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Can Malaysia Escape the Middle-Income Trap?

A Strategy for Penang

Shahid Yusuf
Kaoru Nabeshima

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Abstract

How can Penang upgrade and diversify its economy? This paper addresses this question using a number of methodologies that have been developed for assessing competitiveness and identifying the direction of future industrial evolution. The results show that although Penang was successful in attracting foreign direct investment to the electronics industry, this has not translated into a deepening of industrial capabilities or the nurturing of innovation capacity in Penang. No large Malaysian firms in Penang have taken the lead in innovation and there is little new entry by local firms, despite incentives provided by local and national governments are generous. Universiti Sains Malaysia, the principal university in Penang, is contributing through provision of skills, and it is beginning to multiply university industry linkages. However, the university's research activities are too limited and too diffuse to significantly initiate innovation by local industry. Under the current circumstances, and given its relatively small size, Penang will have to try much harder to strengthen its competitive advantage in its most important industry —electronics—through actions that build research capital. It will also have to increase its efforts to develop the potential of other value-adding activities, such as medical services and tourism. A strategy focused on localization economies is likely to be the most feasible option.

This paper—a product of the Director's Office, Development Research Group—is part of a larger effort in the department to study industrial change and development of innovation capabilities in East Asian economies. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. The author may be contacted at syusuf@worldbank.org.

Can Malaysia Escape the Middle-Income Trap?
A Strategy for Penang*

Shahid Yusuf and Kaoru Nabeshima
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Starting with the investment by Matsushita in 1972, foreign direct investment (FDI) has enabled Penang to become a manufacturing hub specializing in electronics and electrical machinery. Penang acquired manufacturing capabilities through a concentration of multinational corporations (MNCs) operating in the electronics industry in the city's industrial parks. In spite of the pull exerted by other locations in Asia, there is little imminent risk of a mass exodus of these MNCs. Most MNCs have focused on downstream activities, in particular assembly and testing although some engage in design and development. They are in Penang because the quality of the workforce is at least on par with that of neighboring countries, the incentives and overhead costs are competitive, local suppliers of components and support services are experienced and reliable, the logistical arrangements are efficient, and given the need to maintain multiple production sites so as to contain risks, Penang compares favorably with other locations in the region.

Thanks to the export competitiveness of the manufacturing activities in Penang – and in Malaysia more generally – wages have risen steadily. This is a positive development but it is undermining the "low cost" model of development and necessitating a move up the value chain. In other words, the future of the electronics and electrical engineering industry and of other industries rests upon a successful transition to profitable and higher value adding activities. Instead of the traditional 'high volume, low mix' production of electronic products, Penang's industry must graduate to a 'low volume, high mix' of technology intensive products.[1] Moreover, the future growth of Penang's economy also calls for further diversification of tradeable activities so as to complement the core electronics industry and nurture new leading sectors.

I. Strategic Options

Penang's accumulated comparative advantage argues for a deepening of the local capabilities in electronics and electrical engineering in order to maintain growth momentum during the next 5-7 years. There is probably no other alternative. However,

[1] GBC Scientific Equipment, an Australian firm, is attempting to do so in Penang.

the prudent strategy for the longer term must be multi-stranded. Other industries need to be developed to supplement electronics or to displace it should electronics begin migrating elsewhere. This development strategy could have the following strands:

- Backward linkages from the current suite of electronics manufacturing activities to technology intensive components and services, some of which stimulate and leverage research done locally. This is the logical development path as traced by the analysis presented below and one which has been favored for some time. But experience has demonstrated that such backward integration will depend upon the initiative of Malaysian firms, institutions and entrepreneurs. MNCs are likely to be fairly passive participants. Not opposing such a push but not aggressively assisting it either.
- Diversification into product lines which leverage expertise in current lines of business. For example, electronic and IT equipment for medical purposes are possibilities, as are biopharmaceuticals although growing a profitable biotech subsector is a far more demanding proposition. Penang's size and skill mix limits the scope for radical departures. The pool of skills is too small and specialized and the diversity of talent is limited. Building on core competence would be the sensible approach and that competence is in electronics and electrical engineering.
- Enhancing the economic footprint of the medical services and of the education sectors by increasing the export of their services and multiplying their linkages with other manufacturing industries and services in Penang.
- Developing tourism by refurbishing and leveraging the cultural assets of the city so as to maximize the benefits to the local economy from both short term visitors and others who are persuaded to make Penang their second home.

In this paper, we will concentrate on the growth potential inherent in the first three strands, starting with an analysis of the scope for diversification from the current mix of industrial activities.

II. Export Performance of Penang

Penang accounts for 31% of Malaysia's exports and close to half of the electronics exports of Malaysia (see Table 1). The bulk of its exports are electronics products mainly shipped by air, reflecting their higher value-to-weight ratio. Below we examine the evolution of Penang's export mix and possible future directions.

