 1990s – e.g. Komag, Quantum and Solectron - also benefited from absorbing managers from developmental MNCs in Penang. Human capital deepening in local divisions of MNCs fostering technology transfer, particularly via skilled personnel moving to local firms has been documented extensively (Rasiah 1995: chs. 6-7).

Intel, AMD, Fairchild (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 (Rasiah 1998: 10).

The increase in the creation of entrepreneurs, managers, technicians and skilled human capital has helped MNCs upgrade their own operations. The increased movement of human capital between firms has stimulated greater outsourcing of dissimilar activities while allowing MNCs to upgrade and specialize in higher value added operations.

Transfer of Embodied Knowledge
Loose firm formations have exploited the open systems and integrated business network of Penang to encourage the exit of entrepreneurial, technical and skilled human capital with tacit and experiential knowledge to start and support new firms. The spread of MNC-driven synergies could not have reached high levels without the active intermediary role of PDC and the Penang government. The PDC also actively participated – directly and indirectly – to match potentially capable local firms with the developmental firms. Also collective action problems such as scale and scope involving training were resolved by PDC, which translated MNC demand into the formation of the Penang Skills development Center (PSDC) in 1989 and in the 1990s the Penang Design Center. The PDC initiated the opening of the PSDEC by offering a highly subsidized building – charging a symbolic rent of RM1 a year instead of the market rate estimated at RM1 million a year.17 The PDC and Penang government also actively promoted the growth of local innovation. Trans Capital, UNICO and Globetronics are examples that have benefited from such thrusts. Its critical role was also instrumental in attracting capitalization of Globetronics from Malaysian Technology Development Corporation (MTDC).

The founding of Trans Capital, UNICO and Globetronics in the 1990s added a new dimension to Penang, which helped raise local demand for skills for “front-end” operations like chip design, systems integration, and applications engineering in Penang. In addition to offering demand for the absorption of R&D personnel from MNCs, these firms helped widen knowledge accumulation in local firms, though the lack of R&D scientists and engineers in the country has limited the scale of expansion.

Entrepreneurial and developmental firms strive to raise the skill levels of their employees to be state of the art – using a long term vision of human resource development. Employees acquiring knowledge and skills by doing in firms work at the frontier of skill levels. The importance of local skill development cannot be over emphasized. Company CEOs in electronics MNCs insist that the application of Total Quality Management (TQM) requires that they continuously strive to improve operations at all levels. While PDC and the Penang
government have recognized the size of this problem and thus have been trying to diversify their training activities, interviews show growing shortfalls in the supply of R&D scientists and engineers to broaden designing activities in Penang. Managing Directors of Intel, AMD and Motorola reported looking out for such Malaysian expertise in universities both locally and abroad.

The open integrated business networks in Penang has stimulated the movement of human capital embodied with tacit and experiential knowledge from older firms for new firm creation. A major vehicle for the absorption of entrepreneurs, technical and skilled human capital has been through dissimilar product lines created in the production dynamics of developmental firms. Intel, Micro Machining (renamed as Micro Components Technology and sold in 1989 to Towam) and Motorola have been important training grounds for the creation of new entrepreneurs in Penang. Human capital with tacit and experiential knowledge acquired in MNCs has been critical in driving linkages and the transfer of knowledge in local firms. The continuous movement of personnel trained in the developmental firms has boosted the pool of entrepreneurs, technicians and skilled machinists to open new firms. The increasing outsourcing of dissimilar products and technology transfer has also expanded demand for local suppliers in Penang, such that the number of ancillary firms linked to electronics MNCs and their suppliers expanded around three-fold in the period 1989-93, and 1993-98. Estimates from industry association officials show that it expanded from around 45 firms in 1989 to around 155 firms in 1993 and 455 in 2001.18

In addition, rapid process and product upgrades achieved by local suppliers such as Trans Capital, LKT and Eng Teknologi – through constant in-house process engineering improvements and smooth technology interfacing with MNCs - have also offered MNCs in Penang world class supplies. Especially disk drive and computer assembly firms in Penang have developed a strong supplier base that is driven by experienced entrepreneurs, technicians and skilled personnel. Hence, there are not only a larger number of local suppliers linked to electronics MNCs in Penang (see Table 4 for 1993 figures), they have also developed stronger technological capabilities than suppliers in the Kelang Valley (see Table 5 for 1993 figures). However, entrepreneurs in Penang are hardly involved in new product development, and the lack of a critical mass of high tech human capital has restricted its capacity to reach the technological dynamism achieved by the Silicon Valley. Supporting firms in Penang have to move towards greater R&D activities so that they participate equally with MNCs in the development of new products. The transition to new product development and systems integration activities will enable supplier firms to appropriate market opportunities better.

Strong inter-firm and institutional network cohesion will also offer the high tech support firms need for continuous integration and re-integration. Penang’s deficiency in the supply of high tech human capital must be overcome – through expansion in high tech education and imports – to stimulate new product development.

Open system firms have played a developmental role in Penang as employees gaining tacit and experiential skills made their way to start new or join other firms. The increased supply of such human capital has enhanced the skill and entrepreneurial base of the northern region. Technical and managerial human capital has moved extensively from these firms to start new firms. Former employees of Intel managed Shinca, Shintel, Sanmatech, Unico, Globetronics and Solectron in 1999. Former employees of Micro Machining (then a subsidiary of National Semiconductor which subsequently acquired Fairchild) started the local firms of Prodelcon, Polytool, Rapid Synergy and Metfab.

The increased differentiation and division of labor helped raise slightly local sourcing by Penang’s electronics industry from RM1.6 billion in 1996 to RM1.9 billion in 1997. The average per-firm local sourcing figures show a slight rise from RM56.1 million in 1995 to RM57.9 million in 1997. The breakdown using 10 major companies in the respective categories for local sourcing of total purchases in 1998 were 40-50 percent for consumer electronics, 4-10 percent for semiconductor components, 20-40 percent for other electronics components and communication equipment and 13-60 percent for computers and peripherals in 1998. The significance of production links in the Penang network is demonstrated more by the expansion of local suppliers rather than their supplies to MNCs. Value added recorded by Penang’s electronics’ ancillary firms rose from RM257.6 million in 1990 to RM736.2 million in 1996. Penang’s machine tool supplier firms also show significantly higher technological deepening – using both human capital, process technology and precision machinery indexes as proxies – than Kelang Valley firms (see Tables 4 and 5).

