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Institutions and Public-Private Partnerships: Learning and Innovation in Electronics Firms in Penang, Johor and Batam-Karawang

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Abstract: Using the systemic quad model, this paper seeks to examine the extent to which electronics firms are linked with the critical pillars of basic infrastructure, high tech infrastructure, global integration and network cohesion, and their impact on knowledge depth and technological capabilities in Penang, Johor, and Batam-Karawang. Penang's superior systemic quad is reflected in higher firm-level knowledge depth and technological capabilities compared to Johor and Batam-Karawang. It is only in HR practices that technological capabilities of electronics firms in the three locations are not very different. The results show that attempts to stimulate technological catch up will require policy efforts to strengthen the four critical systemic pillars.

Keywords: systemic quad, technological capabilities, knowledge, Indonesia, Malaysia

JEL Classifications: L67, O14, O19, O33, O38

1. Introduction

Electronics manufacturing evolved in Southeast Asia when Japanese and American firms relocated assembly activities in Singapore, Malaysia and Philippines in the 1960s, Thailand in the 1970s, Indonesia in the 1980s and Vietnam in 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 capacity of electronics manufacturing to support technological upgrading in Indonesia, Malaysia, Philippines and Thailand.

In addition, assessments of benefits and costs of export processing zones in the Southeast Asian countries tend to be negative (see Warr, 1987, 1989, 1990; Rasiah, 1993). The picture changes somewhat when dynamic instruments are used to examine industrial clustering. Rasiah (2003a, 2003b, 2007) showed that technological depth and synergies have evolved unevenly in Malaysia because of differences in institutions. Given that policy formulation and implementational issues are often governed by the relative strength of coordination between public and private interests (particularly firms), this paper seeks to examine firms' assessment of instruments in three government-targeted regions. It is argued that the goals, composition and depth of public-private interlock are critical in affecting the systemic pillars that are necessary to promote technological upgrading and economic performance in firms.[1]

The systemic quad (see Figure 1) is used to analyze clustering in the industry in the states of Penang and Johor in Malaysia, and Batam and Karawang in Indonesia. Henceforth, Batam and Karawang together is referred to as Batam-Karawang. Four policy pillars that require simultaneous coordination are identified in the systemic quad, viz., (1) basic infrastructure to provide systemic stability and efficiency; (2) high tech infrastructure to provide systemic support for participation in learning and innovation; (3) network cohesion to provide the systemic price, technological and social relationships necessary to drive interactive and interdependent coordination; and (4) integration in global markets and value chains to provide the scale, scope and competition to drive learning and innovation. Typically, the drivers of the quad of systemic pillars come from the relative power relations, in particular political milieus. The concept of public-private partnerships helps in the understanding of these dynamics but the interlocks between the two domains is never horizontal and is often blurred by competing interests. Nevertheless, successful upgrading requires a systematic and focused engagement of the critical actors that shape public private partnerships.

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 Batam-Karawang. 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, and Section 6 completes the article by presenting 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.

Marshall (1890) provided the earliest known elements that constituted a regionally defined set of firms by referring to industrial districts. Young (1928) articulated the advantages industry offers from its differentiating and division of labour potential. In addition to markets and command, Brusco (1982), Piore and Sabel (1982), Becatini (1990), Wilkinson and You (1994), Rasiah (1994), Sengenberger and Pyke (1991) 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.[2] Piore and Sabel (1982), Hirst and Zeitlin (1991) and Loveman and Sengenberger (1991) 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 power of state 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, 1950, 1970; Boudeville, 1966; Hirschman, 1958, 1970; Myrdal, 1957) on regional development. Unlike the concept of clusters which examines the regional dynamics as a network, growth pole was referred to by Perroux (1950) as an industry or a group of firms that drove the growth of other firms and economic activities most in the region: this led to polarization arising from the propulsive development of a firm or industry. Growth poles eventually assumed the meaning of growth polarization and stimulated external economies and linkages. The synergy effects of agglomeration economies have been documented lucidly by Cooke and Morgan (1998), Garofoli (1992), Porter (2001), Scott (1988) and Storper (1995). 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 that were 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 participating in 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.

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) presented 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.

2.1 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., (1) factor conditions; (2) firm strategy, structure and rivalry; (3) demand conditions; and (4) 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.

2.2 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) added 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. For clusters to drive differentiation and division of labour, Best (2001) argued that they must have the capacity to stimulate new species of industries. Rasiah (2002) drew from this logic to explain speciation of industries not new to the universe at the regional level in Penang. Piore and Sabel (1982) 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 the 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. This 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 (2001) 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 diffusion, its focus has been on developed regions. Hence, it lacks the dynamics to address institutional shortfalls that typically characterize underdeveloped regions, which is important to initiate and drive regions lacking a critical mass of specialized firms and organizations.

