Electronics Clustering and Technological Intensities in Indonesia and Malaysia

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1. Introduction

Foreign-driven electronics manufacturing evolved in Southeast Asia when Japanese and American firms relocated assembly activities in Singapore, Malaysia and Philippines in the 1960s, Thailand from the 1970s, Indonesia from the 1980s and Vietnam from the late 1990s. Whereas there is consensus that Singapore has experienced integrated operations with specialization in technology-intensive high value added activities such as design, regional customization and wafer fabrication (see Best, 2001), there are still doubts over the direction electronics manufacturing has headed in the remaining part of Southeast Asia.

In addition, whereas considerable accounts exist on the positive role of foreign firms in generating employment and exports in Indonesia (see Audretsch and Donnithorne, 1957; Panglaykim, 1983; Hill, 1988, 1995, 1996; Sjoholm, 2002; Okamoto and Sjoholm, 2003) and Malaysia (see Thoburn, 1977; Rasiah, 1994; 1995; Rasiah, 2003a), little work has examined how foreign and local firms are networked around institutions in these economies. Thus, this paper examines how foreign and local electronics firms are clustered and the consequent impact of this on firm-level technological intensities in Karawang-Batam in Indonesia, and Penang and Johor in Malaysia .

The systemic quad is used to analyze clustering in the industry in the states of Penang and Johor in Malaysia, and the islands of Karawang and Batam in Indonesia. Four policy pillars that require simultaneous coordination are identified in the systemic quad, *viz*., one, basic infrastructure to provide systemic stability and efficiency; two, high tech infrastructure to provide systemic support for participation in learning and innovation; three, network cohesion to provide the systemic price, technological and social relationships necessary to drive interactive and interdependent coordination; and four, integration in global markets and value chains to provide the scale, scope and competition to drive learning and innovation.

The rest of the paper is organized as follows. Section 2 reviews past literature related to agglomeration economies and provides the justification for using the systemic quad as the approach for evaluating clustering in the electronics industry in Malaysia and Indonesia. Section 3 presents the methodology used and breakdown of data collected from Penang, Johor, and Karawang and Batam. Section 4 examines the state of development of the four pillars that drive systemic synergies in the three regions from the two economies. Section 5 assesses the impact of these developments on technological capabilities and knowledge complexities. Section 6 finishes with the conclusions.

2. Regional Development Models

Four critical concepts have dominated region-centred industrial promotion in developing economies, viz., industrial districts, growth pole, export-processing zones and industrial clustering. Given the central focus on regional development all four concepts overlap.

Economies that managed to strengthen the four pillars of the systemic quad have managed to sustain several decades of rapid growth and employment absorption, value addition and sustained exports (e.g. Singapore, Taiwan Province of China, Hong Kong, Ireland and Israel). Economies that simply focused on providing basic infrastructure, political stability and security at least in EPZs and industrial estates have failed to enjoy sustained growth and employment absorption, value addition, sustained exports (e.g. Brazil, Indonesia and Philippines). Whereas sustained value addition, differentiation and division of labour, and wage increase has helped raise sharply standards of living human development in the successful economies noted, the lack of it has denied the latter economies this experience.

3. Methodology and Data

The paper uses comparisons of simple means to examine differences of firms' assessment of institutional and systemic instruments facing them, as well as, technology, wages and productivity of foreign and local firms in in Penang and Johor in Malaysia, and Karawang-Batam in Indonesia. Likert scale scores ranging from 0-5 were used to score firms' rating of connections and coordination quality with critical institutions. The estimation of the technological intensity variables is shown in Table 1. Trajectories and taxonomies were used to differentiate technology, and technological intensities were captured by normalizing related proxies (see Table 2). The original typology of knowledge depth contained level 6 referred to firms having their own R&D centres with specialized R&D personnel, and participation in new process and product R&D including take up of process and product patents in the United States. However, none of the firms in the sample responded positively to level 6, and hence the distinction was dropped from Table 2.

5. Learning and Innovation

Although both Penang and Johor share the same federal policies and are located in the same national economy, differences in state-level governance and systemic coordination has produced distinctly different learning and innovation capabilities in electronics firms located in these states. Given the inferior institutions, networking and weaker integration enjoyed electronics firms in Karawang-Batam are expected to show lower technological intensities and complexities than electronics firms in especially Penang. This section captures these differences using an adapted version of the technological capability methodology approach. The approach was pioneered by Lall (1992), Bell and Pavitt (1995), Westphal et al (1995) and Ernst, Ganiatsos and Mytelka (1998), and extended by, Figueiredo (2002), Ariffin and Figueiredo (2003) and Rasiah (2004). Two exercises are carried out in this section, viz., one, a taxonomy locating the depth of participation of firms by human resource (HR), process technology and product technology, and two, comparisons of technological, skills intensity and wage means by ownership between electronics firms in Johor and Penang.

Technological Complexity

This sub-section examines technological capabilities by the incidence of knowledge depth achieved in electronics firms in Penang, Johor and Karawang-Batam. Only embodied technology – in humans, processes and equipment, and product – is examined here. Each of the three technology components are differentiated by knowledge depth (see Table 1). The results from a survey carried out in 2004 using a random sampling procedure are compiled in Table 8. The scores show incidence of participation of firms in the respective knowledge categories. Frontier research was not included because none of the firms in both states reported participation in this category.

The overall incidence of participation of firms in higher technology activities are significantly higher in Penang then in Johor (see Table 6). Foreign firms enjoyed higher incidence of participation in the high segments of technology than local firms. Participation in product R&D was extremely low in both states but no firms reported involvement in Johor and Karawang-Batam compared to 3 foreign and 2 local firms in Penang. None of the firms in Penang were engaged in totally new product development, but the 5 firms that reported yes to the fifth knowledge depth category reported that they carried out designing to meet regional tastes. A computer manufacturing firm in Penang reported carrying out designing of computers specifically to meet East Asian customers' needs. The two local firms engaged in product designing in Penang that reported having original design manufacturing capability noted that they enjoy strong interface with their buyers to develop product technologies jointly. Both these local firms are also multinationals with manufacturing plants located in over four countries – including in Karawang, Indonesia.