The limited experience involving R&D in MNCs has also produced movement of staff between firms. Two of Motorola’s staff joined the R&D division of Sapura, which is a local firm located in Ulu Kelang in the late 1980s. Two of Intel’s R&D personnel left for AMD’s NVD design center, which is an American MNC located in Penang, in the mid-1990s. However, restrictions on the import of high tech human capital in Penang has stifled MNCs capacity to upgrade further. Intel, Motorola, AMD, HP and Fairchild, and the supplier firms of Eng Technology,

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19 Based on 32 electronics companies that responded to the PDC Industrial Surveys for three consecutive years.
20 Derived from PDC surveys.
Trans Capital and Unico reported trying in vain to bring foreign experts to facilitate stronger participation in R&D activities.\textsuperscript{21}

Increased differentiation and division of labor has encouraged inter-firm movement of tacit and experiential knowledge embodied in human capital in Penang. However, the lack of human capital supply and R&D capabilities in the face of rising production costs and competition from cheap cost sites such as China and Philippines is threatening to stall further differentiation and division of labor. The lack of new product development and systems integration capabilities has impeded the evolution of high value added activities such as software development, TFT screens and high precision machinery – all of which are sourced by MNCs from abroad. Examples of such components include fabricated wafers, TFT-LCD, STN-TFT, aluminum and lead frames. Silterra – located in Kulim – might generate some local supplies of fabricated wafers, though MNCs are likely to import most of their demand from abroad.

\textit{Klang Valley: Uncoordinated and Porous}

Klang Valley was better endowed than Penang when the first major influx of electronics MNCs relocated in Malaysia in the early 1970s. Matsushita – Malaysia’s first electric and electronics firm – relocated operations in the Klang Valley in 1965. With Kuala Lumpur being the administrative capital until 1998, the promotional agency of MIDA, and federal support was strongest in the Klang Valley. While Malaysia’s capital changed to Putra Jaya in 1998, Kuala Lumpur has remained the commercial hub of the country. Negeri Sembilan and Melaka benefited from the spillover effects from expansion in Klang Valley. Hence, the Klang Valley has achieved rapid industrialization. The concentration of electronics firms and institutions in the region offered considerable room for the development of entrepreneurs, and professional, technical and skilled human capital from new firm creation.

The Klang Valley has built high volume production capabilities in consumer electronics (e.g. television sets, video and audio equipment), semiconductors and and picture tubes. However, many of these parts and components have remained as elements in global production networks, which are coordinated from parent MNC plants.

The Klang Valley lacks network cohesion and hence has developed much less knowledge spillovers to stimulate inter-firm links and new firm creation. While different sub-species exist, the region lacks well-connected species of firms for the whole to exceed the sum of the parts. Hence, while the latent potential for in-firm development of tacit and experiential knowledge is strong, the lack of network cohesion has restricted deepening, appropriation and inter-firm flow in the Klang Valley. The lack of network cohesion to stimulate movement of tacit and

\textsuperscript{21} Interviews by author (2002).
experiential knowledge embodied in entrepreneurs and professional, technical and skilled personnel has restricted new firm creation capabilities in the Kelang Valley.

Differentiation and Division of Labor
Despite enjoying a concentration of manufacturing firms, the Kelang Valley lacks strong inter-firm links. Electronics MNCs have supplanted local supply requirements by either importing or sourcing from their own subsidiaries in Malaysia. For example, Taiwanese owned Chunghwa Picture Tubes has a range of suppliers of its own in Shah Alam. A number of high value added components such as LCD displays and TFT screens are imported from their subsidiaries or suppliers located in home-sites. Local firms such as Sapura and OYL electronics have not been able to penetrate intermediate MNC markets in the Klang Valley. Japanese, Taiwanese and South Korean firms generally supply the critical components sourced domestically to their mother firms.

A number of Japanese and Taiwanese firms act as anchors, which has helped create supplier links. In the Klang Valley, 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. Examples of local-entrepreneur-led anchors in the Klang Valley include Sapura, OYL, M-SMM Electronics and Jasa Kita. Local firms – started largely with federal government support - usually license their technology from the market. The anchors offer markets and technological support for foreign and local firms. However, interviews show that most local suppliers – producing air-conditioner, television, video and refrigerator component - are limited to low value-added non-core activities. Key technologies such as LCD are 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. Local firms such as OYL and Sapura are exceptions in that they have R&D operations, but they have yet to launch new products. Firms such as MEC have also entered production by building their knowledge of the domestic consumer market. These firms show little production linkages in the domestic economy. The inter-firm production division of labor is either non-existent or generally limited to one supplier firm.

The low level of inter-firm division of labor has reduced the flow of knowledge between firms. A limited number of local suppliers in the same region supply MNCs, but are all confined to non-core components. The lack of differentiation has constrained supply networks to first-tier suppliers with no further layers below them. Procurement officers in four Japanese firms involved in the assembly of videos, CTVs and car air-conditioners in Bangi reported sourcing
core components from Japanese suppliers, including from own subsidiaries in Malaysia. Capannelli (1999: 213) reported 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.

Capannelli (1999: 233) also showed that only about a fourth of Japanese consumer electronics firms’ in Kuala Lumpur sourced from Malaysian firms. Suppliers operating from Southeast Asia – primarily Japanese owned - accounted for 60 percent of the supplies.