Table 1: Penang's Share of Exports in Malaysia

	1995	2000	2007
Penang's exports as a share of Malaysia's exports	23.6	27.7	31.0
Penang's electronics exports as a share of Malaysia's electronics exports	35.8	36.1	49.0

Source: UN Comtrade

Revealed Comparative Advantage

Revealed comparative advantage (RCA) is a technique which is frequently used to analyze export competitiveness.[2] In 1995, Penang's strength was in resource-based

[2] Revealed comparative advantage (RCA) is often used to measure the export competitiveness of a commodity (or an industry) of a country. It is a ratio of two shares: the share of a commodity's export in the overall exports of a country; and the share of the same commodity in global exports (see the equation below).

$$RCA = \frac{Export_{ij} \Big/ \sum_i Export_{ij}}{\sum_j Export_{ij} \Big/ \sum_i \sum_j Export_{ij}},$$

where i denotes the commodity and j denotes countries (over the set of commodities, i = 1…I, and over the set of countries, j = 1…J). An RCA greater than one means that the country has a "revealed comparative advantage" in that commodity. This is assuming that the numerator and the denominator are increasing. If that is not the case, greater care is needed in interpreting the results. Rearranging the equation, one can obtain,

$$RCA = \frac{Export_{ij} \Big/ \sum_j Export_{ij}}{\sum_i Export_{ij} \Big/ \sum_i \sum_j Export_{ij}}.$$

The numerator is now country j's market share of commodity i in the world export market and the denominator is country j's share of exports in overall world exports. Thus, even if country j is losing

and medium tech goods along with an assortment of other items (see Table 2). Tin and clothing headed the list. There were only four high-tech products among the top 20. By 2000, the composition had changed dramatically. Tin was no longer at the top (reflecting the lower tin production overall in Malaysia). It was replaced by apparel. The number of resource-based products had decreased to three and the number of high-tech goods had risen to seven. In fact, eleven of the top 20 products were electronic or audio-visual products (see Table 3). Between 2000 and 2007, the composition of the top 20 items shifted further towards high-tech products. Computer-related products continued moving up the list of exports enjoying the greatest comparative advantage and only three resource-based products remained in the top 20 (see Table 4).

market share, if overall exports from country j relative to world exports are shrinking faster, the RCA will be greater than one (S. Lall, Weiss and Zhang 2006).

Table 2: Penang's Top 20 Commodities Based on Revealed Comparative Advantage, 1995

sitc4	RCA	short description	Lall Class
6871	45.03	Tin and tin alloys, unwrought	PP
8482	25.22	Articles of apparel, clothing accessories of plastic or rubber	LT1
7631	24.28	Gramophones and record players, electric	MT3
7628	23.25	Other radio receivers	MT3
7622	22.27	Portable radio receivers	MT3
2320	17.12	Natural rubber latex; natural rubber and gums	PP
4242	14.95	Palm oil	RB1
6642	14.74	Optical glass and elements of optical glass (unworked)	RB2
6639	13.96	Articles of ceramic materials, nes	RB2
4313	9.67	Fatty acids, acid oils, and residues; degras	RB1
7621	9.11	Radio receivers for motor-vehicles	MT3
7764	8.99	Electronic microcircuits	HT1
2231	8.92	Copra	PP
7512	8.25	Calculating, accounting, cash registers, ticketing, etc, machines	HT1
4312	8.01	Hydrogenated animal or vegetable oils and fats	RB1
7599	8.00	Parts, nes of and accessories for machines of headings 7512 and 752	HT1
8973	7.37	Precious jewelry, goldsmiths' or silversmiths' wares	LT2
6281	5.94	Hygienic, pharmaceutical articles of unhardened vulcanized rubber	RB1
7763	5.16	Diodes, transistors, photocells, etc	HT1
7722	4.79	Printed circuits, and parts thereof, nes	MT3

Note: PP: Primary Products, RB1: Agro-Based, RB2: Other Resource-Based, LT1: Textile, garment & footwear, LT2: Other, Low-Technology, MT1: Automotive, MT2: Process, MT3: Engineering, HT1: Electronic & Electrical, and HT2: Other, High-Technology.
Source: authors' calculation

Table 3: Penang's Top 20 Commodities Based on Revealed Comparative Advantage, 2000

sitc4	RCA	short description	Lall Class
8482	25.03	Articles of apparel, clothing accessories of plastic or rubber	LT1
6642	22.42	Optical glass and elements of optical glass (unworked)	RB2
7628	21.49	Other radio receivers	MT3
6871	19.21	Tin and tin alloys, unwrought	PP
4313	15.22	Fatty acids, acid oils, and residues; degras	RB1
2320	11.69	Natural rubber latex; natural rubber and gums	PP
7521	10.43	Analogue and hybrid data processing machines	HT1
7599	10.42	Parts, nes of and accessories for machines of headings 7512 and 752	HT1
7722	7.62	Printed circuits, and parts thereof, nes	MT3
7622	7.54	Portable radio receivers	MT3
8812	7.36	Cinematographic cameras, projectors, etc, parts, accessories, nes	HT2
7764	6.15	Electronic microcircuits	HT1
8974	5.95	Other articles of precious metals or rolled precious metals, nes	LT2
7768	5.89	Crystals, and parts, nes of electronic components of heading 776	HT1
7621	5.44	Radio receivers for motor-vehicles	MT3
7763	5.07	Diodes, transistors, photocells, etc	HT1
8973	4.78	Precious jewelry, goldsmiths' or silversmiths' wares	LT2
4242	4.51	Palm oil	RB1
7642	4.23	Microphones; loud-speakers; audio-frequency electric amplifiers	HT1
7638	4.04	Other sound recording and reproducer, nes; video recorders	MT3

Note: PP: Primary Products, RB1: Agro-Based, RB2: Other Resource-Based, LT1: Textile, garment & footwear, LT2: Other, Low-Technology, MT1: Automotive, MT2: Process, MT3: Engineering, HT1: Electronic & Electrical, and HT2: Other, High-Technology.
Source: authors' calculation