It is the failure of EPZs to engender upgrading and hence long-term growth that drove several countries to experiment with industrial clustering. Porter (1990) and Best (2001) discussed arguably the most popular notions of clustering. It is thus useful to evaluate the work of Porter and Best on clusters before an alternative framework is developed to examine clustering in the electronics industry in Indonesia and Malaysia.

Porter's Diamond

The critical feature in Porter's (1990) competitive cluster defined within a geographical space is critical mass of resources and competences that provides the region with a key position in an economic activity so that it enjoys a competitively supreme position in global markets. The concept has gained significance primarily because of the emphasis on increasing productivity and innovation in the embedding firms, and the creation of new firms. High tech clusters are characterized by the agglomeration of firms around renowned science and technology-based universities and research labs. Historically emerging clusters were generally driven by critical sectors over the years as tacit knowledge snowballed over from traditional industries. These industries then stimulated the growth of supplier and complimentary economic activities.

The essence of Porter's (1990) model of competitive advantage is the diamond, viz., one, factor conditions; two, firm strategy, structure and rivalry; three, demand conditions; and four, related and supporting industries. National competitive advantage is achieved when particular industries meet the four ingredients above. Because critical technologies (core competence) drive Porter's competitive clusters, specialization in particular goods and services are the drivers.

While Porter helped make the concept of clusters famous, his work neither connects the concept historically to capture its evolution nor offers a full understanding of the term systemically. Hence, it is difficult to establish a coherent framework and a roadmap to assist policy makers to drive clustering in emerging regions.

Best's Productivity Triad

Introducing the productivity triad, Best (2001) provided a triangular relationship between a business model, production capability and skills formation as drivers of regional growth. Drawing from Smith (1776), Marshall (1890), Young (1928), Schumpeter (1934) and Penrose (1959) and using a profound understanding of organizational change historically, Best (2001) advanced further elements to the concept of regional development.

Best (2001) argued that techno-diversity rather than a simple focus on techno-clusters was a crucial element of dynamic clusters as it offered the impetus for the creation of demand (new technology and firms) on one side, and differentiation and division of labour on the other side. Best also argued, for clusters to drive differentiation and division of labour it must have the capacity to stimulate new species of industries. Rasiah (2002)

Clusters in this paper is defined as a regionally networked set of economic agents (firms and institutions) that refer to localized systems connecting all critical economic agents necessary to drive learning, innovation and competitiveness. Clusters here are considered to produce the most synergies when all requisite institutions to drive learning, innovation and competitiveness and economic agents are horizontally connected (interdependent interface is important). Clusters can generate an egalitarian network if all participants are effectively networked so that all views are equally embodied in policy formulations. Governments in developing economies tend to accept the former because of the interest on growth not realizing that the effective pursuance of the latter is pertinent for balanced development.

Attempts to formulate public policy intervention on clusters do not necessitate a clear identification of the role of government in the development of dynamic clusters in history. What is important is whether dynamic clusters offer room for government policy. Governments can promote particular agglomeration of competence to provide a snowballing effect to attract the relocation of other firms or the creation of new ones. Such a role will purely be promotional. Government can also screen particular clusters and identify bottlenecks, holes and weaknesses to ease, fill and ameliorate these problems. Such problems can take the form of critical basic infrastructure, high tech infrastructure, or supplier firms. Given the problems of information asymmetries between government and firms intermediary organizations such as chambers of commerce, parastatal-type training institutions and R&D labs often help resolve collective action problems. Interdependent relationships that are driven by the discipline of the market, the participation of government when public goods are involved and complementation through trust-loyalty to extract social commitment from the humans directing all of them is vital for the development of competitive clusters. Industry-government-consumer/labour coordination councils often help form and expand social capital.

Systemic forces have largely driven Porter-type (1990) clustering in some locations. For example, the success of software engineers and related firms has convinced a number of high-tech companies to set up operations in Bangalore, India. Likewise, a critical mass of gambling casinos has attracted further gambling casinos to Las Vegas. Although developing governments have often promoted Porter-type clustering in particular regions on the basis of the identification of industries such as electronics, auto parts, wood-based products, garments, shoes or ceramics, few have retained the same industries in the long term.

A combination of a lack of firm-level drive, and a lack of the requisite human capital and high tech institutions necessary to stimulate the innovation and with it competitiveness have often undermined the capacity of such clusters to enjoy sustainable differentiation and division of labour. These are also the prime reasons for the stagnation that has characterized export-processing zones and industrial estates in developing economies. Central to any effort to revive fading old industrial concentrations must be a focus on planting the right pillars to stimulate upgrading, innovate, industrial differentiation and new firms. The strategy must be one of mapping regions of their firms, institutions, effectively to stimulate technology acquisition through learning by doing, licensing, adaptation, training, standards appraisal mechanisms, a strong intellectual property right framework to prevent moral hazard problems facing innovators and R&D. The second is vital for the continuous evolution of technological capabilities in the cluster.

The third requires that the cluster is globally connected – markets and value chains. Global markets provide the economies of scale and scope and the competitive pressure to innovate. Global value chains assist economic agents in the cluster to orientate their strategies to the critical dynamics that determine upgrading and value addition (see Gerrefi, 2002; Gerrefi, Humphrey and Sturgeon, 2005). Examples of such changes include the introduction of cutting edge just in time and flexible specialization techniques in electronics, and the proliferation of software technology in the use of cad-cam machines and the interface between firms assembly activities and the major markets abroad. In Indonesia for example, Texmaco which is located in an EPZ in the outskirts of Jakarta responded to the changing nature of global value chains in the garment industry by integration assembly, fashion design, packaging and logistics to supply brand-name holders. Lacking in institutional support – both basic and high tech infrastructure – Texmaco has managed to compete globally despite facing tremendous transactions costs in Indonesia.

The fourth differentiates a cohesively networked cluster from others defined by truncated operations. Lundvall (1988) expanded the elements of interdependence and interactiveness by articulating the role of producer-user relations in innovation. The nature of interface and coordination between vertically connected economic agents is vital in the horizontal evolution of innovation activities. Connectivity and coordination is critical for knowledge flows – beyond simply codified information that markets can coordinate. Intermediary organizations such as industry-government coordination councils and chambers of commerce play an important role to increase connectivity and coordination in dynamic clusters. In emerging regions, governments have initiated such platforms (e.g. Penang in Malaysia) (see Rasiah, 2002). The appropriation of knowledge through rubbing off effect as humans employed by the critical economic agents in the cluster meet and interact, and the movement of tacit knowledge embodied in humans to start new firms rises as trust-loyalty (social capital) becomes a critical coordination mode.