Four other studies also reported weak production linkages between MNCs and local firms in the Klang Valley (Rasiah 1996, 1999; 2002; Narayanan, 1997). Supplier firms in these areas have hardly passed the first stage of technology transfer (adoption). Hence, human capital in supplier firms in the Kelang Valley has not been exposed to strong tacit and experiential knowledge beyond the second stage of absorption. Instead of local firms creating synergies from an extensive division of labor as in Penang, MNCs source minimally and directly from first-tier suppliers.

American and European firms source far less locally in the Klang Valley than in Penang. Motorola, Texas Instruments, Western Digital and Intersil reported sourcing between 2-20 percent of their purchases locally. Swedish owned Ericsson reported sourcing around 45 percent of its purchases from domestic firms, primarily from other foreign MNCs. Japanese, Taiwanese and South Korean firms source most of their supplies from firms of their own nationalities – a consequence of poor network cohesion rather than national idiosyncracies. Given the weak technological capabilities of local suppliers, American and European firms either source directly from the foreign East Asian and Singaporean firms or import. Motorola in Sungai Way and Intersil in Ulu Klang reported sourcing higher value added supplies from local firms located in Penang (Rasiah 1996). Texas Instruments reported accessing machinery supplies from its subsidiary in Singapore.

A study of linkages between four MNCs and four local suppliers in the Klang Valley found that the latter has evolved little over the years (Rasiah 2002). Only one of the four local suppliers had gained tacit and experiential knowledge from working as an employee of MNCs in the Kelang Valley. Interviews in 1999 showed that:

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22 Interviews by the author (2002).
The first-tier local vendors (those who had the first links with the electronics sector firms) still perform low-end activities outsourced by MNCs. Few second tier firms exist. When they do exist, the first-tier firms are either owned by Japanese firms, or both the first and second tiers are owned by Taiwanese, Singaporean and South Korean firms. Hence the division of labor between firms is very low, while within firms high.\(^{23}\)

Not only are there fewer suppliers linked to MNCs (see Table 1 for 1993 figures), firms have not developed strong technological capabilities (see Tables 4 and 5 for 1993 figures). 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) instituted in the late 1980s. Each MNC has attempted to use three to four suppliers for low-end inputs, including plastic injection molding. However, local firms enjoying supply relationships with MNCs do not have a division of labor vertically below them. MNCs reported that local firms were undermining their competitiveness because of costly and poor quality supplies. Suppliers reported obtaining low margins due to competition created between them by the MNC clients. Such cut-throat business strategies have undermined further network cohesion.

Interviews with 16 firms in 1999 suggest that component firms source between 2-10 percent of inputs locally in the Kelang Valley.\(^{24}\) The commensurate figures for consumer and computer peripherals firms ranged between 40-60 percent and 20-70 percent respectively. These figures included inputs from foreign suppliers operating in Malaysia.

In the absence of a coordinating body to stimulate information flow, connectivity and identification of latent capabilities, MNCs in the Kelang Valley have operated essentially truncatedly with little linkages domestically. As senior officer of Motorola put it:

> The risk of failure is just too high. Private firms generally do not individually search and canvas for greater inter-firm collaboration and sourcing when known suppliers do not exist. It was possible in Penang because of the dynamic role of PDC, which created deliberation councils and took on a proactive role of promoting and matching firms. We will be glad to assist if some reliable organization assumes such a role here. We are aware of these developments from the operations of our telecommunications components and products subsidiary in Penang.\(^{25}\)

\(^{23}\) Interviews conducted by author (1999; 2001).

\(^{24}\) Interviews conducted by author (1999; 2001) and Chang, Colin (1999).

\(^{25}\) Interview by author (1999; 2001).
Hence, while MNC operations increasingly encourage outsourcing, the lack of systemic coordination in Kelang Valley has restricted network synergies. MNCs generally source from abroad or internalize production of dissimilar activities, which explains why the intra-firm division of labor in the Kelang Valley has been high, while that between firms low. Most supplier firms in the Kelang Valley show no backward production linkages. The lack of connectivity and network cohesion has reduced the movement of tacit and experiential knowledge embodied in human capital to engender new firm creation, differentiation and specialization.

Uncoordinated Species
The Kelang Valley enjoys a range of sub-species of electronics industries transplanted from abroad. Unlike Penang, the closed and generally opaque business networks have restricted the capacity of developmental firms to generate spillovers of dissimilar activities to other firms. Dissimilar complementary products are either imported or produced in-house. The Kelang Valley lacks the capacity for engendering techno-diversity to strengthen cluster dynamics and new firm creation. Hence, the Kelang Valley has not developed speciation capabilities at all – including agglomerations of sub-species of industries not new to the universe.

While considerable technological and product diversity has emerged in the Kelang Valley, most firms do not show strong levels of connectivity between each other. The disconnected operations of firms and a lack of techno-diversity have seriously impeded the creation and appropriation of cluster synergies. The bigger and more successful local firms tend to operate without production links with MNCs. Hence market opportunities arising from technological constraints generated from the continuous reconstitution of production in MNCs have not been appropriated in the Kelang Valley. Where such MNC-local firms links exist they are generally confined to technology tie-ups as between Sapura and Nokia and OYL and York. The emergence of Sapura and OYL Electronics benefited little from sourcing links with MNCs in the Klang Valley, though MNC-trained local personnel have been instrumental in their growth. Sapura and OYL have R&D capabilities and export extensively telecommunication products and air-conditioners respectively.

The lack of systemic coordination in industrial promotion has meant that new species of firms are not attracted systematically to further clustering. The Kelang Valley either lacks a critical mass of firms (e.g. disk drives) or where sufficient numbers exist they are not connected to generate systemic synergies. The lack of a systematic relocation of foreign industrial species and the weak development of industrial species locally has reduced the Kelang Valley to a porous conurbation.
Training Ground

MNCs have developed world class in-house manufacturing capabilities in the Kelang Valley that use mass production capabilities including JIT, MRP2 and TQM systems. These production practices enable participation in world-class performance standards in cost, quality, and time, though rising costs has made China, Thailand and Philippines more attractive from the mid-1990s. The shortage of scientists and engineers in Malaysia and restrictive immigration policies – with the exception of the MSC region where IT firms enjoy a waiver to import high tech human capital from abroad – has undermined the capacity of the region to make the transition to higher value added activities.