Table 4: Penang's Top 20 Commodities Based on Revealed Comparative Advantage, 2007

sitc4	RCA	short description	Lall Class
6642	30.75	Optical glass and elements of optical glass (unworked)	RB2
7631	26.55	Gramophones and record players, electric	MT3
4313	24.25	Fatty acids, acid oils, and residues; degras	RB1
7522	21.51	Complete digital data processing machines	HT1
6871	20.13	Tin and tin alloys, unwrought	PP
8482	18.72	Articles of apparel, clothing accessories of plastic or rubber	LT1
7528	18.17	Off-line data processing equipment, nes	HT1
7628	16.48	Other radio receivers	MT3
7768	12.88	Crystals, and parts, nes of electronic components of heading 776	HT1
8748	10.69	Electrical measuring, controlling, etc, instruments, apparatus, nes	HT2
2320	9.66	Natural rubber latex; natural rubber and gums	PP
7621	9.36	Radio receivers for motor-vehicles	MT3
7764	8.02	Electronic microcircuits	HT1
7622	7.28	Portable radio receivers	MT3
8973	6.91	Precious jewelry, goldsmiths' or silversmiths' wares	LT2
7267	6.85	Other printing machinery; machines for uses ancillary to printing	MT3
7599	6.69	Parts, nes of and accessories for machines of headings 7512 and 752	HT1
6852	6.58	Lead and lead alloys, worked	PP
7763	5.50	Diodes, transistors, photocells, etc	HT1
4242	4.89	Palm oil	RB1

Note: PP: Primary Products, RB1: Agro-Based, RB2: Other Resource-Based, LT1: Textile, garment & footwear, LT2: Other, Low-Technology, MT1: Automotive, MT2: Process, MT3: Engineering, HT1: Electronic & Electrical, and HT2: Other, High-Technology.
Source: authors' calculation

By comparison, for Malaysia as a whole, more than half of the top 10 exports with the highest ratings in 1995 were resource-based products and none were in the high-tech category. Five years later, there were 5 resource-based products and 3 high-tech items among the top 10 exports with the highest RCA. In 2006, the top 10 included five resource-based items, one high-tech item and three medium-tech products. Overall, the impression conveyed by the diverse mix of leading export products is that Malaysia's apparent comparative advantage continues to lie in resource-based products, mainly in wood and palm oil (Yusuf and Nabeshima 2009). However, the revealed comparative advantage of Penang is quite different. Increasingly, Penang's comparative advantage appears to be in high-tech products, especially electronics, telecommunication equipment, and computer-related products, mostly produced in plants owned by MNCs.

Product space analysis

While RCA highlights comparative advantage by examining export shares, it does not indicate the direction a country could take so as to upgrade or diversify its product mix. One problem with any technique attempting to identify products that could be candidates for upgrading is difficulty with the definition of upgrading. The simplest definition calls for the export of goods that are more sophisticated than the ones currently exported. The product-space analysis proposed by Hausmann, Hwang and Rodrik (2007) enables researchers to identify such goods. Their analysis relies on two quantities, PRODY and EXPY. PRODY is calculated at the commodity level and is the weighted average of income of exporting countries. The intuition behind this is that if a rich country is exporting more of a particular commodity, it should be more sophisticated. Thus, each commodity is assigned a PRODY value which represent the sophistication of a product (Hausmann, Hwang and Rodrik 2007).[3] EXPY is defined as the weighted average of PRODY for each country. Therefore, EXPY is a proxy for the overall quality of the export basket of a country. EXPY for Penang in 2006 was $13,768.47, much higher than the average income for Penang residents. The positive difference between PRODY and EXPY signifies 'upgrading' from the average sophistication of exports. This is represented by the vertical axis in Figure 1.

Diversification possibilities are measured along the horizontal axis (inverse of DENSITY). This is based on the 'capabilities' already present in Penang to export a product. Construction of this measure is based on the assumption that exporting a product requires certain 'capabilities' and some of such 'capabilities' are shared among different products. Therefore, if many countries export both goods A and B, a country that exports only good B may have enough capabilities to start exporting good A. For each commodity, then there are many related commodities (i.e. high probability of a country exporting both goods). DENSITY shows as how many of these related products that a country exports (more specifically, goods enjoying comparative advantage). High DENSITY means that a country is exporting a large number of related goods in which a

[3] There are other ways to measure a sophistication of a product such as unit value. Often unit value is hard to calculate because not all the countries report consistent quantity units. It is well-known that unit value is a highly unreliable measure.

country also has comparative advantage. The closer an item is to the origin, the more capabilities that a country has for that particular product. All the figures in this section are based on UN Comtrade SITC rev. 2 4-digit data for 1995, 2000, and 2006 and 6-digit level data for Penang. To foreshadow the results, the analysis reveals that capabilities in Penang are increasing; however, such increases are seen mainly in those products that Penang already exports and where it has a comparative advantage. For other products that Penang does not export or in which Penang does not have comparative advantage, there is no evidence from the test conducted that Penang is accumulating necessary capabilities to upgrade or diversify. This suggests that Penang is becoming more specialized in certain export commodities, mainly electronics. Opportunities for Penang to upgrade or diversify remain, of course, but they will be harder to grasp. We explain in detail, the evolution of Penang's capabilities using product space analysis.