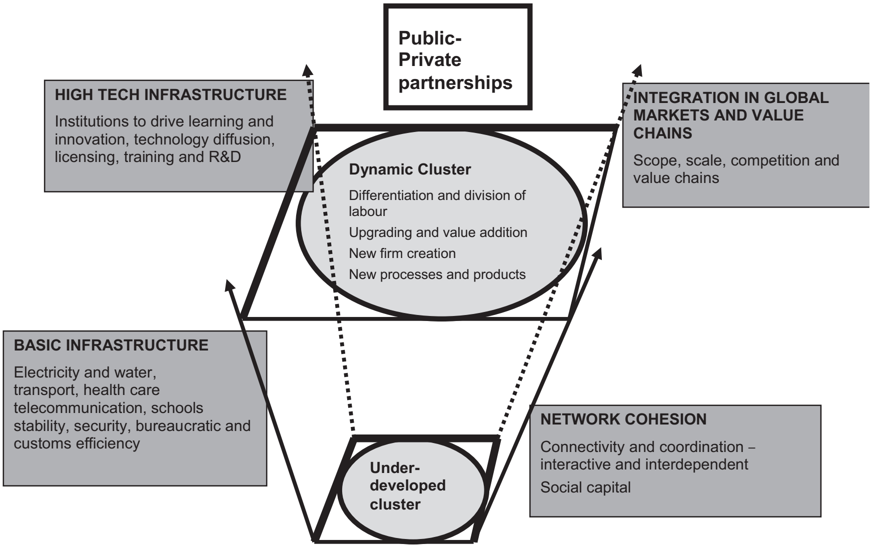
2.3 Alternative Model: The Systemic Quad

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 governments 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, and Batam-Karawang in Indonesia using the lenses of electronics firms.

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. Public-private partnerships that take various different channels and alliances that help bring together particular demands and resolve collective action problems are considered key in the development of the dynamic pillars of clusters (see Figure 1).

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. Critical here is how the objectives of the population (representing both public and private interests) in a particular region shape the institutions that are relevant for achieving their ends (see Figure 1). In a region targeted for material development much of these interests interlock along public-private lines. 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. However, in the end the organizations and firms that emerge must meet the social objectives of communities in the region. More often than not a harmonious network of

Figure 1: Systemic quad



Source: Rasiah (2007).

individuals, firms and organizations cannot be achieved owing to disjunctures in interests. Such a role will purely be promotional. Governments 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 (1990) type 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, innovation, industrial differentiation and new firms. The strategy must be one of mapping regions of their firms, institutions, 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 (e.g. firms and institutions that provide 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 (1973) 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 which 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 of 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, and 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 in the shaded rectangles (see Figure

1). The long term objective of government policy in these economies has been to ensure sustained increase in labour force participation as well as increased 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 1 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 evolved effectively to stimulate technology acquisition through learning by doing, licensing, adaptation, training, standards appraisal mechanisms, a strong intellectual property rights framework to prevent moral hazard problems facing innovators, and R&D. The latter is vital for the continuous evolution of technological capabilities in the cluster.

The third pillar of the dynamic cluster requires that the cluster is globally connected in terms of markets and value chains. Global markets provide the economies of scale and scope and the competitive pressure to innovate, while 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, 1994; 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 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 in terms of both basic and high tech infrastructure, Texmaco has managed to compete globally despite facing tremendous transactions costs.

The fourth pillar 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, for example, Penang in Malaysia (see Rasiah, 2002). The appropriation of knowledge through both the 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.

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, and sustained exports (e.g. Brazil, Indonesia and Philippines). Whereas sustained value addition, differentiation and division of labour and wage increase have 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 Penang and Johor in Malaysia, and Batam-Karawang 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 in 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.

Table 1: Variables, proxies and measurement formulas in electronics firms in 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 operations – 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 in electronics firms in 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 (1994).

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 the firms for this 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 in electronics firms in Malaysia and Indonesia, 2001

	Johor		Penang		Batam-Karawang	
	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-INTECH, World Bank and DFID Survey (2004).

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 Batam-Karawang in Indonesia. Past work shows that infrastructure in Penang and Johor (both basic and high) can be expected to be superior to that in Batam-Karawang. Booth (1998, 1999), Hill (1995), Pangestu (1993), Prawiro (1998), Thee (2000) and Thee and Pangestu (1998) have discussed extensively institutional failure in Indonesia. The focus in this section is to examine how strongly developed are the four pillars of the systemic quad facing these firms in Penang and Johor, and Batam-Karawang.

4.1 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 Batam-Karawang (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

Table 4: Basic infrastructure in electronics firms in Indonesia and Malaysia, 2001

	Foreign			Local		
	Johor	Penang	Batam-Karawang	Johor	Penang	Batam-Karawang
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 ranging from none to highest possible rating used). Figures reported are means.
Source: UNU-INTECH, World Bank and DFID Survey (2004).