The in-house skill formation process is considerable in the Kelang Valley. Many of the large American and Japanese companies invest sizeable amounts, individually and collectively, in shop-floor skills. However, the region lacks systemic coordination and network cohesion, which has restricted the outflow of entrepreneurs from MNCs to new firms. The potential created can be utilized effectively if the right policy is adopted. The lack of employee outflow to other firms, especially to start new ones irrespective of the ownership background of the MNCs suggest that systemic conditions regionally are important in explaining inter-firm movement of managerial and technical personnel.

MNCs in the Klang Valley have concentrated their innovative activities more on process developments, but still face considerable problems. While human capital in these firms has acquired considerable tacit and experiential knowledge, the lack of strong network cohesion has restricted symmetric interface between firms, including restricting MNCs’ capacity to upgrade operations through continuous process engineering improvements.

Some aspects of R&D have emerged in MNCs located in the Kelang Valley, confined to adaptations and minor extensions. Examples include the development of split-level air-conditioners by Matsushita air-conditioners in Shah Alam. The latter emerged from a R&D department that focuses on product adaptation and development. Matsushita operates using a flexible production model, approximating the Toyota multi-flow system. Matsushita’s marketing division is developed to handle customization. However, weak network cohesion has limited the room for personnel exposed to adaptation to carry their tacit and experiential knowledge to new firms. The Malaysian executive director of the firm reported that their product enhancement activities would be strongly magnified if more qualified R&D personnel were available in the country. Serious shortfalls in the supply of technical and R&D personnel was reported as a major constraint in MNCs’ efforts to expand innovative activities in the Kelang Valley.

26 Interviews by author (1999; 2001)
Companies such as Texas Instruments, Intersil, Matsushita, Sony and Toshiba have not attracted or developed world-class first-tier suppliers including contract manufacturers, owing to a lack of systemic coordination and network cohesion. Most MNCs use JIT and MRP2, but continue to retain in-house a number of even dissimilar activities such as machine tool support. Where specialized 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, and dissimilar product segments such as machine tools and plastics engineering has also restricted the spread of experiential knowledge another key segment of the electronics product chain.

Eight MNCs interviewed in the Klang Valley, Negeri Sembilan and Melaka contended that their operations will be enhanced if local suppliers develop to substitute imports. As Roger Bertelson 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. We don’t see any other institutions even approaching us to stimulate local sourcing. (Rasiah 1999: 14).

The lack of systemic coordination has reduced the capacity of Kelang Valley to raise the network cohesion necessary to stimulate differentiation and division of labor. Driven by similar capabilities and market structures as with the semiconductor and consumer electronics MNCs in Penang, MNCs in the Klang Valley reported having interest in assisting the development of local suppliers if the requisite coordinating framework is put in place.

The success of PSDC in Penang led to the modeling of the Selangor Human Resource Development Center (SHRDC) in the Kelang Valley. However, the SHRDC lacks coordination dynamism from intermediary organizations. There is also a lack of institutional coordination and cooperation to strengthen relationships between firms. Apart from uncoordinated assistance from intra-national organizations such as American Business Council, JACTIM, JETRO and German Malaysian Institute (GMI), the extent of inter-firm coordination in the development and distribution of human capital is limited. The participation of MNCs in deliberation councils has also be passive. Similarly, electronics firms enjoy little collaborative links on training and R&D with universities in the region. Yet, the Kelang Valley has more than eight public and private universities in 2000. The lack of systemic coordination has also left serious problems

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27 Interviews by the author (2002).
associated with scale, scope and learning externalities such as training and R&D unresolved. Hence, MNCs and local firms face considerable collective action problems from the lack of institutions to service continuous market development and technical training.

Transfer of Embodied Knowledge
Open systems MNCs such as Motorola have their biggest Malaysian operations in Petaling Jaya, but the synergies generated in the Kelang Valley has not been appropriated effectively to support new firm creation on a large scale. Support organizations such the SEDC have hardly played intermediary roles to gather and disseminate information, coordinate the matching of firms and appraise economic performance in such detailed areas as technology and skills development, R&D, linkages and clustering.28

While a number of developmental firms in the Klang Valley have incorporated incremental engineering capabilities in-house, weak supplier support and the lack of firm-specific skills development and technical professionals has restricted headquarters ability to transfer sophisticated technologies to the central states. Where such transfers have occurred, it is confined largely to in-house developments as with Matsushita Air-conditioners. Nevertheless, the emphasis on redesigning older technologies in Klang Valley firms does demonstrate the potential for higher human capital synergies.29 The lack of systemic relations between firms and support institutions and the community has restricted the movement of entrepreneurs, professionals, technicians and skilled personnel developed in MNCs to start new firms in the region. Eight managers reported interest in starting their own firms after detecting considerable market potential for specialized capabilities, but have stuck with their MNCs owing to a lack of institutional support.30

MNCs in the Kelang Valley offer state-of-the-art manufacturing and rapid ramp-up to high performance capabilities, though confined largely to mass assembly and test and partially developed flexible production capabilities. However, the lack of network cohesion has restricted the movement of professional, technical and skilled personnel to start new firms. Also, Klang Valley firms do not offer strong market-led or design-led start up opportunities. Also, the pool of managers, professionals, technicians and skilled personnel from the Kelang Valley have generally either remained in old firms or left to join newly relocating MNCs.

The lower level of inter-firm human capital movement in the Klang Valley is also the result of a much lower proportion of outsourcing by local firms. No MNC in the Klang Valley reported developing local firms, stating that state institutions have not stimulated such activities. The

28 Interviews by author in 1990 and 1999.
29 Interviews by author (1999; 2002).
limited supplier capabilities developed has restricted MNC purchases domestically to less than 13 percent (Narayanan 1997: 23).

The scale of transfer of entrepreneurs, professionals, technicians and skilled personnel to local firms from MNCs has been limited. The limited reported cases of transfers have involved movement of personnel to new MNC start-ups or local firms.