Whereas Penang enjoys a world class airport to undertake quick cargo transport, the Johor airport lacks the capacity to provide such service. Because state government officials did not pro-actively target and attract flagship firms engaged in quick cargo flights to relocate in Johor and Karawang-Batam the airport there do not have the demand to support world class flight facilities for micro-chip firms. Hence, with the exception of ST Microelectronics (located in Muar) no other semiconductor firms have relocated in Johor and Karawang-Batam while there are over 10 semiconductor firms in Penang. Customs and security coordination are better in Penang than in Johor only because of better connections and interactions between the authorities and the firms.

Basic infrastructure in Karawang-Batam is worse than than in Johor but special provisions in export processing zones have ensured that labour-intensive activities such as low priced telephones, components and PCB assembly can be undertaken smoothly in Batam and Karawang. In addition, small-scale customized computer assembly, and high volume consumer electronics products such as television, DVD and stereo sets are also assembled in Karawang. Most of these items are exported by ship. Although general security an customs are a big problem in Batam and Karawang the coordination of these activities by foreign logistics companies has reduced such problems.

Source: Compiled from UNU-MERIT, World Bank and DFID Survey (2004)

The local computer assembly firms sell wholly in domestic markets and hence do not enjoy forward linkages in export markets. These firms import most of their micro-chips from Malaysia and Singapore. One local firm – which is a conglomerate engaged in textile and garment, and machinery and truck assembly activities - has amassed a critical mass of skilled personnel locally and from abroad to undertake small batch high margin surface mount operations to support precision engineering and components manufacture for foreign electronics firms engaged in export-oriented television, DVD and stereo sets manufacturing in Karawang. Most of the remaining electronics firms are engaged in high volume assembly depending wholly on foreign expertise.

drew from this logic to explain speciation of industries not new to the universe at the regional level in Penang. Piore and Sabel (1984) and Rasiah (1999; 2002; 2004) emphasized the significance of intermediary organizations – coordinated through the operations of markets, government and trust-loyalty - that strengthened interdependence in the relationships between economic agents to resolve collective action problems and coordinate effectively the allocation and performance of public and private goods providers. Hence, the synergy involved in cluster effect goes beyond simply the attraction offered by buyers and sellers of a particular good or service located in a certain place to induce other buyers and sellers to relocate there.

Cluster effect in Best's definition includes the capacity of a network of firms and institutions to drive differentiation and division of labour, and new firm creation. That capacity led to the amplification of the role of network cohesion. Just how well firms and institutions are connected explained the smoothness with which coordination of demand-supply conditions and knowledge flows interacted to drive the generation and appropriation of economic and social synergies.

Because Best (2001) focuses on horizontal integration and re-integration so that all firms participate in innovations in value chains in a technological diverse cluster, the dynamic technologies and goods and services frequently change. At any one time a dynamic cluster competes globally in a range of products and services, and not simply in a particular industry as articulated by Porter (1990). Best also emphasized the critical importance of heterogeneity and diversity in the evolution of dynamic clusters. Differentiation and division of labour and new firm creation are central to the long term growth of clusters.

While Best connects the concept of clusters historically and provides the necessary feel for knowledge flows and its diffusion, because the focus has been on developed regions it lacks the dynamics to address institutional shortfalls that typically characterize underdeveloped regions. The latter is necessary to initiate and drive regions lacking a critical mass of specialized firms.

Alternative Model: The Systemic Quad

It can be seen that the critical focus of Porter has been on the agglomeration effects of clusters led by a critical mass of firms specializing in a key competency, while Best emphasizes more the business model and production capability to drive differentiation and division of labour. Both approaches explain how mature networked regions enjoy synergies but lack focus on how underdeveloped regions can be transformed to such regions. Both approaches do not identify exhaustively the critical pillars government should focus on. They tend to obfuscate the boundaries between firm-level strategies and government policy. Hence, an alternative framework is constructed to examine clustering achieved in the states of Penang and Johor in Malaysia from the lenses of electronics firms.

policy framework and their integration with markets (global and local), and to identify the drivers or the lack of drivers that explain the vibrancy of the region.

Regions endowed with a dynamic set of economic agents effectively connected and coordinated – firms and institutions (e.g. provision of utilities such as power, water, telecommunications, education and training institutions and R&D labs) drive innovation and competitiveness through flows of circular and cumulative causation. What Young (1928), Kaldor (1957; 1984) and Cripps and Tarling (1977) argued at a structural level can be presented in networks terms through the concept of clusters.

Frontier clusters (high tech clusters in Porter's notion and any dynamic cluster in Best's definition) are characterized by innovation. The focal point of innovation in a dynamic cluster is essentially the interdependent and interactive flow of knowledge and information among people, enterprises and institutions. It must obviously include coordination between the critical economic and technological agents across value chains who are needed in order to turn an idea into a process, product or service on the market. In dynamic clusters such as the Silicon Valley and Route 128, innovations evolve from a complex set of inter-relationships among actors located in a range of enterprises, universities and research institutes. The execution and appropriation of these innovations *inter alia* expand further actors in dynamic clusters to intermediary organizations such as suppliers, venture capitalists, property rights lawyers and marketing specialists. The government is a major player providing a significant share of the funding public goods, though, the National Science Foundation (NSF, 2003) has warned about a decline in it over the last decade. Government funding comes in the form of research supported in the military, support of research undertaken in firms and other laboratories.

Most efficiently governed industrial estates and EPZs in the past generally only focused on the elements that are shaded blue. The long term objective of government policy in these economies has been to ensure sustained increase in labour force participation, and wages so that the broader objectives of poverty alleviation and human development are met. The original exponents calls to limit the role of government to just the provision of excellent basic infrastructure proved to be the shortcoming of the EPZ strategy. Without a policy to ensure learning and innovation, increased integration in the global economy undermined the capacity of these regions to compete against rising wages, the emergence of new sites such as China, and to meet the rising technological deepening requirements in them (e.g. electronics) with deleterious consequences on underemployment, poverty and human development. Lall (2001) was to assert that economies that failed to develop their technological capabilities became losers in the globalization process.

