The systemic quad: learning, innovation and productivity in Computer and Component Firms in Penang and Johor, Malaysia

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(first draft)

1. Introduction

This paper examines the impact of the embedding environment on learning, innovation and productivity in the computer and related component industries in Penang and Johor – two regions in Malaysia facing similar federal policies but different state-level coordination. Following a review of the works of economists such as Marshall (1890), Perroux (1950, 1970), Myrdal (1957), Hirschman (1958; 1970) and Krugman (1980), geographers such as Saxenian (1994), Cooke and Morgan (1998), Garofoli (1992), Darwent (1969), Scott (1988) and Storper (1997), industrial district exponents such as Piore and Sabel (1984), Sabel (1989), Sengenberger and Pyke (1988), Hirst and Zeitlin (1991), Brusco (1986), Wilkinson and You (1995), Rasiah (1994) and Becatini (1992) and subsequently business exponents such as Porter (1990) and Best (2001) and evolutionary economists such as Nelson and Winter (1982), Freeman (1986), Lundvall (1988; 1992), Dosi (1982), Pavitt (1984), Kim (1997) and Edquist (2004) the paper constructs a stylized model for evaluating the development of learning and innovation synergies in Penang and Johor.

Four policy pillars that require simultaneous coordination are identified in the systemic quad as the basis for promoting systemically technological and productivity synergies. The four pillars are: 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.

This 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 comparing computer and related component firms in Penang and Johor. Section 3 presents the methodology used and breakdown of data collected from Penang and Johor. Section 4 examines the state of development of the four pillars that drive systemic synergies in the two states. Section 5 assesses the impact of these developments on technological capabilities and productivity in these states. Section 6 finishes with the conclusions.

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2. Towards a Dynamic Model of Learning and Innovation: The Systemic Quad

Following federal government initiatives under the Second Industrial Master Plan (IMP2) in 1996 to promote cluster development in the country, this report uses this approach as the vantage point to examine and frame policy recommendations for promoting Southern Johor as a platform for the operations of globally competitive firms. In doing so it screens two major approaches to clustering, *viz*., Porter's (1990) diamond and Best's (2001) productivity triad. Given that these approaches provide abstractions of theory that is grounded on empirical evidence from already established clusters, an alternative framework developed by Rasiah's (2005), i.e. the systemic quad, is preferred to provide the policy nexus necessary to transform underdeveloped regions.

Industrial districts and clusters in developing economies more often than not originated from the promotion of these industrial estates and export processing zones. Industrial estates and export processing zones such as Shannon International Airport in Ireland, Kaohsiung in Taiwan, Masan and Inchon in the Republic of Korea, Singapore, Bayan Lepas, Sungai Way and Ulu Kelang in Malaysia, Guadalajara in Mexico, Pearl river valley in China expanded into clusters that spread across larger areas. In some economies government provided high tech infrastructure and the requisite incentives in designated areas to stimulate upgrading to higher value added activities in firms. Examples include the Hsinchu Science Park in Taiwan, Shannon International Airport, Tientjin Science Park in China, Singapore, Sao Paolo in Brazil, Multimedia Super Corridor (MSC) in Malaysia. Some of these regions transformed into dynamic clusters enjoying strong differentiation and division of labour and innovation (e.g. Hsinchu Science Park in Taiwan and Singapore, while others have yet to show the dynamism necessary to stimulate sustainable upgrading and innovation (e.g. the MSC in Malaysia).

Three critical concepts have dominated region-centred industrial promotion in developing economies prior to the emergence of clusters, viz., industrial districts, growth pole and export-processing zones. 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.[2] 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

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

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). UNCTAD and UNIDO saw such regional development initiatives through strong government intervention – either through supporting import-substitution in industrial estates or export-orientation in free trade zones – as a major instrument to improve the terms of trade and balance of payments of developing economies. Hirschman (1958; 1970) canvassed strongly for export-orientation to attract the discipline and scale effects of markets to promote competition and backward linkages.