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.

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 Batam-Karawang, the airport there does 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 Batam-Karawang 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 Batam-Karawang is worse than that 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-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 and customs are big problems in Batam-Karawang, the coordination of these activities by foreign logistics companies has reduced such problems.

4.2 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 Batam-Karawang 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 5). Penang also enjoyed a statistically significant and higher mean for the supply of skilled labour than Johor and Batam-Karawang. 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.

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 the 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

Table 5: High tech infrastructure in electronics firms in Malaysia and Indonesia, 2001

	Foreign			Local		
	Johor	Penang	Batam-Karawang	Johor	Penang	Batam-Karawang
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 institutes	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 ranging from none to highest possible rating). Figures reported are means.
Source: Compiled from UNU-INTECH, World Bank and DFID Survey (2004).

in developmental R&D activities in Karawang reported having no problems in 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.

4.3 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 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 Batam-

Karawang. Nevertheless, the administration of Batam's export processing zone by Temasik Holdings of Singapore is reported to have helped coordination significantly.

The empirical evidence shows that Penang firms are better networked than firms in Johor and Batam-Karawang (see Table 6). Using Likert scale scores, firms were asked to rate the strength of connections and coordination between them and critical institutions, as well as 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 Batam-Karawang where interviews show that these firms have no R&D labs to link to.

Table 6: Systemic networks in electronic firms in Indonesia and Malaysia, 2001

	Foreign			Local		
	Johor	Penang	Batam-Karawang	Johor	Penang	Batam-Karawang
Industry association	2.17	3.67	1.01	2.05	3.25	1.96
Training institutes	2.01	3.98	1.60	2.15	3.33	1.50
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 organizations	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 ranging from none to highest possible rating). Figures reported are means.
Source: Compiled from UNU-INTECH, World Bank and DFID Survey (2004).

Although Penang's 36 years' experience with electronics firms against Johor's 26 years and Batam-Karawang'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 Batam-Karawang. The active promotion of connections and interactions between firms and institutions through both formal and informal institutions can obviously quicken networking.

4.4 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 Batam-Karawang are integrated in global markets through either direct or indirect import-export links. Penang is better integrated to global markets than Johor and Batam-Karawang as it is a platform where firms export globally and absorb technology from parent plants located in the United States, Europe, Japan, Korea and Taiwan. In addition, it has also developed the capabilities to participate in ramping up operations abroad and regional customization.

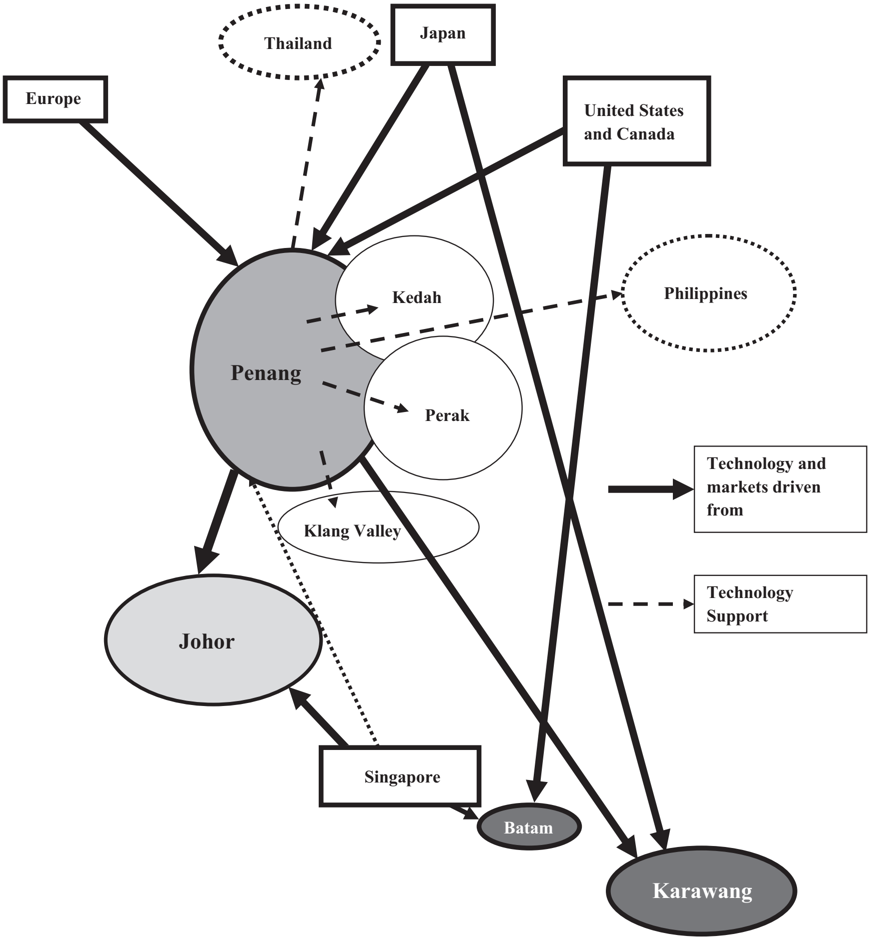
The Penang government started to stimulate integration with global markets from the outset when electronics firms were targeted for promotion in 1970. Despite launching a strategic plan in 2006 to turn Johor into a globally competitive high tech region, the government has yet to provide significant support 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, for example, 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 Klang Valley region. Such expertise ranges 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 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 to 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 a 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),