Central to the failure of EPZs and industrial estates in developing economies has been the lack of development of an effective enabling environment for technological upgrading, differentiation and division of labour, and new firm and industry creation. Figure 3 identifies the critical pillars that drive dynamic clustering. The first central pillar of a dynamic cluster is a strong role by governments (federal or local) to provide stability (macroeconomic, political and security) and efficient basic infrastructure. The second is the environment where the institutions coordinating learning and innovation are evolve

Marshall (1890) provided the earliest known elements that constituted regionally defined set of firms by referring to industrial districts. Young (1928) articulated the advantages industry offers from its differentiating and division of labor potential. In addition to markets and command, Brusco (1982), Sabel (1982), Piore and Sabel (1984), Becatini (1982), Wilkinson and You (1995), Rasiah (1994), Pyke and Sengenberger (1988) and Rasiah and Lin (2005) showed how a systemic framework with a blend of influence from markets, government and trust-loyalty (social capital) have been instrumental in driving productive networks of industrial synergies.[1] Piore and Sabel (1984), Hirst and Zeitlin (1988) and Sengenberger, Loveman and Piore (1990) provided a dynamic and coherent account of inter- and intra-firm coordination on how horizontally evolving relationships provide the impetus for the transition to a high road to industrialization.

There has been an initially parallel but eventually converging development of the theory of agglomeration economies – with a focus on growth poles and lead sectors. Theories of state power and regional organizations have focused on the role development organizations play in stimulating industrial activities by concentrating infrastructure in particular locations. Early work from geographers and development economists examined the advantages of developing growth-pole strategies (see Perroux, 1949, 1961; Boudeville, 1966; Hirschman, 1958, 1977; Myrdal, 1958) on regional development. Unlike the concept of clusters which examines the regional dynamics as a network, growth pole was referred to by Perroux (1949) as an industry or a group of firms that drove the growth of other firms and economic activities most in the region: polarization arising from the propulsive development of a firm or industry. Growth poles eventually assumed the meaning of growth polarization stimulated external economies and linkages. The synergy effects of agglomeration economies have been documented lucidly subsequently by Cooke and Morgan (1998), Garofoli (1992), Porter (2001), Scott (1988) and Storper (1997). Hirschman (1958; 1970) canvassed strongly for export-orientation to attract the discipline and scale effects of markets to promote competition and backward linkages.

Export processing zones (EPZs) became important from the 1950s when UNCTAD and UNIDO initially promoted these institutions in poor economies unable to provide good infrastructure, industrial support and security throughout whole countries. The initial absorption of the views of Perroux, Hirschman and Mydral on lead sector drivers in industrial estates was quickly replaced by the World Bank approach of limiting export-processing zones to simply the provision of basic infrastructure, smooth customs coordination and security. It is the latter hands-off approach that proliferated across developing economies. The initial success from FDI inflows that helped create jobs by targeting production to exports proved successful even in small economies such as Malaysia, Ireland and Singapore, albeit trade leakage became a problem right from the start. However, countries that simply continued this hands-off approach gradually began to lose FDI interest as production costs rose and cheaper sites emerged. Singapore and Ireland took on an interventionist approach to stimulate upgrading and value addition to match rising production costs.

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[1] The significance of trust in raising economic performance was earlier noted by Mill (1844).

The superiority of systemic coordination in Penang over Johor and Karawang-Batam is reflected in the incidence and depth of participation of firms in technological activities. Apart from HR practices firms – irrespective of ownership Penang showed higher technological intensities (process and product) than firms in Johor and Karawang-Batam. The skills-intensity levels of firms in Penang were also higher than firms in Johor. Firms in Penang also seem to be paying higher wages to support higher technological and skills intensities than firms in Johor and Karawang-Batam.

The evidence reinforces the evolutionary argument that institutional and systemic support is critical to drive learning, innovation and competitiveness in firms. Stronger institutional and systemic coordination – despite both states sharing largely similar federal policies – has helped attract and subsequently drive higher technological capabilities and productivity in Penang compared to Johor and Karawang-Batam. The evidence also helped to demonstrate the importance of the systemic quad as a policy framework to understand learning and innovation synergies in developing regions.

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Technological Intensities and wages

The mean scores of the variables computer from Table 2 is shown in Table 8. It can be seen that the HR and process technology means were not statistically significant. Foreign firms, in all of which foreign MNCs owned at least 50 percent equity, consistently enjoyed higher means than local firms in both states. Whilst foreign electronics firms in Penang also enjoyed higher means than foreign electronics firms in Johor, the commensurate comparison was also the same with local electronics firms.

Penang firms enjoyed higher means than firms in Johor involving skills intensity (SI) and wages (see Table 8). Mean wages in Karawang-Batam was the lowest. Given that the labour market in Malaysia has been tightening since the early 1990s despite massive imports of unskilled labour from Indonesia and Bangladesh, managers, professionals (including engineers), technicians, production superintendents and machinists continue to enjoy a wage premium. While higher wages have made Penang more attractive to skilled workers than Johor, the work atmosphere in Penang has changed to value motivational elements so much so that workers are also unwilling to relocate back to their hometowns in Malaysia even when firms there offered comparable wages. Indeed, an official from Flextronics located in Johor reported in March 2006 that the firm failed to attract Johor born engineers, technicians and machinists from Penang despite offering them slightly better wages then what they were getting in Penang. Interviews with firms in Karawang showed that there still existed a huge reserve army to slow down wage rise in Indonesia.

Interviews with electronics firms in Johor in 2004 and 2006 showed that Singapore continues to attract skilled Malaysian workers with salaries reaching no less than three times what firms are willing to pay in Johor. All 15 firms interviewed in Johor in March 2006 reported losing skilled workers to Singapore for wages exceeding 3 times more.[2] Although the numbers are much less firms in Penang also reported losing engineers to Singapore: a number of foreign educated Malaysian R&D engineers are engaged in designing activities in Singapore. Interviews with officials from Intel, AMD, National Semiconductor, Hewlett Packard and Dell in 2004 in Penang suggest that the supply of R&D engineers and technicians are too small for these firms to upgrade further into R&D activities. Singapore managed to ameliorate this problem by opening policy to the world to attract high tech human capital. Until 2006 Malaysia limited this benefit to areas classified under the Multimedia Super Corridor (MSC) initially involving only an area stretching from Kuala Lumpur to the Kuala Lumpur International Airport (KLIA) located in Sepang.