Whereas growth pole and agglomeration strategies had focused on the appropriation of economic synergies from the provision of infrastructure and firms' at proximate locations, clusters in addition emphasized inter-firm and firm-institution connectivity and coordination. The application of theory to the creation and growth of entrepreneurs became more dynamic with the works of Saxenian (1994; 1999) and Best (2001) as clusters enjoying open system frameworks and cohesive integration stimulated the flow of tacit knowledge for new firm creation. The term clustering itself refers to a network of inter-connected firms, institutions and other organizations whose synergy strength depends on strong systemic coordination and network cohesion. Clusters of firms and institutions enjoying strong network cohesion are likely to offer greater flexibility, and generate technological and market synergies than those characterized by truncated operations of individual firms. Causation involving the propellants of synergies in clusters is complex and is not uni-directional (Young, 1928; Best, 2001). Porter (1990) had discussed clustering alongside the four diamonds that drive competitiveness, but offered vague reference to systemic instruments and network cohesion. Marshall (1890), Brusco (1976), Wilkinson and You (1992), Piore and Sabel (1984), Sabel (1995), Sengenberger and Pyke (1988) and Hirst and Zeitlin (1991), Rasiah (1994) and Best (2001) offered a much more dynamic feel of the synergies associated with clustering when discussing the dynamics of industrial districts.[3]

Inter-firm pecuniary relations through sales and purchases is only one channel of inter-firm interactions (Rasiah, 1995). Knowledge flows –rubbing off effects from the interaction between workers (Marshall, 1890), and the movement of tacit and experiential skills embodied in human capital – produce systems synergies (Penrose, 1959). Open integrated clusters encourage inter-firm movement of tacit and experiential knowledge

[3] Variants of these arguments related to transactions costs to explain the existence of firms was advanced by Coase (1937) and Williamson (1990), and the relevance of non-market modes of coordination by Richardson (1960; 1972) and North (1991).

embodied in human capital, which, *inter alia*, distinguishes dynamic from truncated clusters (see Best 2001; Rasiah, 2001). New firms benefited from gaining managerial and technical personnel from older firms in the Silicon Valley irrespective of national ownership. American owned Intel, Dell and Solectron, and Japanese owned Sun Micro Systems hired technical and managerial personnel from old firms in the Silicon Valley.[4] Mature firms gain new ideas and processes to ensure continuous organizational change as some old employees are replaced to make way for fresh ones with new ideas, while new firms benefit from the entrepreneurial and technical – tacit and experiential – knowledge to start new firms (Rasiah, 2001).[5] Saxenian (1994; 1999) offered an impressive documentation of inter-firm movement of human capital, which helped support new firm creation capabilities in the Silicon Valley.

While the prime propellants of cluster dynamics in the successful industrial districts of Emelia Romagna and Silicon Valley are local firms, five important developments have made this approach applicable even to TNC-driven clusters. First, host government investments in basic infrastructure and bureaucratic coordination helped resolve customs, security and labour problems. Second, TNCs have increasingly integrated production at selected host-sites (e.g. Ireland and Singapore). Third, production reorganizations in electronics value chains has encouraged TNCs to subcontract out dissimilar activities to suppliers and contract manufacturers. Fourth, growing horizontal integration has diffused synergies to several layers of firms at host sites (e.g. Israel and Singapore). Fifth, TNCs increasingly rely on host-site institutions to access scarce high tech human capital – through relocation and immigration (e.g. software in India).

Evolutionary economists introduced the concept of national innovation systems (NIS) to explain systemic effects on innovations (Freeman, 1988; Lundvall, 1992; Nelson, 1993).[6] The NIS framework posits the role of a range of economic agents - institutions and firms – which are critical for stimulating innovation synergies. Where national systems fail to meet human capital demand-supply conditions, dynamic clusters such as the Silicon Valley, Ireland and Singapore introduced selective immigration policies (Best, 2001). Some TNCs have also relocated abroad to access human capital where large-scale immigration was difficult (e.g. software companies in India). Although existing work has hardly dealt with the construction of emerging systems, which is necessary for underdeveloped locations, its focus on the necessary links between economic agents is similar to the cluster concept where a mix of firms and institutions is viewed as critical to stimulate innovative activities. The application of the NIS approach to clusters have led to the integration of the development of critical high tech institutions alongside systemic effects that expand inter-firm and firm-institution connectivity and coordination (see Mytelka, 2002; Rasiah, 2004). The use of the cluster approach in NIS amplifies the systemic synergies that arise from dynamic inter-firm and institutional links. Given the strongly overlapping and complementary nature of the two approaches, this paper integrates systemic coordination and network cohesion and examines the NIS from the lenses of firms.