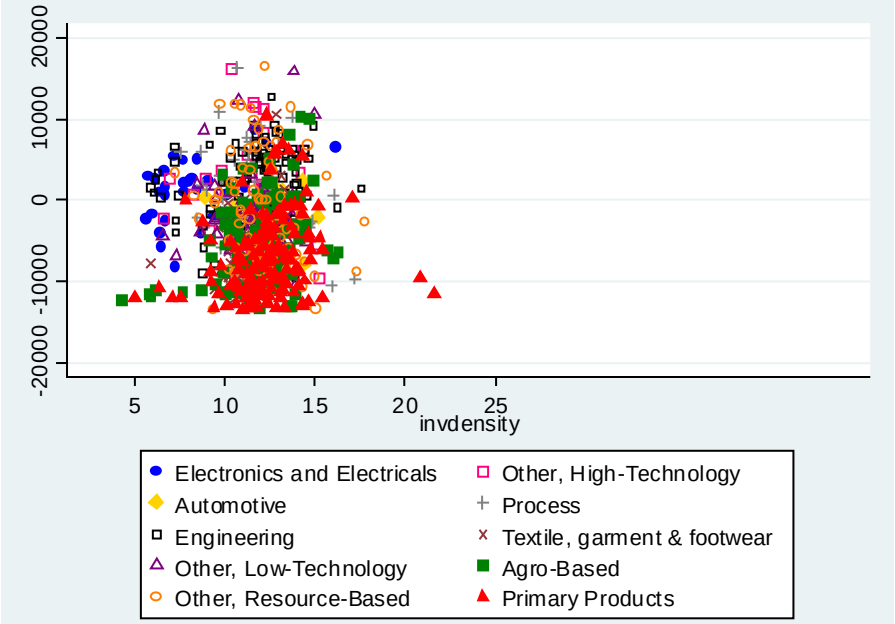
Figure 1 shows the graphical representation of product-space for Penang in 2007. Each point in the graph is a commodity exported by all the countries in the world. Therefore, these points include products that are exported by Penang and others that are not. The coordinates of these points were calculated using the export basket of Penang. From the graph it appears that not many products in Penang are high density (i.e. easier to diversify into) and upscale. The scope for diversification and upgrading is significantly narrower than for Malaysia as a whole, or for China (see Figure 2 and Figure 3).

Table 5: Changes in Average Sophistication of Penang's Exports

Year	EXPY
1995	11,073.01
2000	11,004.57
2006	13,768.47

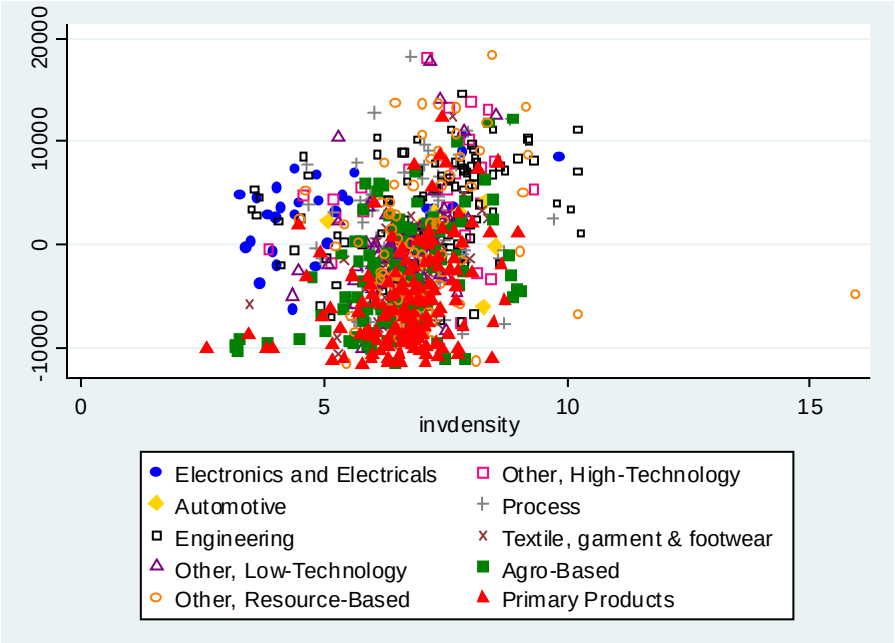
Source: Authors' calculation

Figure 1: Product-space for Penang, 2007



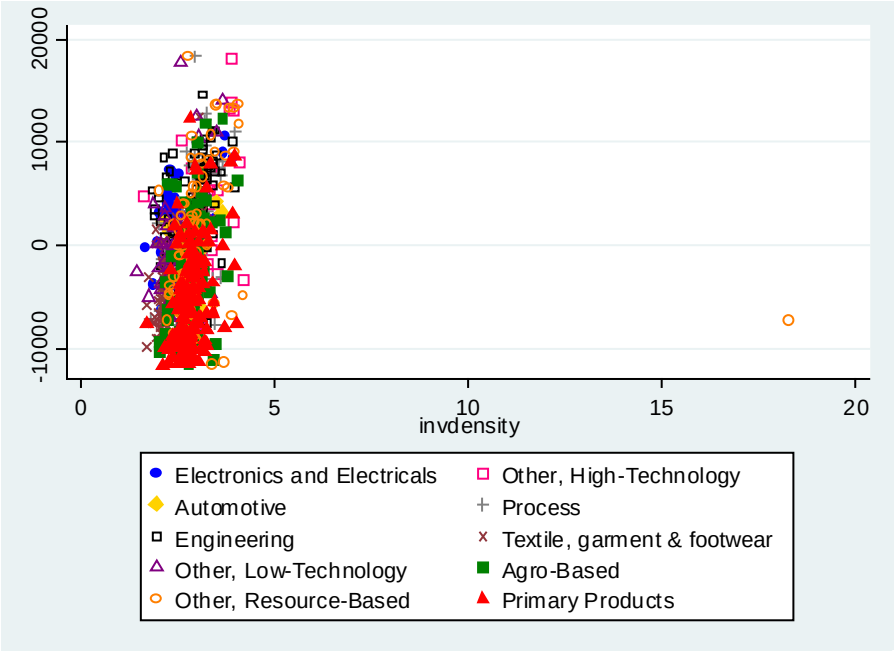
Source: authors' calculation

Figure 2: Product-space for Malaysia, 2006



Source: authors' calculation

Figure 3: Product-space for China, 2006



Source: authors' calculation

This is inevitable given that the variety of products exported from Penang is smaller relative to that from Malaysia and China (see Table 6). In each year, there were about 780 products exported by at least one country in the world. China and Malaysia exported almost as many products. Penang exported significantly fewer.