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[2] These interviews were organized by Asokkumar Malaikolunthu.

Integration in Global Markets and Value Chains

All computer and component firms in Penang and Johor are either directly or indirectly integrated in global markets. Apart from the local computer firms in Karawang, the remaining electronics firms in Karawang-Batam are integrated in global markets. Penang is better integrated to global markets than Johor and Karawang-Batam as it is a platform where firms not only export globally and absorb technology from parent plants located in the United States, Europe, Japan, Korea and Taiwan, it has also developed the capabilities to participate in ramping up operations abroad and regional customization.

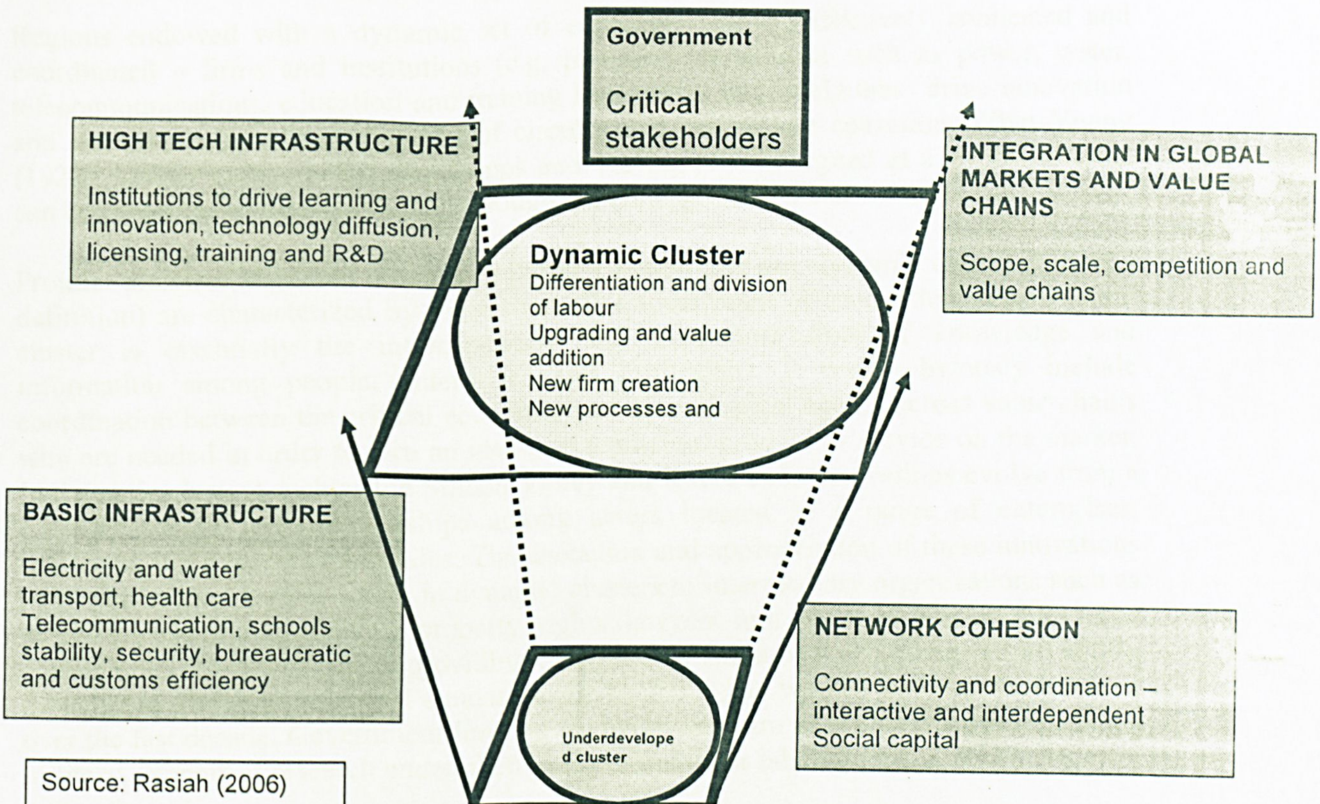
The Penang government started early to stimulate integration with global markets from the outset when electronics firms were targeted for promotion in 1970. Despite launching a strategic plan in 2006 to turn Johor to a globally competitive high tech region, the government has yet to provide significant support to effect this goal. Hence, Johor looks to remain a platform for the assembly of tail-end activities to support a regional high tech hub in Singapore.

Electronics firms in Penang enjoy multinational coordination, market access and technology support from all the major markets – i.e. United States, Europe, Japan and Canada. A few of these firms in Penang also enjoy some technology support from Singapore – e.g. Hewlett Packard (see Figure 2). Electronics firms in Johor largely depend on technology support from regional headquarters or parent plants in Singapore. Very few exceptions exist, the largest of which ST Microelectronics in Muar exports largely through Singapore.

In addition, electronics firms in Penang also provide technology support to firms in Thailand, Philippines and Indonesia, and the Malaysian states of Kedah, Perak, and the Kelang Valley region. Such expertise range from the transfer of process technologies to human resource training. Contract manufacturers also evolved to provide support services to foreign multinationals operating in Indonesia, Philippines and Thailand.

Better state-level coordination of FDI inflow by the local government and PDC as well as high wages and a tight labour market has also driven out highly labour-intensive stages of production out from Penang to Perak and Kedah. Indeed deliberate efforts to connect with high value added firms helped Penang attract a critical mass of firms by species – from semiconductors, passive components (e.g. diodes, resistors and capacitors), disk drives and photonics. The only two microprocessor assembly and test plants in Malaysia are located in Penang. The lack of such focused role by the local government as well as the lack of high tech coordination has restricted Johor to primarily low value added activities such as printed circuit boards (PCBs), monitor assembly, ink cartriges and printers. The breakdown of type of specialization is shown in Table 7. Typical with the computer industry, none of the firms enjoyed integrated operations in Penang and Johor. All the firms had assembly and test activities in both states. None of the firms reported having Original Brand Manufacturing (OBM) activities. Weaknesses in the high tech infrastructure has obviously meant that foreign MNCs have off-shored little and local firms have lacked the institutional support to expand into R&D activities.