[4] Author Interviews (1995).
[5] Author Interviews (1995; 1999).
[6] Elements of the NIS can be traced to Smith (1776), Hamilton (1791) and List (1885).

In economies with successful upgrading the role of government shifted from a focus on simply basic infrastructure to in addition the provision of high tech infrastructure. The discipline, and scale and scope effects of markets and the role of government in guiding markets and providing public goods were important in all rapid industrializers (see Chang, 2003). In addition, trust-loyalty (social capital) was also argued by Richardson (1960; 1973), North (1972), Sabel (1982), Piore and Sabel (1984), Burchell and Wilkinson (1997), Rasiah (1994), and Rasiah and Lin (2005) to have been critical. The simultaneous and often overlapping role of trust alongside markets and government helped synergize clusters in successful regions. Hence, networking among human capital based firms and institutions have been vital to stimulate synergies in dynamic clusters.

A number of definitions exist on clusters. Some focus more on the physical elements that constitute a cluster, others on connectivity and coordination, while others still on all of them. Porter (1990) Best (2001) developed this further by examining the conditions that drove entrepreneurship and new species of industries regionally. Rasiah (2002) discussed the synergistic advantages the Silicon Valley and Route 128 have introduced to the continuous reinvention of old firms and the birth of new firms in clusters where there exists ease of movement of human capital – tacit to start new firms and new to galvanize old firms. Guerreri , Iammarino and Pietrobelli (2003) summarized the three dominant types of industrial clusters that have emerged to compete at the global frontier, viz., one, the atomized Marshallian small firms that typify Italy and Taipei,China, two, a handful of large firms defining the roles of suppliers in Detroit, and three, the single large mother firm defining the roles of suppliers in Japan. Two major contemporaneous definitions are examined here before a working definition is framed for use in this study, *viz*., Porter (1990) and Best (2001).

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 competively 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 generally evolve along industry lines over the years as tacit knowledge snowballs over from tradition. These industries then stimulate 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) 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 a 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.

Towards a Synthesis

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.

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, 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.

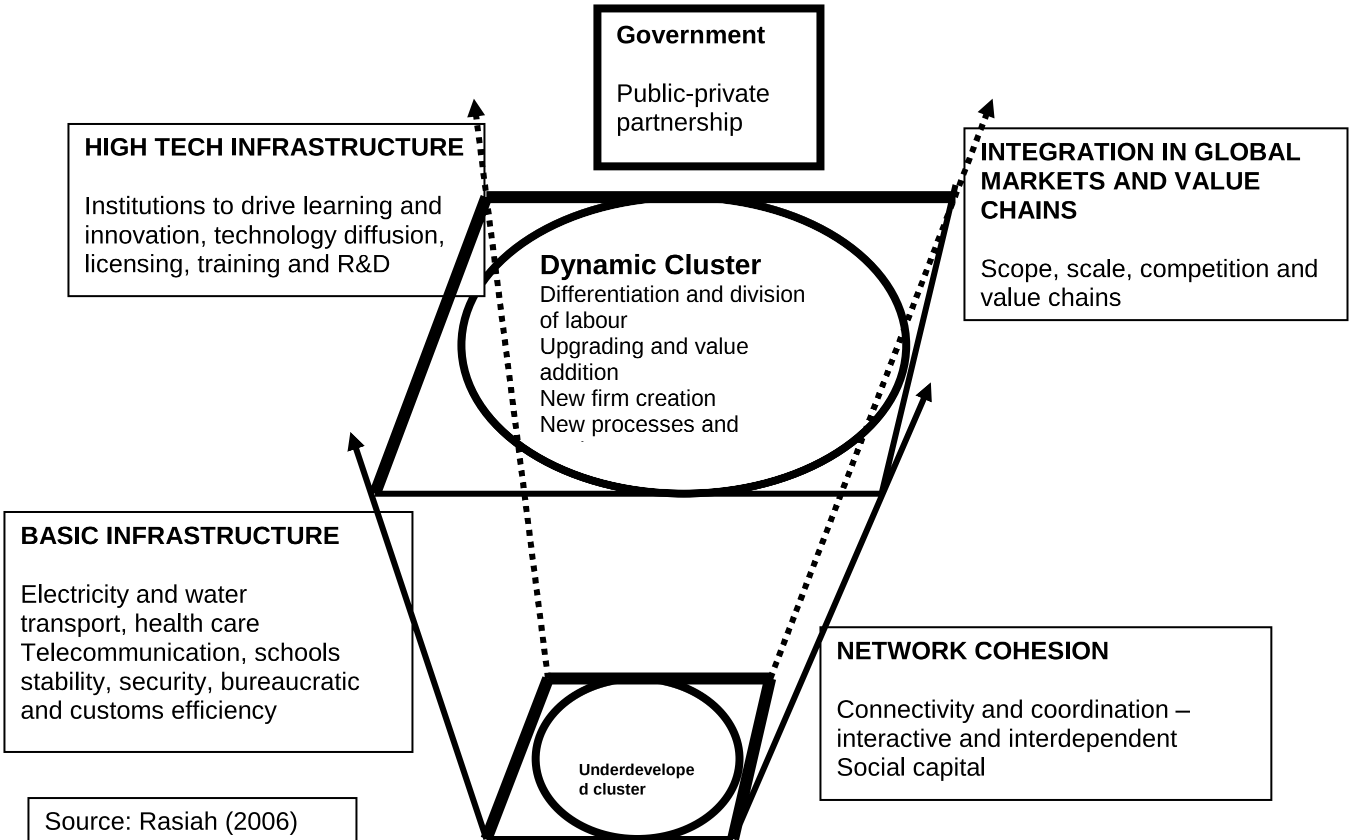
Most efficiently governed industrial estates and EPZs in the past generally only focused on the elements that are shaded blue. The long term objective of government policy in these economies has been to ensure sustained increase in labour force participation, and wages so that the broader objectives 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 effectively to stimulate technology acquisition through learning by doing, licensing, adaptation, training, standards appraisal mechanisms, a strong intellectual property right framework to provent 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 cadcam 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 brandname 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 clusters defined by truncated operations. Connectivity and coordination is critical for knowledge flows – beyond simply codified information that markets alone 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.