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.31

Also, the extent of inter-firm training relationships involving MNC assistance to local firms has been limited. Much of it comes through the support of business councils representing the different foreign nationalities. Examples include JETRO and JACTIM and American Business Council. Because much of the drive has revolved around effective business-government relations to safeguard their own firms’ activities, little efforts have gone beyond national interests. The Japanese, German and French have promoted their own training centers in the Klang Valley, which lack cross-national coordination and consequently generate little spillovers to the local economy. Japanese cooperation has included training of tool and die makers, and the Germans on precision engineering. Japanese participation in the training of supplier firms involved in molds, tools, dies, jigs and fixtures in the Klang Valley have been important. However, much of the support has involved low-end supplier activities. Although the MSC offers easy access to hiring foreign high tech human capital, the MNCs involved in this study are not classified as IT-based and those that are IT-based reported being unsure about the future of their participation in Malaysia.32 Motorola, Intersil, Matsushita, Sony and Texas Instruments reported restrictions in their capacity to hire foreign high tech human capital.

In short, despite the long history and presence of a critical mass of electronics MNCs, the Klang Valley has lacked systemic coordination and network cohesion necessary to stimulate and appropriate tacit and experiential knowledge effectively. Klang Valley has particularly lacked the development of entrepreneurs for new firm creation. While a myriad of industries exist, four fundamental problems have undermined the region’s capacity to engender techno-diversity to strengthen cluster dynamics and new firm creation. First, low levels of connectivity and inter-firm links has reduced the capacity of the region to stimulate the movement of entrepreneurs, professionals, technicians and skilled personnel to support new firm creation. Second, the lack of a coherent institutional strategy to attract a critical mass of new species of firms to appropriate systemic synergies as well as to stimulate sub-specie creation that are new

31 Interviews by author (1999, 2001-02).
to the region (e.g. machine tools and plastics) has reduced the room for differentiation and
division of labor. Third, the lack of differentiation and division of labor has constrained the
capacity of the region to generate tacit and experiential knowledge embodied in human capital.
Fourth, the lack of systemic coordination has constrained the ability of firms to resolve
collective action problems associated with human capital development.

32 Interview with an NTT official.
Table 4: Local Machine Tool Firms, 1993

<table>
<thead>
<tr>
<th>Firm</th>
<th>State</th>
<th>Year Began</th>
<th>Process techniques</th>
<th>Emp</th>
<th>Sales RM mn</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>BA</td>
<td>Penang</td>
<td>1979</td>
<td>TMS, JIT, QCC</td>
<td>45</td>
<td>2.5</td>
<td>Precision components</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>TMS, JIT, TQM, QCC, SPC</td>
<td>22</td>
<td>1.4</td>
<td>Precision parts, automated machines</td>
</tr>
<tr>
<td>BB</td>
<td>Penang</td>
<td>1983</td>
<td>TMS, Codified</td>
<td>15</td>
<td>0.3</td>
<td>Precision fabrication</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>instructions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BC</td>
<td>Penang</td>
<td>1988</td>
<td>QCC, SPC</td>
<td>34</td>
<td>1.5</td>
<td>Precision parts, automated machinery</td>
</tr>
<tr>
<td>BD</td>
<td>Penang</td>
<td>1991</td>
<td>TMS, Codified</td>
<td>17</td>
<td>0.3</td>
<td>Precision parts</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>instructions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BF</td>
<td>Penang</td>
<td>1976</td>
<td>JIT, TQM, TMS, TMS</td>
<td>200</td>
<td>20.0</td>
<td>Precision components, automated machines</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>QCC, SPC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BG</td>
<td>Penang</td>
<td>1978</td>
<td>JIT, SPC, QCC</td>
<td>85</td>
<td>10.0</td>
<td>Precision components</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BH</td>
<td>Penang</td>
<td>1984</td>
<td>JIT, TPM, QCC, TMS</td>
<td>68</td>
<td>15.0</td>
<td>Precision parts, automated machinery</td>
</tr>
<tr>
<td>BI</td>
<td>Penang</td>
<td>1980</td>
<td>JIT, TPM, QCC, TMS</td>
<td>40</td>
<td>2.5</td>
<td>Precision parts</td>
</tr>
<tr>
<td>BJ</td>
<td>Penang</td>
<td>1984</td>
<td>JIT, TPM, QCC, TMS</td>
<td>40</td>
<td>2.5</td>
<td>Precision parts</td>
</tr>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BK</td>
<td>Penang</td>
<td>1950</td>
<td>JIT, TQM, TPM, QCC, SPC</td>
<td>120</td>
<td>10.0</td>
<td>Precision parts, automated machines</td>
</tr>
<tr>
<td>BL</td>
<td>Penang</td>
<td>1980</td>
<td>JIT, TQM, TPM, QCC, SPC</td>
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<td>Automated machines</td>
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<td>1982</td>
<td>JIT, TQM, TPM, QCC, SPC</td>
<td>128</td>
<td>12.0</td>
<td>Parts fabrication, jigs, fixtures, moulds, dies</td>
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<td></td>
<td>Kelang</td>
<td>1988</td>
<td>JIT, TQM, TPM, QCC, SPC</td>
<td>18</td>
<td>0.15</td>
<td>Jigs, fixtures, moulds, dies</td>
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<td>BN</td>
<td>Kelang</td>
<td>1988</td>
<td>Codified instructions</td>
<td>14</td>
<td>0.36</td>
<td>Jigs, fixtures, moulds, dies</td>
</tr>
<tr>
<td>BO</td>
<td>Kelang</td>
<td>1984</td>
<td>Codified instructions</td>
<td>32</td>
<td>0.56</td>
<td>Parts fabrication, moulds, dies</td>
</tr>
<tr>
<td>BP</td>
<td>Kelang</td>
<td>1975</td>
<td>TQM, QCC</td>
<td>69</td>
<td>2.5</td>
<td>Parts fabrication, jigs, fixtures, moulds, dies</td>
</tr>
</tbody>
</table>