Figure 1: Systemic Quad



Source: Rasiah (2006)

Figure 2: Market and Value Chain Links of Electronics Firms, Indonesia and Malaysia, 2001

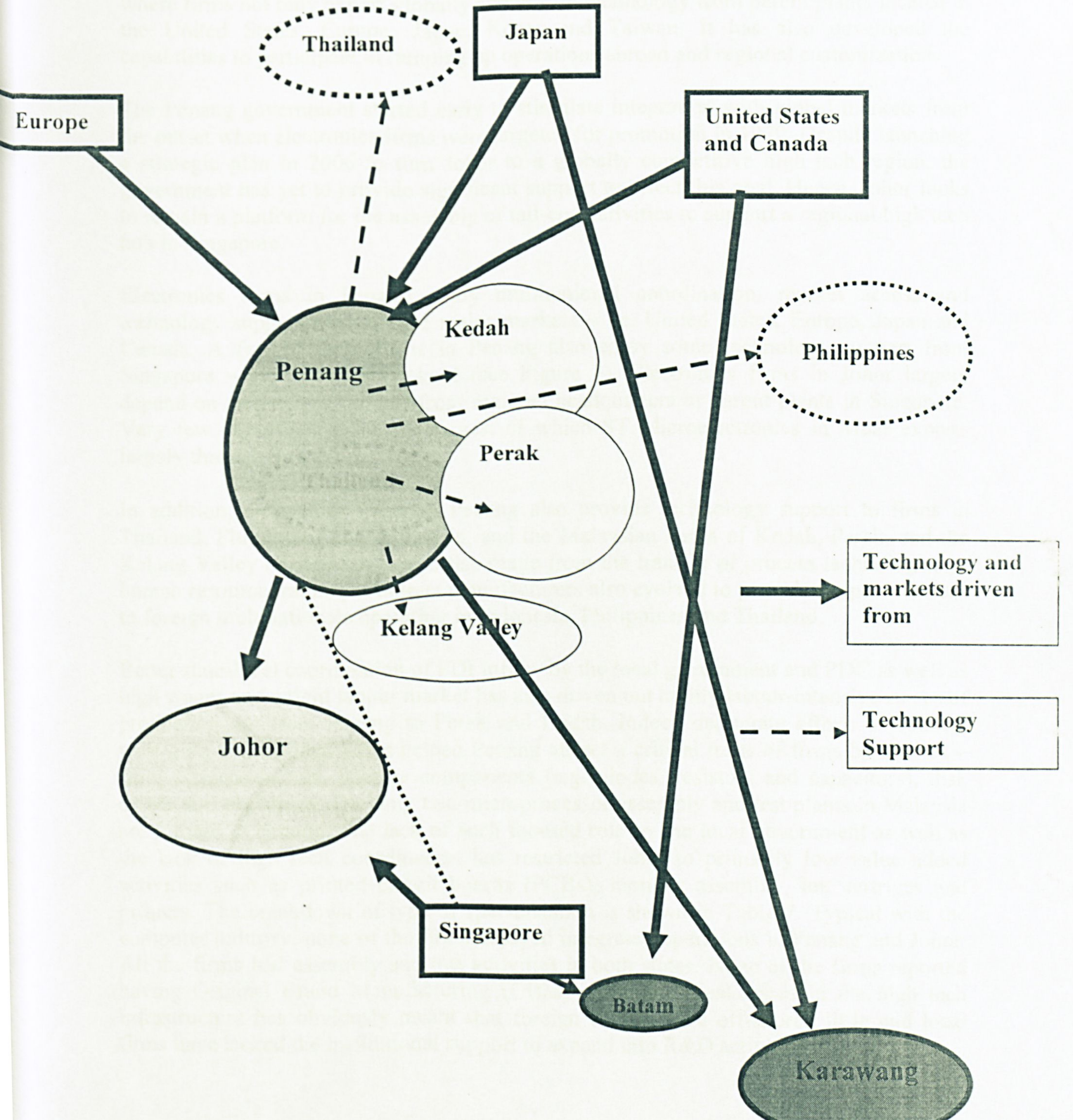


Table 1
Variables, Proxies and Measurement Formulas, Electronics Firms, Indonesia and Malaysia, 2004

Variable	Proxies	Specification
Labour productivity		VA divided by workforce
Export intensity		Exports in output
Skills intensity		Skilled, technical and professional personnel in workforce
Wages		Actual monthly wages in ringgit
HR	Training expenditure in payroll, cutting edge HR practices, scale of HR operation (training centre (4), department (3), staff with training responsibility (2) and training undertaken externally (1)	Normalized using formula: $(x_i-x_{min})/(x_{max}-x_{min})$
Process Technology	Age of machinery and equipment, cutting edge process (inventory and quality) technology (TPM, TQM, JIT, MRPI, MRPII), expenditure on physical reorganization of the firm as a share in sales.,	Normalized using formula: $(x_i-x_{min})/(x_{max}-x_{min})$
Product R&D expenditure	Product R&D expenditure in sales	Actual percentage
Product RD	Product R&D expenditure in sales, Product R&D personnel in workforce	Actual percentage

Table 2
Technological Intensities , Electronics Firms, Indonesia and Malaysia, 2005

Knowledge depth	HR	Process	Product
Simple activities (1)	On the job and in-house training	Dated machinery with simple inventory control techniques	Assembly or processing of low value added components
Minor improvements (2)	In-house training and performance rewards	Advanced machinery and problem solving	Precision engineering and CKD assembly
Major improvements (3)	Extensive focus on training and retraining; staff with training responsibility	Cutting edge inventory control techniques, SPC, TQM, TPM	Cutting edge quality control systems (QCC and TQC)
Engineering (4)	Hiring engineers; Separate training department	Process adaptation: layouts, equipment and techniques	Product adaptation
R&D (5)	Hiring R&D personnel and devising new modes of HR development; Separate training centre	Process R&D: layouts, machinery and equipment and processes	Product Development (e.g. ODM and OBM)

Source: Developed from Rasiah (1992)

The paper draws from a larger survey conducted in 2004-2005 on the electronics industry. Information on the computer and related components firms in Penang and Johor was extracted from this survey. The national consultants engaged in the survey used a sampling frame supplied by the national statistics department to select for study. The data collected came from the responses obtained and is shown in Table 3. The response rate was around three times higher for local firms than foreign firms in both states. Unless otherwise stated all information presented are for the year 2004.