Figure 1: Systemic Quad



Source: Rasiah (2006)

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 two-tailed t-tests to examine statistical differences of firms' assessment of institutional and systemic instruments facing them in the two states, as well as, technology, wages and productivity of foreign and local firms in the two states. 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, productivity and export-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).

Table 1
Variables, Proxies and Measurement Formulas, Computer and Related Component Firms in Johor and Penang, 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, 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	Normalized using formula: $(x_i - x_{min})/(x_{max} - x_{min})$

Table 2
Technological Capabilities, Computer and Related Component Firms, 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, SPC, TQM, TPM	Cutting edge inventory control techniques	Cutting edge quality control systems (QCC and TQC)
Engineering (4)	Hiring engineers	Process adaptation: layouts, equipment and techniques	Product adaptation
R&D (5)	Hiring R&D personnel and devising new modes of HR development	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, Computer and Related Component Firms, Johor and Penang, 2004

	Johor		**Penang**	
	Foreign	**Local**	**Foreign**	**Local**
Population of firms	401	100	362	90
Mailed	301	75	271	68
Full response	33	39	28	37
Response rate	10.3	32.0	11.0	31.1

Source: UNU-MERIT, World Bank and DFID Survey

4. Systemic Development in Penang and Johor

Having introduced the systemic quad, this section uses this approach to examine the development of the computer and components industry in Penang and Johor. Although very few firms assembler computers in Malaysia, the number of firms engaged in computer component (e.g. capacitors, resistors, PCBs, diodes and semiconductor chips) and completely knocked down (CKD) parts (e.g. monitors, keyboards and LCD screens) assembly is large. 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.

Basic Infrastructure

Both Penang and Johor enjoy fairly good basic physical infrastructure with strong links to the modern North-South Highway. Johor is in addition located just across the causeway from Singapore where a vibrant industrial region has emerged. Yet, basic infrastructure coordination in the more congested Penang is superior to that in Johor (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.

Whereas Penang enjoys a world class airport to undertake quick cargo transport, Johor's 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 the airport the airport there does have the demand to support world class flight facilities. Hence, with the exception of SGS Malaysia (located in Muar) no other semiconductor firms have relocated in Johor while there are over 10 semiconductor firms in Penang.