Table 6: Number of Products Exported by Penang, Malaysia, and China

	1995	2000	2006/7
China	766	763	763
Malaysia	740	740	746
Penang	582	608	601

Source: authors' calculation

Furthermore, the lower number of individual export items also reduces the number of products in which Penang has a revealed comparative advantage (see Table 7), and on which the product space analysis is based. The small number of products with a revealed comparative advantage implies lower export capability and consequently, this moves the distribution farther away from the origin. Remarkably, China has revealed

comparative advantage in more than one-third of the products which it exports. For Malaysia, the share is only 16.4 percent in 2006 and for Penang, 12 percent in 2007 (see Table 7). Penang's restricted capability stems from the smaller number of exported goods and lower share of these goods having revealed comparative advantage. Given the size of Penang's economy, the first aspect is difficult to change. Larger economies (or economic area however defined) tend to have more diversified exports. Nevertheless, improving the competitiveness of the current mix of exports may be feasible, especially through innovation and improvements in productivity.[4]

Table 7: Number of Products with Revealed Comparative Advantage for Penang, Malaysia, and China

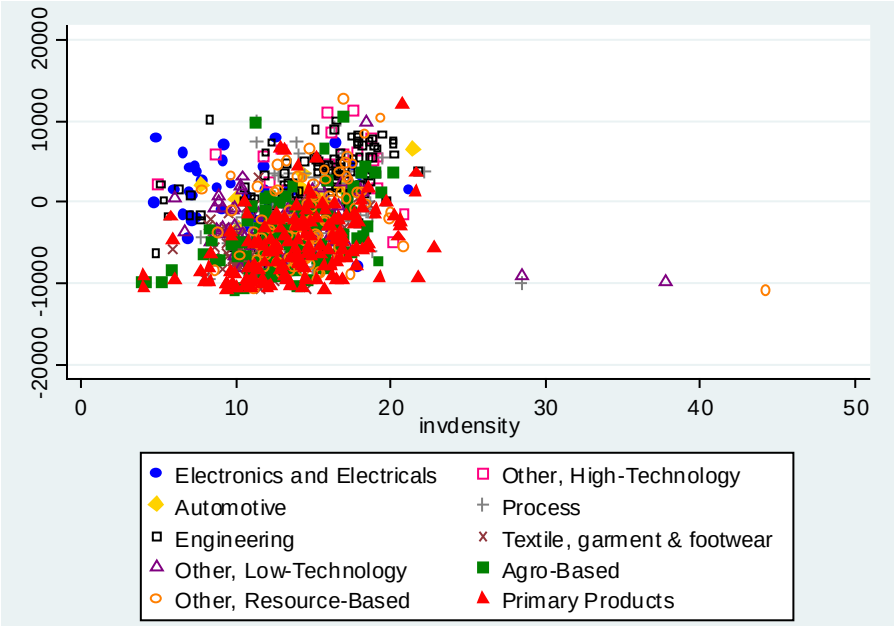
	1995	2000	2006/7
China	274	279	278
Malaysia	103	101	122
Penang	65	71	72
Share of Products with RCA (%)			
China	35.8	36.6	36.4
Malaysia	13.9	13.6	16.4
Penang	11.2	11.7	12.0

Source: Authors' calculation

Comparing Penang's performance in 1995 to that in 2007, the distribution of export categories with sophisticated products moved close to the origin (see Figure 4). This would imply that Penang has been able to build up industrial capabilities for these sophisticated products. But between 2000 and 2007, there was little further increase in capabilities (see Figure 5).

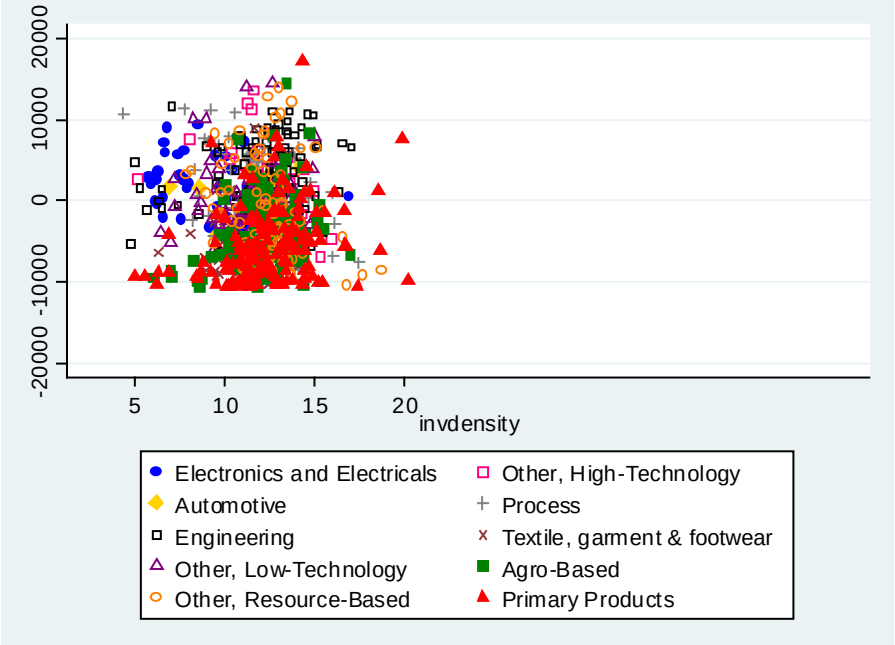
[4] Improvement in RCA may also require additional resources where a smaller country or place would not be able to secure. There are several ways to improve RCA. Either improve the efficiency of production so that output can be increased or to focus resources on fewer products.