Source: Adapted from Rasiah (2002: Table IV).
Table 5: Technology Indicators, Local Machine Tool Firms, 1993

<table>
<thead>
<tr>
<th>Firm</th>
<th>Technology index.</th>
<th>Precision tolerance level (±“)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Engineer</td>
<td>Techno-</td>
</tr>
<tr>
<td></td>
<td>machinist</td>
<td>production</td>
</tr>
<tr>
<td>BA</td>
<td>0.0</td>
<td>26.7</td>
</tr>
<tr>
<td>BB</td>
<td>0.0</td>
<td>68.2</td>
</tr>
<tr>
<td>BC</td>
<td>0.0</td>
<td>40.0</td>
</tr>
<tr>
<td>BD</td>
<td>0.0</td>
<td>60.0</td>
</tr>
<tr>
<td>BE</td>
<td>0.0</td>
<td>45.2</td>
</tr>
<tr>
<td>BF</td>
<td>2.0</td>
<td>47.0</td>
</tr>
<tr>
<td>BG</td>
<td>0.0</td>
<td>40.9</td>
</tr>
<tr>
<td>BH</td>
<td>0.0</td>
<td>42.4</td>
</tr>
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<td>BI</td>
<td>1.5</td>
<td>44.1</td>
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<tr>
<td>BJ</td>
<td>2.5</td>
<td>50.0</td>
</tr>
<tr>
<td>BK</td>
<td>1.7</td>
<td>41.7</td>
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<tr>
<td>BL</td>
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<td>52.5</td>
</tr>
<tr>
<td>BM</td>
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<td>BN</td>
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<td>BO</td>
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<td>BP</td>
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<tr>
<td>BQ</td>
<td>0.0</td>
<td>35.4</td>
</tr>
</tbody>
</table>

Source: Adapted from Rasiah (2002: Table V).
4. IMPLICATIONS FOR THEORY AND POLICY

The development of explicit, tacit and experiential knowledge embodied in human capital is critical in the evolution of industrial districts. Both formal education and training institutions and the invisible “colleges” of firms were critical training grounds in Penang and Kelang Valley. Better systemic coordination and network cohesion facilitated greater differentiation, division of labor and new firm creation in Penang. The lack of systemic coordination and network cohesion restricted differentiation, division of labor and new firm creation in the Kelang Valley. The four dynamic features crystallized in Section 2 underlined the analysis in Section 3 and hence form the basis for theory and policy in this section.

Systemic Coordination and Network Cohesion

The implementation of efficient flexible production systems and re-engineering capabilities require strong supplier capabilities and systemic coordination. Strong systemic coordination and network cohesion has stimulated MNCs’ active participation to strengthen inter-firm links in Penang.

The government’s role of being the provider and coordinator of basic infrastructure was similar between the two locations throughout the 30 years of MNC-driven electronics manufacturing operations in Penang and Kelang Valley. In addition to the development and installation of roads, drains, water, electricity, telecommunication lines and access to other basic needs such as hospitals and clinics, the Penang Development Corporation in Penang and the Malaysian Industrial Development Corporation in the Kelang Valley coordinate any blips in supply. Both locations have enjoyed similar systemic support involving basic infrastructure.

However, the coordination of the rest of the support services differ in the two locations. The Penang government and the PDC actively encouraged inter-firm links by initiating networks. A range of contacts – from past schooling connections to relationships cultivated in industry associations and chambers of commerce – helped forge a relatively cohesive community to build social capital and relationships.

From the coordination of basic infrastructure such as transport, the PDC acted as an intermediary to initiate several important developments in Penang. The PDC accelerated the development of local suppliers by initiating several dialogues between electronics MNCs and potential local suppliers. The initial growth of machine tool, plastic injection moulds firms such
as Eng Hardware, Loh Kim Teow, Loshta, Sanda Plastics and Precico – themselves stimulated by considerable movement of knowhow through both human capital transfers and formal technical support - offered new entrepreneurs the confidence to leave MNCs and start their own firms. Prodelcon, Polytool, Metfab and Rapid Synergy are some of the next batch of firms that were started by former employees of National Semiconductor.

The PDC was instrumental in the founding of the PSDC to support off firm training that is uneconomic for firms to internalize. This role becomes even more critical for underdeveloped structures where firms lack the maturity and critical mass to leave such functions wholly to markets. In fact the PDC subsidized heavily the premises of the PDC.

In addition, the PDC actively sought to establish stronger industry-university ties. Similar initiatives took place between MIMOS and firms in the Kelang Valley. These initiatives generally failed to strengthen participation in firms’ R&D operations by university personnel in Malaysia. University and schooling institutions are governed directly by the Ministry of Education headquartered in Kuala Lumpur. Participation exists on a limited scale, developed on the basis of intimate relationships established between particular academics and company officials.33

The Penang government also actively sought species of industries, which were not new to the universe but new to the region from the 1980s. Unlike the 1970s when the efforts had no technical focus, from the late 1980s the government approached targeted industries with the objective of stimulating industrial upgrading and adding greater differentiation to the region (Rasiah, 1995). The Kelang Valley did not enjoy similar selective promotions and hence the synergies generated was much less than in Penang.

Better institutional coordination involving firms and institutions helped form a dynamic platform for systemic links, which ensured that the mechanisms of governance were connected and oiled smoothly. The Penang government diversified from confinement of their roles to the development and provision of basic infrastructure to participate more actively in developing the institutions to support inter-firm relations, training organizations and engage strongly in bargaining with the federal government to encourage investment incentives to a wider range of local firms and build high tech infrastructure. The Kelang Valley enjoyed these initiatives directly from the federal government, whose critical organizations were located there. Proactive Penang enjoyed far higher systemic synergies than the Kelang Valley, and hence enjoyed higher synergies.