Table 4
Basic Infrastructure, Computer and Related Component Firms in Johor and Penang, 2004

	Foreign		***t***	**Local**		***t***
	Johor	**Penang**		**Johor**	**Penang**	
Water	3.12	3.11	-0.02	3.14	3.01	-0.31
Electricity	3.18	3.97	2.44**	3.25	3.04	-0.65
Primary and secondary schools	3.57	3.68	0.01	3.45	3.23	-0.10
Health care	3.11	3.19	0.07	3.17	3.12	-0.04
Customs	3.45	3.98	1.45	2.95	3.27	1.37
Security	2.75	3.12	2.01**	2.98	3.25	1.45
Transport	2.21	3.87	2.52**	2.11	3.45	2.72*
Telecommunications	3.55	3.67	0.45	3.12	3.55	0.91
N	33	28		39	37	

Note: Likert scale score of firms (0-5 with from none to highest possible rating); * and ** - statistically significant at 1% and 5% respectively.

Source: UNU-INTECH, 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 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.

The empirical evidence showing that Penang firms are better networked is shown in Table 5. 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 results for R&D support was statistically insignificant, which is reflected by a lack of significant R&D relationships between firms (both foreign and local) and R&D institutions (e.g. university R&D, Malaysian Institute of Microelectronics System and the incubators put up in technology parks by the government). Networks between local firms and standards organizations were only statistically significant (at 5% level). Interviews showed that local firms mainly sought the international standards organization 9000 series certification from the Standards and Industrial Research Institute of Malaysia (SIRIM). Five foreign firms who qualified for this series in the 1990s reported no longer being interested in the series.

Table 5
Systemic Networks, Computer and Related Component Firms', Penang and Johor, 2004

	Foreign		***t***	**Local**		***t***
	Johor	**Penang**		**Johor**	**Penang**	
Ministries						
Industry Association	2.17	3.67	3.15*	2.05	3.25	2.95*
Training institutions	2.01	3.98	3.25*	2.15	3.33	3.02*
Universities	1.03	2.01	3.11*			
State Development Corporation	2.35	3.57	2.75*	2.11	2.63	2.25**
R&D support Units	0.1	0.3	0.01	0.2	0.5	0.10
Incubators	0	0	0.00	0	0	0.00
Standards Organization	2.01	2.15	0.70	1.88	2.54	2.45**
Horizontal inter-firm links	1.87	2.45	2.68*	1.90	2.33	1.88
Vertical inter-firm links	2.11	2.95	2.45**	2.00	2.47	2.01**
Complementary Supplier links	2.21	3.13	2.97*	2.02	2.94	2.54**
N	332	28		39	37	

Note: Likert scale score of firms (0-5 with from none to highest possible rating); * and ** - statistically significant at 1% and 5% respectively.

Source: Compiled from UNU-INTECH, 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. Although electronics firms have expanded strongly in Penang since 1970 (Penang Electronics was the first electronics firm, which was followed by Orion and National Semiconductor in 1971) whereas electronics firms only began to move in strongly in Johor from the 1980s, the reasons for   have more to do with systemic coordination and institutional development. 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. This section explains these differences.

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. In addition to losing skilled workers to Singapore, 5 firms also reported that the lack of skilled labour has restricted their upgrading plans.

The assessment on R&D produced extremely low scores. 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.

Table 6
High Tech Infrastructure, Computer and Related Component Firms in Penang and Johor, 2004

	Foreign		t	Local		t
	Johor	Penang		Johor	Penang	
Supply of skilled labour	1.67	2.25	2.21**	1.55	2.01	1.99**
Supply of engineers and R&D human capital	0.57	1.15	1.35	0.35	0.55	1.35
Industry-University collaboration	1.57	2.11	1.88	1.63	1.71	0.01
Standards Organization	1.87	2.01	0.60	1.57	2.31	1.55
Training Institutions	2.11	3.25	2.97*	2.34	3.11	2.45**
R&D incentives	2.45	2.55	0.10	2.11	2.57	1.55
R&D grants	0.00	0.00	0.00	0.56	0.77	0.99
IPR governance	1.25	1.91	1.13	1.55	1.75	1.05
Venture capital	1.55	1.87	0.65	1.88	2.11	0.33
N	33	28		39	37	

Note: Likert scale score of firms (0-5 with from none to highest possible rating); * and ** - statistically significant at 1% and 5% respectively.

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

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. Penang is better connected to global markets. 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.

Computer and related component 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). Computer and related component firms in Johor largely depend on technology support from regional headquarters or parent plants in Singapore. Very few exceptions exist, the largest of which SGS in Muar exports largely through Singapore.