Figure 4: Product-space for Penang, 1995



Source: authors' calculation

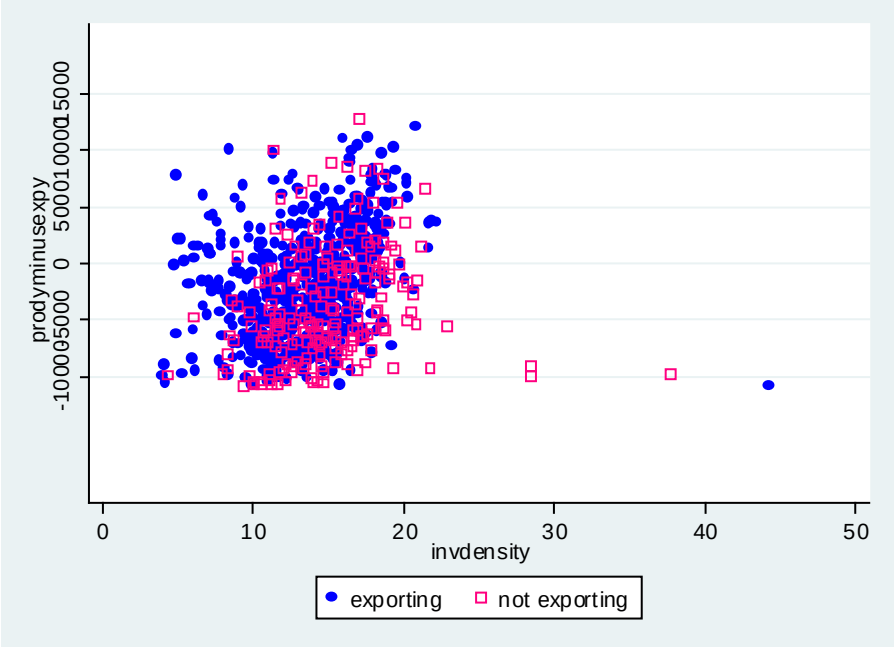
Figure 5: Product-space for Penang, 2000



Source: authors' calculation

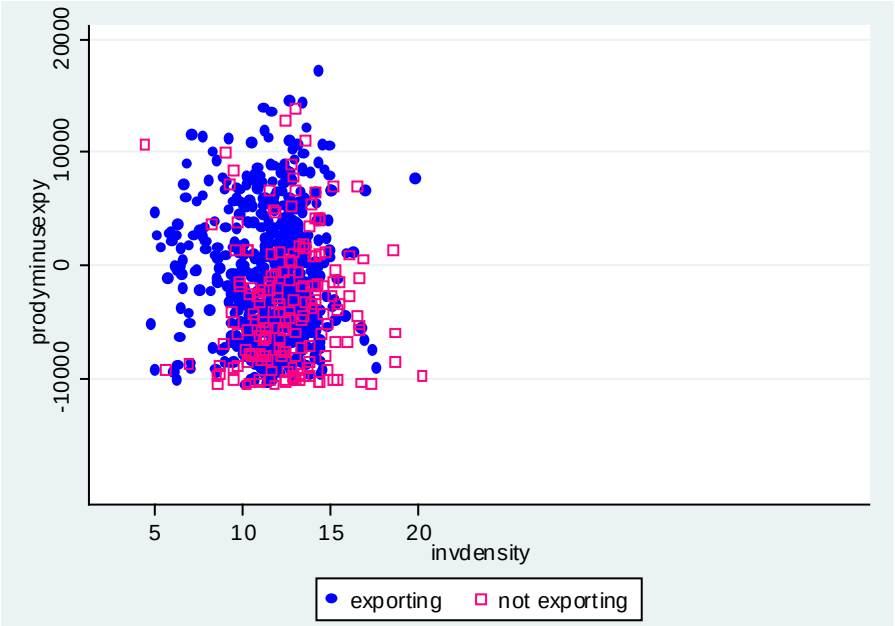
The above analysis was based on the complete set of products regardless of whether Penang exported these products. What follows is based on separating those products actually exported by Penang and those that are not. It is apparent that exported goods have higher densities than those that are not exported (see Figure 6, Figure 7, and Figure 8). This is consistent with the premise of the product space analysis. Products with higher density (closer to origin) should have higher probability of being exported. Overall, this is the case in Penang.