33 Samion Abdullah (Interviews, 1995-97) reported similar findings from his research.
Firms as Training Grounds

It can be seen that open systems formations of firms offer a dynamic channel for the entry of personnel to accumulate tacit and experiential knowledge, which is then carried to new firms when they exit. In regions where institutional and organizational innovations are at the frontier, the entry of fresh personnel offers room for the infusion of new ideas. Young entrants bring new ideas and some more receptive to change in older firms while mature employees carry tacit and experiential knowledge to new firms. Both Malaysian electronics conurbation examined in this paper lack institutional and organizational innovation capabilities at the frontier. The lack of a critical mass of R&D human capital and R&D institutions has constrained the development of cutting edge capabilities on a large scale in the Kelang Valley. Hence, parent firms still dominate the supply of ideas and process knowhow used by mature subsidiaries at host-sites in Malaysia. Nevertheless, Penang has achieved greater adaptive capabilities to meet local conditions.

The need for efficient supplier networks to strengthen production flexibility drove several MNCs to support the development of local firms. The externalization of complementary but dissimilar product lines and the transmission of changes in input demands – both production inputs and machine tool support – required the participation of world class suppliers. Since production coordination required proximate spaces, a strong interface evolved between demand (market opportunities) constraints) and supply (technological constraints). Given the underdeveloped state of supplier firms initially, technical, managerial and other professional staff with tacit and experiential knowledge had to be created to support new firm creation. Hence, MNCs became an important vehicle for the creation and supply of entrepreneurs to start new firms, or professionals, technicians and skilled personnel to support emerging firms.

Technicians, engineers, managers and other skilled professionals easily moved from one firm to another and often to start new firms. The precision engineering firms of Prodelcon, Metfab, Polytool and Rapid Synergy were began by engineers who gained their tacit and experiential knowledge from working in Micro Machining, which was then a subsidiary of National Semiconductor. Similar experiences involved the movement of personnel from Intel who started the local firms of Globetronics, Unico, Shinca, Shintel and Sanmatech. Newly relocating MNCs such as Komag, Quantum, read-rite, Conner Peripherals and Solectron also benefited from such entrepreneurial synergies.

The lack of network cohesion restricted the movement of tacit and experiential knowledge embodied in human capital in the Kelang Valley. New firms not only lacked supply of entrepreneurs but also professional, technical and skilled personnel. The local firms of Sapura,
OYL Electronics generally either trained fresh graduates, hired staff from employees with experience from other industries or from electronics MNCs in Penang.

**Regional Innovation Capabilities**

Entrepreneurs lead industrial dynamism in particular locations. However, for the progression of industrial dynamics from mere assembly and minor innovations operations to the frontiers of new product development, institutional mechanisms geared towards supporting R&D and innovation is critical. Unlike scientists and technologists, entrepreneurs by definition will be unwilling to face uncertainty. Entrepreneurs will not be attracted to investments when the potential returns are lower than the risks involved. R&D support institutions are necessary to stimulate entrepreneurs’ participation in innovative activities on a large scale. In addition to R&D human capital, regions also require high tech infrastructure such as university-industry links, R&D labs and complementing grants – all of involve serious collective action problems. The lessons generated from Penang and Kelang Valley is that strong systemic coordination – including the direct state support initially - is necessary to overcome shortcomings associated with the supply of R&D infrastructure. Interventions in markets to resolve collective action problems associated with R&D will be higher in underdeveloped regions given the scale of uncertainties. The technological trajectory of firms’ metamorphosis includes new product development only when the requisite R&D support institutions exist. One way of ameliorating this problem is to integrate Penang’s localized form of systemic coordination at the national level.

Two major pillars of R&D need state support, *viz.*, high tech human capital and support or protection to stimulate investment in uncertain research and scaling aspects. Given that rents (see Marshal, 1920) are involved when intervention to subsidize or protect occurs (e.g. patents and tariffs), such efforts could generate government failures. However, given that high tech human capital (e.g. scientists and engineers), and public financing of basic, and scaling and commercialization activities is critical to support innovations at the technology frontier, selective interventions are unavoidable. Selective interventions are necessary but not sufficient conditions for stimulating risky productive activities. Deficiencies exist with both Malaysian electronics conurbation. Whether driven by MNCs or local firms, institutions are necessary to produce the high tech human capital necessary to drive firms’ participation and R&D institutions in innovation activities.

Hence, it is critical that regions build their high tech infrastructure – engendering requiring strong government support – to supply the innovative capabilities necessary to drive entrepreneurs to the technology frontier. Government participation becomes even stronger in
infant regions whose demand for innovations begin to outstrip supply. Japan, Korea and Taiwan began with strong government funding of R&D operations. Although private funding of R&D has overtaken government funding, governments still support R&D operations in a number of critical areas.

Open National Systems

Regions characterized national innovation systems open to the inflow of foreign high tech human capital have managed to overcome shortcomings associated with widening demand-supply human capital deficits to drive innovative activities. Open national systems framework help attract human capital from abroad.

The Malaysian government restricted the immigration of professional human capital to drive firms – MNCs and local firms – transition from low to high value added activities. Firms with the most developed innovation capabilities in Penang reported serious shortcomings with available labor and have constantly called the government to relax immigration controls involving high tech human capital. The Kelang valley managed to extract these benefits from 1997, but only in locations classified under the Multimedia Super Corridor (MSC), and confined to IT companies. The demands are even higher in Malaysia where growing demand-supply human capital gaps have constrained the capacity of regions to support innovative activities. Social and political structures that inhibit the flow of tacit and experiential knowledge embodied in human capital are likely to generate sub-optimal synergies.

The lack of high tech human capital endowments has restricted Penang firms’ participation in high value added activities. Some regions have overcome such deficiencies by importing foreign human capital. Small economies such as Ireland, Israel and Singapore have relied extensively on selective immigration policies to drive industrial upgrading and the development of innovation capabilities. Selective immigration policies have also been instrumental in the United States attracting large numbers of foreign human capital to drive production and innovation capabilities in such high tech industries as information technology. The Silicon Valley has also benefited considerably from numerous start-ups by foreigners (see Saxenian, 1999).