Table 3
Breakdown of Sampled Data, Electronics Firms, Malaysia and Indonesia, 2001

	Johor		Penang		Karawang-Batam	
	Foreign	Local	Foreign	Local	Foreign	Local
Population of firms	357	89	379	97	NA	NA
Mailed	250	70	271	68	50	100
Full response	27	25	28	33	22	45
Response rate (%)	10.8	35.7	10.3	48.5	44.0	45.0
Interviewed	18	15	27	17	4	10

Source: UNU-MERIT, World Bank and DFID Survey

4. Systemic Development

This section uses the systemic quad approach to examine the development of the electronics industry in Penang and Johor in Malaysia, and Karawang and Batam in Indonesia. Past work show that infrastructure in Penang and Johor – both basic and high – can be expected to be superior to that in Karawang-Batam. Booth (1998, 1999), Pangestu (1993), Prawiro (1998), Thee (2000), Rasiah (1993b) and Thee and Pangestu (1998) have discussed extensively institutional failure in Indonesia. The focus in the section is to examine how strongly developed are the four pillars of the systemic quad facing these firms in Penang and Johor, and Karawang and Batam.

Basic Infrastructure

Both Penang and Johor enjoy fairly good basic physical infrastructure with strong links to the modern North-South Highway. In addition, Johor is located just across the causeway from Singapore in the North where a vibrant industrial region has emerged. Batam's basic infrastructure is fairly developed. In addition Batam is also located across Singapore in the South. Karawang is located Southeast of Batam. Basic infrastructure in the export processing zones in Karawang is relatively good. Yet, basic infrastructure coordination in the more congested Penang is superior to that in Johor, and Karawang-Batam (see Table 4).

Smooth coordination between the state's Penang Development Corporation and firms was the basis behind rapid improvements in the provision of basic infrastructure in Penang. Indeed, the coordination of the Free Trade Zone Penang Companies Association (FREPENCA) with PDC led to the Penang government expanding its airport to world class status in 1978. Similarly, PDC also helped strengthen links between the power supply, waterworks, customs, police, housing, transport and immigration departments to ensure that firms located in Penang faced minimal logistics problems.

Table 4
Basic Infrastructure, Electronics Firms, Indonesia and Malaysia, 2001

	Foreign			Local		
	Johor	**Penang**	**Karawang-Batam**	**Johor**	**Penang**	**Karawang-Batam**
Secondary school	2.98	3.11	1.45	2.77	2.86	2.12
Health care	3.11	3.15	2.11	3.19	3.17	2.00
Customs	3.12	3.95	2.27	2.81	3.12	1.97
Security	2.75	3.12	2.25	2.98	3.25	1.85
Transport	2.21	3.87	2.03	2.11	3.45	2.09
Telecommunications	3.23	3.17	2.06	3.05	3.47	1.74
N	27	28	22	25	33	45

Note: Likert scale score of firms (0-5 with from none to highest possible rating) used. Figures reported are means.

Source: UNU-MERIT, World Bank and DFID Survey (2004)

High Tech Infrastructure

The high tech infrastructure in Penang is better than that in Johor but the whole country is deficient in R&D labs and R&D human capital. Technological capabilities developed in Penang's electronics firms are significantly higher and varied than electronics firms in Johor. While incoherent federal education and innovation policies denied both states the human capital and knowledge base necessary to stimulate participation in R&D activities, state-oriented institutional development provided the support essential to resolve collective action problems and with that offer greater learning and problem solving opportunities in Penang. Weak capital endowments and the hands-off approach undertaken in Indonesia have left the state of high tech infrastructure facing electronics firms in Karawang-Batam weak. Indeed, interviews show that electronics firms in Batam are engaged in low margin low tech activities with no symptoms of upgrading.

Although federal policies on the development of high tech infrastructure has offered similar environment for the entire Western Corridor that includes the states of Penang and Johor, with the exception of support for R&D – resources such as incentives and grants, labs and R&D human capital – Penang still managed to provide greater high tech synergies than Johor in some areas. The Penang Skills Development Centre in Penang was rated highly by both foreign and local firms. Indeed training institutions in Penang enjoyed a much higher and statistically significant mean Likert scale score than those in Johor (see Table 6). Penang also enjoyed a statistically significant and higher mean for the supply of skilled labour than Johor and Karawang-Batam. In addition to losing skilled workers to Singapore, 5 firms also reported that the lack of skilled labour has restricted their upgrading plans. Whereas firms in Johor reported failed plans to upgrade, firms in Batam did not state any such plans. Only one firm in Karawang reported upgrading successfully.

government sought to industrialize the state. Although these institutions and the links between them were promoted by the federal government across the country since the introduction of the Second Industrial Master Plan (IMP11), the strength of connections and coordination between them and firms, and inter-firm links have been fairly weak in Johor. These relationships are even weaker in Karawang-Batam. Nevertheless, the administration of Batam's export processing zone by Temasik Holdings of Singapore is reported to have helped coordination significantly.

The empirical evidence show that Penang firms are better networked as shown in Table 5 than firms in Johor and Karawang-Batam. Using Likert scale scores, firms were asked to rate the strength of connections and coordination between them and critical institutions, and other firms. Firms located in Penang showed superior rating than firms located in Johor in all the statistically significant two-tailed results. The R&D support means were extremely low in all three regions, but was zero in Karawang-Batam where interviews show that these firms have no R&D labs to link to.

Although Penang's 36 years experience with electronics firms against Johor's 26 years and Karawang-Batam's 16 years would have had a bearing on the degree of integration between the firms and the institutions, interviews also suggest that there has not been much proactive promotion of clustering in Johor and Karawang-Batam. The active promotion of connections and interactions between firms and institutions through both formal and informal institutions can obviously quicken networking.