Figure 2: Market and Value Chain Links of Electronics Firms in Indonesia and Malaysia, 2008



monitor assembly, ink cartridges 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 R&D activities and local firms have lacked the institutional support to participate in such activities.

The local computer assembly firms sell wholly in domestic markets and thus do not enjoy forward linkages in export markets. These firms import

Table 7: Knowledge depth of electronics firms in Indonesia and Malaysia, 2001 (incidence of participation)

Knowledge Depth	HR						Process						Product					
	Johor		Penang		Batam-Karawang		Johor		Penang		Batam-Karawang		Johor		Penang		Batam-Karawang	
	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

Note: FO – foreign owned; LO – local owned.
Source: Compiled from UNU-INTECH, World Bank and DFID Survey (2004).

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.

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 in electronics firms in Batam-Karawang, these 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*. (1990) and Ernst, Ganiatsos and Mytelka (1998), and extended by, Figueiredo (2002), Ariffin and Figueiredo (2004) and Rasiah (2004). Two exercises are carried out in this section: first, a taxonomy locating the depth of participation of firms by human resource (HR), process technology and product technology, and second, comparisons of technological capabilities, skills intensity and wage means by ownership between electronics firms in Johor and Penang.

5.1 Technological Complexity

This sub-section examines technological capabilities by the incidence of knowledge depth achieved in electronics firms in Penang, Johor and Batam-Karawang. 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 all three locations 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 7).

Table 8: Skills, technological intensities and wages in electronics firms in Indonesia and Malaysia, 2001

	Foreign			Local		
	Johor	Penang	Batam-Karawang	Johor	Penang	Batam-Karawang
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: UNU-INTECH, World Bank and DFID (2004) "Survey data on Malaysian industrial firms", compiled by the Institute for New Technologies (INTECH), DCT and Pemm Consultants.

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 Batam-Karawang 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 in the affirmative 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.

5.2 Technological Intensities and Wages

The mean scores of the variables computed 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 per cent 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 Batam-Karawang 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 to such an extent 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 than 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.[3] 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 further upgrade their R&D activities. Singapore managed to ameliorate this problem by having an open-door policy to the world that sought to attract high tech human capital wherever it could be found. 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.

6. Conclusion

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 Batam-Karawang in Indonesia.

The results of the subsequent empirical investigation showed that all the four pillars were better developed in Penang than in Johor and Batam-Karawang, 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 the firms reported more efficient delivery of these services in the former. Basic infrastructure in Batam-Karawang 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 Batam-Karawang. 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 than in Johor and Batam-Karawang. Lastly, firms in Penang were also better integrated in global markets and value chains than firms in Johor and Batam-Batam-Karawang.

The superiority of systemic coordination in Penang over Johor and Batam-Batam-Karawang is reflected in the incidence and depth of participation of firms in technological activities. Apart from HR practices firms – irrespective of ownership firms in Penang showed higher technological intensities (process and product) than firms in Johor and Batam-Batam-Karawang. 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 Batam-Batam-Karawang.

The evidence reinforces the evolutionary argument that institutional and systemic support, driven largely through public-private partnerships, 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 Batam-Karawang. It appears that the nature of political and economic policy actions driven by all three regions has emphasized less on designing and R&D activities. The nature of politico-economic alliances that act on the implementation of strategic technology policy in Malaysia seems to have been coloured by sub-optimal considerations, and hence failed to engender the human capital necessary to stimulate technological upgrading. Penang has performed much better because of the superior manifestation of interest groups in the coordination of provincial level utilities and other public services. Inferior coordination between public and private interests seems to have lowered technological intensities and economic performance in Johor.

Batam-Karawang has been the least developed of the three clusters because of both late timing of integration in the global electronics value chain as well as shortages in development expenditure.

Notes

1. Public-private partnerships are used loosely in the paper to denote the meeting of public and private interests in the provision of services that entail collective actions. Hence, the meaning here is broader that formally defined public-private contracts.
2. The significance of trust in raising economic performance was earlier noted by Mills (1844).
3. These interviews were organized by Asokkumar Malakolunthu.

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