Figure 6: Product Space Differentiated by Exporting Status in Penang, 1995



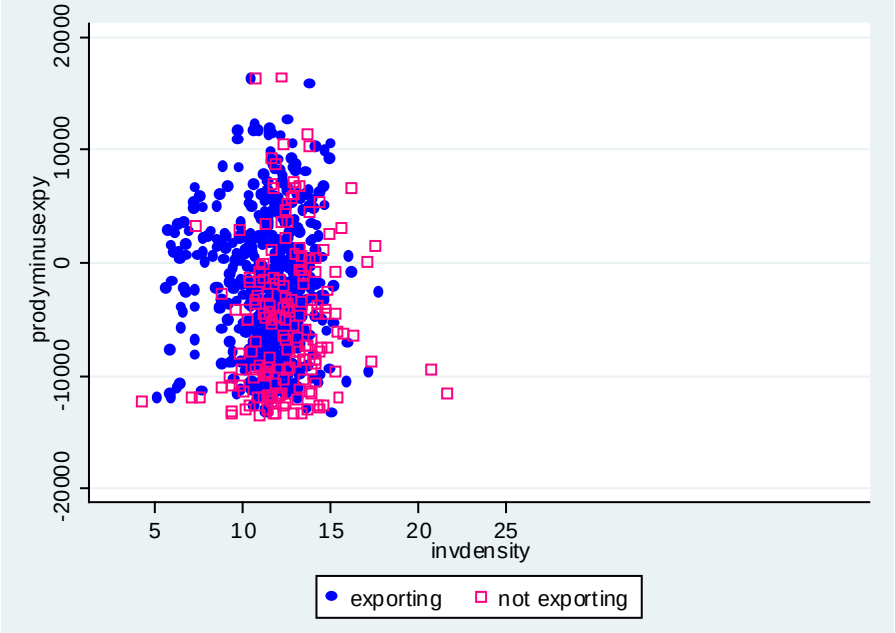
Source: authors' calculation

Figure 7: Product Space Differentiated by Exporting Status in Penang, 2000



Source: authors' calculation

Figure 8: Product Space Differentiated by Exporting Status in Penang, 2007

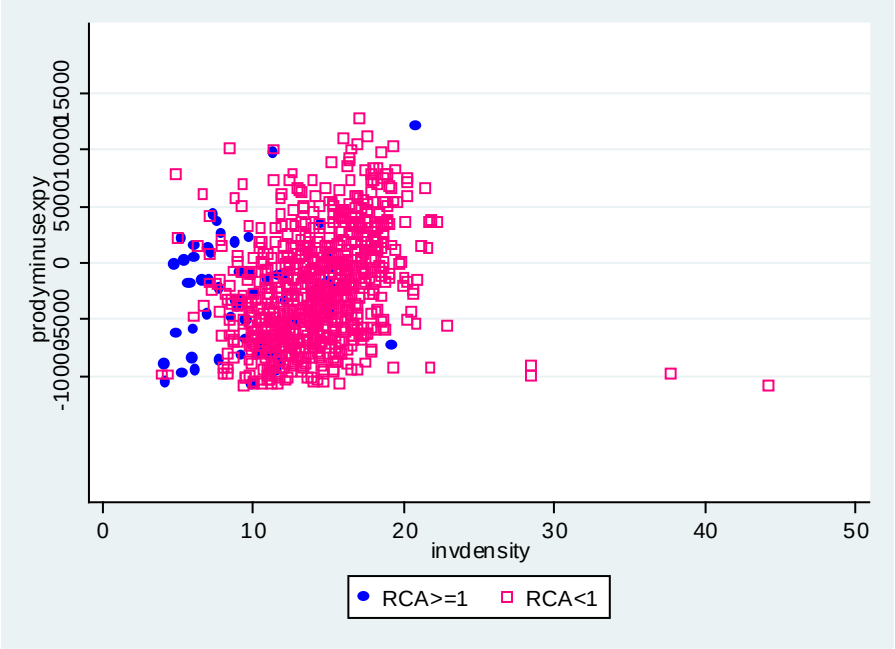


Source: authors' calculation

Upgrading Opportunities

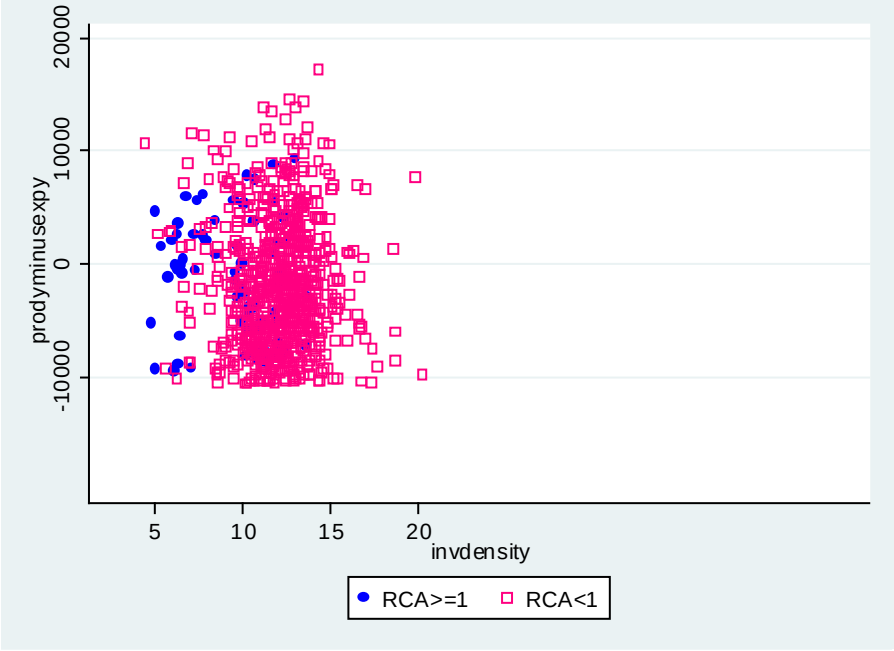
Export of a certain product does not automatically imply that Penang enjoys a comparative advantage. Figure 9, Figure 10, and Figure 11 show the graphical representation of product space based on whether Penang has revealed comparative advantage. As one would expect, those products in which Penang has comparative advantage lie closer to the origin. From the distribution of those products in which Penang does not have comparative advantage (this includes those products that Penang exports but in which it does not have a comparative advantage and those that Penang does not export and hence does not have comparative advantage) between 1995 and 2007, the distribution tightens, suggesting that there are opportunities for upgrading and diversification for Penang, which have not been exploited.