In addition, computer and related component 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 2: Market and Value Chain Links of Computer and Peripherals Firms in Penang and Johor, 2004

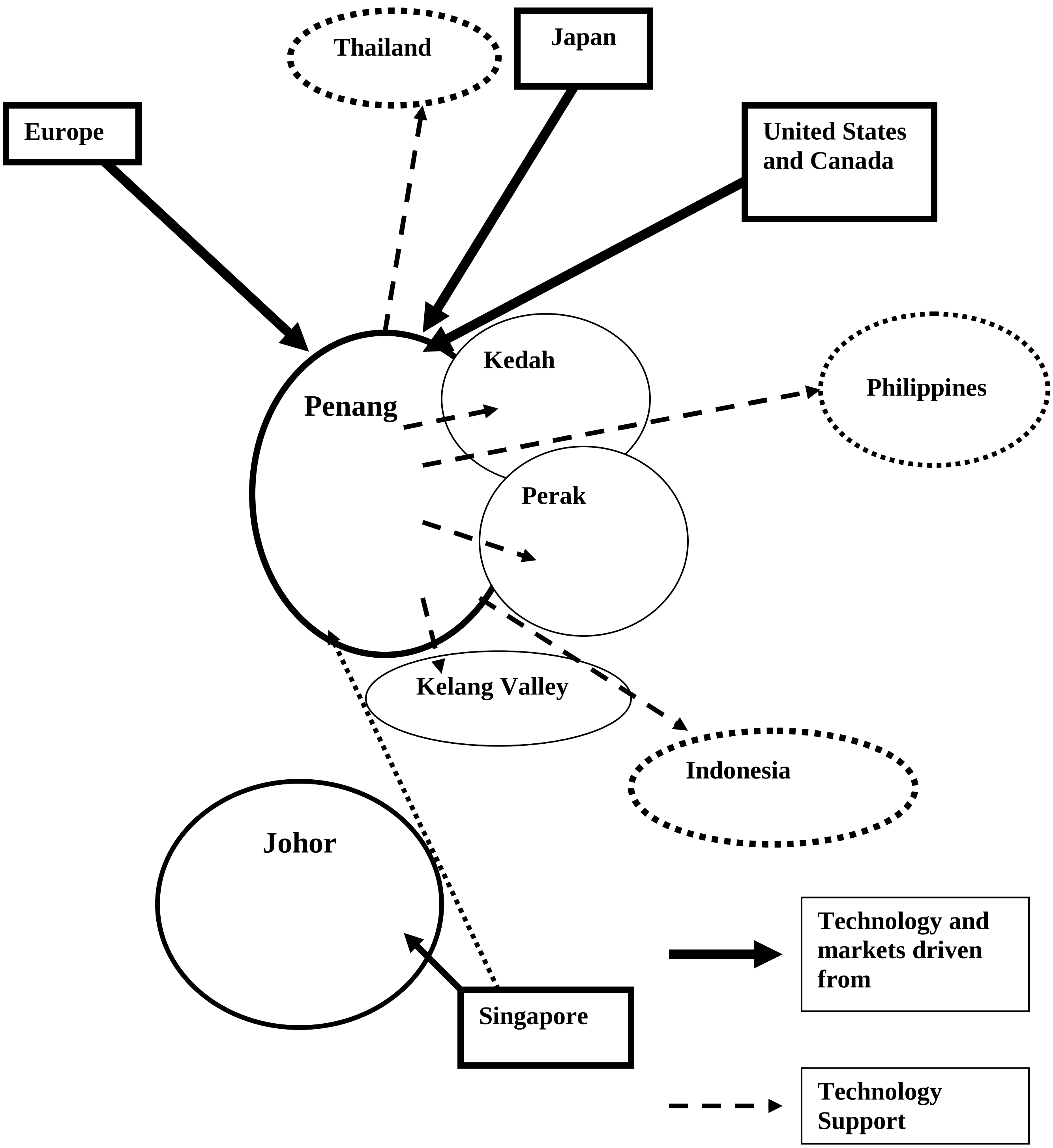


Table 7
Specialization, Computer and Related Component Firms, Penang and Johor, 2004

	Foreign		Local	
	Johor	Penang	Johor	Penang
Assembly and test	33	28	39	37
Microprocessors	0	2	0	0
Memory chips	1	5	0	1
Integrated operation	0	0	0	0
Contract manufacturer	5	13	1	5
Complementary supplier	11	7	1	4
Scale-based	18	21	7	3
Scope-based	15	7	26	34
OEM	affiliate	affiliate	7	29
Designing	0	3	0	2
OBM	affiliate	affiliate	0	0
N	33	28	39	37

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

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. 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.