Table 5
Systemic Networks, Electronic Firms', Indonesia and Malaysia, 2001

	Foreign			Local		
	Johor	**Penang**	**Karawang-Batam**	**Johor**	**Penang**	**Karawang-Batam**
Industry Association	2.17	3.67	1.01	2.05	3.25	1.96
Training institutions	2.01	3.98	1.6	2.15	3.33	1.5
Universities	1.03	2.01	0.91	0.98	1.55	0.99
State Development Authority	2.35	3.57	2.11	2.11	2.63	1.96
R&D support Units	0.05	0.25	0	0.14	0.42	0
Buyer and ancillary firms	1.87	2.45	2.06	1.9	2.33	2.8
N	27	28	22	25	33	45

Note: Likert scale score of firms (0-5 with from none to highest possible rating); Figures reported are means.

The assessment on R&D support produced extremely low scores in all three locations. The supply of R&D human capital yielded very low means irrespective of location or ownership, which is a consequence of the lack of such human capital in Malaysia. Intel, AMD, Hewlett Packard and Dell officials in Penang reported in 2004 their inability to undertake more R&D activities because of limits imposed on the import of foreign human capital. It is unclear if government announcement in 2006 to provide Multimedia Super Corridor (MSC) status to Penang and Johor has effected any changes on firms' conduct on R&D activities. The one local firm engaged in developmental R&D activities in Karawang reported having no problems hiring foreign and local skilled personnel. This firm has wholly internalized its activities owing to the lack of R&D labs specializing on surface mount technologies.

Table 6
High Tech Infrastructure, Electronics Firms, Malaysia and Indonesia, 2001

	Foreign			Local		
	Johor	Penang	Karawang-Batam	Johor	Penang	Karawang-Batam
Supply of skilled labour	1.67	2.25	1.59	1.55	2.01	1.88
University R&D support	1.01	2.25	0.57	1.00	1.55	0.160
R&D labs	0.57	1.15	0	0.35	0.55	0
Training Institutions	2.11	3.25	1.87	2.34	3.11	1.93
R&D incentives	2.45	2.55	0	2.11	2.57	0
R&D grants	0	0	0	0.56	0.77	0
Venture capital	1.55	1.87	0	1.88	2.11	0
N	27	28	22	25	33	45

Note: Likert scale score of firms (0-5 with from none to highest possible rating); Figures reported are means.

Source: Compiled from UNU-MERIT, World Bank and DFID Survey (2004)

Network Cohesion

Greater systemic coordination initiated by the Penang Gerakan Government under the leadership of Lim Chong Eu and closely networked with support from the chambers of commerce, FREPENCA and coordinated by the PDC, helped raise connections and coordination of relationships between firms and institutions in Penang. Although it was only in 1990 that the Penang Industrial Coordination Council was created, informal links between these bodies was already being organized since 1970 when the Penang

Table 7

Technological Capabilities of Electronics Firms, Indonesia and Malaysia, 2001 (Incidence)

Knowledge Depth	HR						Process						Product					
	Johor		*Penang*		*Karawang-Batam*		*Johor*		*Penang*		*Karawang-Batam*		*Johor*		*Penang*		*Karawang-Batam*	
	FO	**LO**	**FO**	**LO**	**FO**	**LO**	**FO**	**LO**	**FO**	**LO**	**FO**	**LO**	**FO**	**LO**	**FO**	**LO**	**FO**	**LO**
(1)	27	25	39	37	22	45	33	28	39	37	22	45	33	28	39	37	22	45
(2)	27	25	39	37	15	27	29	20	39	37	15	27	21	12	39	31	11	21
(3)	27	17	39	36	3	9	23	12	39	33	3	9	17	9	39	25	3	11
(4)	25	9	39	33	0	3	17	7	39	29	0	3	3	3	21	9	0	1
(5)	1	0	11	5	0	1	1	0	11	5	0	1	0	0	3	2	0	1
Total	27	25	28	33	22	45	27	25	28	33	22	45	27	25	28	33	22	45

Source: Compiled from UNU-MERIT, World Bank and DFID Survey (2004)

Table 8
Skills and Technological Intensities, and Wages, Electronics firms, Indonesia and Malaysia, 2001

	Foreign			Local		
	Johor	**Penang**	**Karawang-Batam**	**Johor**	**Penang**	**Karawang-Batam**
SI	0.28	0.43	NA	0.19	0.33	NA
HR	0.42	0.52	0.32	0.37	0.44	0.35
Process	0.53	0.69	0.42	0.31	0.43	0.33
Product	0.03	0.15	0.05	0.01	0.09	0.04
RDExp (%)	0.02	0.17	0.01	0.01	0.11	0.01
W (*US$*)	409	703	219	225	338	183
N	27	28	22	25	33	45

Note: Figures reported refer to means; W are in monthly figures.

Source: Compiled from UNU-INTECH, World Bank and DFID Survey (2004); and ADB survey (2002).

6 Conclusions

This paper used the systemic quad to examine how electronics firms were networked with basic and high tech infrastructure institutions, as well as, the impact of these elements of systemic clustering on technological intensities by taxonomy and trajectory in the states of Penang and Johor in Malaysia, and Karawang-Batam in Indonesia.

The results of the subsequent empirical investigation showed that all the four pillars were better developed in Penang than in Johor and Karawang-Batam, but weaknesses in the high tech infrastructure reduced both foreign and local firms' capacity to undertake R&D activities in all the regions. Penang and Johor enjoyed fairly similar basic infrastructure institutions but better coordination helped firms resolve collective action problems so that firms reported the efficient delivery of these services in the former compared to the latter. Basic infrastructure in Karawang-Batam were inferior to that in Penang and Johor, but firms enjoyed sufficient support in export processing zones to attract participation by low value added electronics firms.

Apart from R&D related support services such as venture capital and IPR environment, firms located in Penang also evaluated the strength of training centres and supply of skilled labour in Penang much higher than in Johor and Karawang-Batam. Firms in Penang also rated connections and degree of coordination between firms and institutions far higher than in Johor. The results clearly show firms are better networked in Penang then in Johor and Karawang-Batam. Lastly, firms in Penang were also better integrated in global markets and value chains than firms in Johor and Karawang-Batam.