Open systems networks also involve firms’ capacity to exploit different national systems of innovation. MNCs appropriate innovation capabilities by targeting particular locations to tap capabilities. Intel access as tremendous innovation synergies by having a key R&D plant in

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34 Regional was preferred here because of wide variations in support for and strength of innovation networks within national boundaries.
Israel. IBM and Microsoft have operations in Bangalore to tap software-engineering capabilities. While firms from Malaysia, especially from Penang (e.g. Eng Technology and Atlan) have multinational operations, they have not evolved to tap human capital capabilities abroad for new product development. These firms’ relocation abroad have been driven by pressures to relocate close to its MNC buyers, and access low wage labor.

Given that innovation systems cannot easily be transplanted, domestic firms should seek to relocate operations in dynamic regional systems to exploit their specific human capital endowments. In addition to long gestation periods, institutional gaps and cultural conditions often raise the transactions costs - forcing firms to seek the relocation alternative than to canvass for its development domestically.

In sum, five critical planks can be summarized from the above discussion. First, a strong high technology infrastructure is critical to stimulate firms’ participation in high value added activities such as in new product development. Penang’s and Kelang Valley’s deficiency is apparent particularly in R&D human capital, which has reduced the innovative capacity of entrepreneurs. Second, network cohesion is necessary for engendering systemic synergies for the development and movement of entrepreneurs, professional, technical and skilled personnel from one firm to another. It is critical in inter-firm relations and links between intermediary organizations, government departments and firms. The lack of network cohesion has reduced the Kelang Valley conurbation of electronics firms to truncated operations with little inter-firm relations. Third, open framework networks are necessary to condition particular clusters with properties of ease of entry and exit so that entrepreneurs, professionals and skilled labor developed will leave to start new firms. Fourth, where the active drivers of production and innovation – i.e. human capital – are lacking – immigration conditions must be open to imports to overcome demand-supply gaps from widening. Fifth and finally, where the specific systemic properties of superior regions that generate particular human capital attributes are difficult to be transplanted, firms should seek relocation initiatives to exploit the benefits of such host-sites.
5. CONCLUSIONS

This paper examined the role of systemic links in coordinating the supply and demand of human capital in two MNC-driven electronics manufacturing industrial districts in Malaysia. While Penang has a long way to go to rival the competitiveness and systemic synergy generating potential of the Silicon Valley, Route 128, Emelia Romagna, Kei Hin, Hsinchu Science Park, Ireland, Israel and Singapore, it has developed considerable cluster synergies. Penang has a semblance of a dynamic cluster with considerable network cohesion to support differentiation, specialization and new firm creation.

The formal institutions of learning in Malaysia – especially governing the supply of graduates and R&D scientists and engineers have lacked effective supply-demand coordination. Formal institutions of education have been governed from Kuala Lumpur, which has been successful generally in the supply of primary and secondary education where demand-supply coordination with industry is minimal. Constraints on immigration policies have also restricted imports to complement shortages. Waivers in the MSC have not only been too narrowly defined industrially but also confined to a strip of location where critical electronics MNCs such as Intel and Motorola are not located. Thus, growing deficits in technical and R&D scientists and engineers has undermined the capacity of electronics firms in Penang and Kelang Valley to introduce higher value added activities on a large scale.

Systemic coordination involving the development of tacit and experiential knowledge embodied in human capital has differed between Penang and the Kelang Valley. Firms in Penang – enjoying network cohesion - have established strong inter-firm links and links with intermediary organizations. The initial role of the Penang government (and PDC) was instrumental in the development of the PSDC for industry-oriented skills development center for resolving collective action problems involving training. The open nature of networking and relations between firms has stimulated strong interface between supply-demand match-ups in the production chain. Technological constraints in one set of firms have easily been transformed into market opportunities in another set of firms as a consequence of smooth inter-firm networks.

Electronics MNCs in the Klang Valley enjoy world-class production operations for pre-designed products but suffer from weak inter-firm links and networking capabilities. Support institutions hardly play effective intermediary roles to strengthen inter-firm links in these states. The Kelang Valley has much to learn from the developmental intermediary role played by
PDC, but the dynamism achieved in Penang requires adapting to meet the specificities of the Kelang Valley.

Network cohesion is critical to help improve systemic coordination so that the quantitative and qualitative aspects of demand-supply human capital requirements in particular regions could be met effectively. A lack of effective systemic coordination of tertiary, and R&D science and engineering education federally cost both the Penang and Kelang Valley regions adequate supply of innovative human capital. Japan, South Korea and Taiwan ameliorated this problem by stepping up the production of technicians, scientists and engineers.

Where local supply capabilities fell behind demand, open national systems enabled imports. The Silicon Valley overcame skills and technical human capital shortages by absorbing foreigners with green cards. The Malaysian government still imposes restrictive conditions on the free import of professional labor. Initiatives to attract Malaysians back are not sufficient to ameliorate this problem.

High tech firms have been important training grounds for the development of tacit and experiential knowledge embodied in entrepreneurs, professionals, technicians and skilled human capital for new firm creation. The open firm formations in Penang enjoying systemic coordination and network cohesion – characterized by ease of entry and ease of exit - encouraged the movement of entrepreneurs to support new firm creation on a large scale. Like in the Silicon Valley, Israel, Ireland and Singapore, Penang benefited considerably from the movement of tacit and experiential knowledge from MNCs to local firms. The lack of systemic coordination and network cohesion restricted the development and inter-firm movement of tacit and experiential knowledge in the Kelang Valley.

In addition to education and training, governments – either through incentives or direct ownership – have supported firms’ activities that generate collective action problems. Firms in Penang and Kelang Valley have not participated in new product development in any significant scale. R&D activities cannot just be stimulated by incentives alone. Entrepreneurs seek stronger support to participate in risky and uncertain activities. Israel, Ireland, South Korea, Singapore and Taiwan stimulated the successful transition of firms to innovative activities by building R&D labs and offering complementing grants (see Rasiah, 2002).
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