Knowledge Depth

This sub-section examines technological capabilities by the incidence of knowledge depth in the computer and peripheral firms in Penang and Johor. 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 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.

Table 8
Technological Capabilities of Computer and Component Firms in Johor and Penang, 2004 (Incidence)

Knowledge Depth	HR				Process				Product			
	Johor		*Penang*		*Johor*		*Penang*		*Johor*		*Penang*	
	Foreign	Local	Foreign	Local	Foreign	Local	Foreign	Local	Foreign	Local	Foreign	Local
(1)	33	28	39	37	33	28	39	37	33	28	39	37
(2)	33	28	39	37	29	20	39	37	21	12	39	31
(3)	33	19	39	36	23	12	39	33	17	9	39	25
(4)	27	12	39	33	17	7	39	29	3	3	21	9
(5)	1	0	11	5	1	0	11	5	0	0	3	2
Total	33	28	39	37	33	28	39	37	33	28	39	37

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

Technological Intensities, wages and productivity

Two-tailed t-tests comparing the means of Johor and Penang firms by ownership is shown in Table 9. 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.

The statistical differences by ownership between Penang and Johor involving skills intensity (SI), wages and labour productivity were highly significant (see Table 9). 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.

Higher skills intensities and wages have also translated into higher labour productivity in firms in Penang compared to firms in Johor. The statistical results from the two-tail t-tests (at 1%) by ownership were highly significant (see Table 9). Foreign firms were more productive than local firms even when the observations from both states were pooled. Local firms in Penang were also significantly more productive than their counterparts in Johor. Hence, the stronger embedding environment in Penang compared to Johor – especially the role of the local government and intermediary institutions (e.g. the PDC and the industry associations) – has attracted higher technological and skills intensities, which in turn has manifested in higher wages and labour productivity in the former compared to the latter.

Singapore continues to attract skilled Malaysian workers with salaries reaching no less than three times what electronics firms pay in Johor. All 15 firms interviewed in Johor in March 2006 reported losing skilled workers to Singapore for wages exceeding 3 times more.[7] 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

[7] These interviews were organized by Asokkumar Malaikolunthu.

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.

Table 9
Technological Capabilities of Computer and Component firms, Two-tailed t-tests, Penang and Johor, 2004

	Foreign		t	Local		t
	Johor	Penang		Johor	Penang	
SI	0.28	0.43	2.67*	0.19	0.33	2.59*
HR	0.42	0.52	0.96	0.37	0.44	0.53
Process	0.53	0.69	1.78	0.31	0.43	0.45
Product	0.03	0.15	2.01**	0.01	0.09	2.11**
RDExp (%)	0.02	0.19	2.43**	0.01	0.13	2.21**
VA/L (*MYR*)	117,201	185,377	3.17*	33,777	63,421	3.77*
W (*MYR*)	1567	2881	3.43*	901	1363	2.97*
N	33	39		28	37	

Note: * and ** - statistically significant at 1% and 5% respectively; VA/L are in annual figures while W are in monthly figures.

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

6 Conclusions

This paper developed an ontologically defined model, i.e. the systemic quad, to compare learning and innovation in computer and related component firms in the states of Penang and Johor in Malaysia.

The results of the subsequent empirical investigation showed that all the four pillars were better developed in Penang than in Johor, though, weaknesses in the high tech infrastructure reduced both foreign and local firms' capacity to undertake R&D activities in both states. Penang and Johor enjoyed fairly similar basic infrastructure institutions but better coordination helped firms helped resolve collective action problems so that firms reported for efficient delivery of these services in the former compared to the latter. 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. 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. Lastly, firms in Penang were also better integrated in global markets and value chains than firms in Johor.

The superiority of systemic coordination in Penang over Johor is reflected in the incidence and depth of participation of firms in learning, innovation and labour productivity. Apart from HR practices firms – irrespective of ownership - in Penang showed higher technological intensities (process and product) than firms in Johor. 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. This strategy has also enabled firms in Penang to enjoy higher labour productivity than firms in Johor.

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. 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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