Figure 9: Product Space for Penang Where Penang Does Not Have Revealed Comparative Advantage, 1995



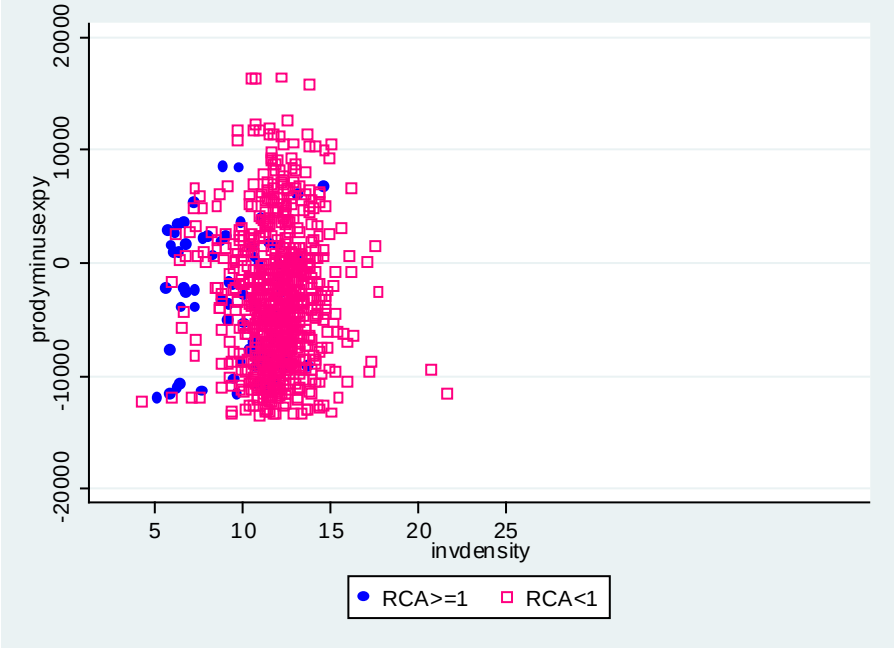
Source: authors' calculation

Figure 10: Product Space for Penang Where Penang Does Not Have Revealed Comparative Advantage, 2000



Source: authors' calculation

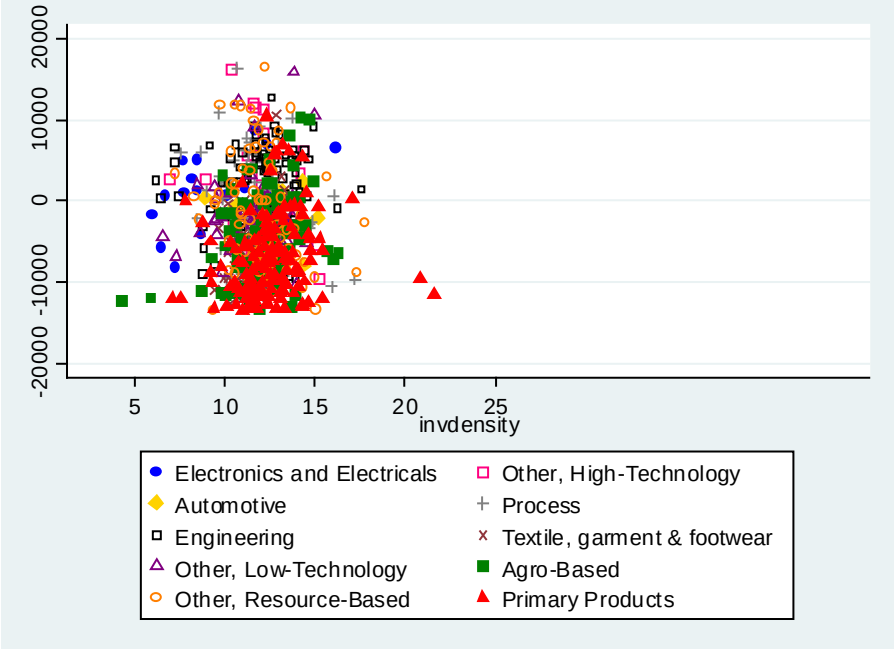
Figure 11: Product Space for Penang Where Penang Does Not Have Revealed Comparative Advantage, 2007



Source: authors' calculation

What are some of the product groups which manufacturers in Penang could upgrade? These include some electronic products, other high-tech products and engineering products in which Penang does not have revealed comparative advantage, yet they are more sophisticated than the current export basket (see Figure 12). They could be the focus of upgrading efforts in Penang, assuming that Malaysian firms perceive them as being profitable opportunities.

Figure 12: Product Space for Penang Where Penang Does Not Have Revealed Comparative Advantage Differentiated by Product Groups, 2007



Source: authors' calculation

Table 17, Table 18, and Table 19 list the highest density products in which Penang does not have comparative advantage (this includes those products exported by Penang and those that are not exported by Penang). In 1995 there were 5 products in high-tech categories. By 2000, this had increased to 9 commodities, but in 2007, more medium-tech and resource-based products had entered the dense category while those in the high-tech category had slipped to 8.

What is troubling is that the densest item in each year is progressively moving away from the origin. Thus, it is becoming harder for Penang to upgrade into these products. Take for instance, 7762 "Other electronic valves and tubes". The density

associated with this is shifting steadily away from the origin.[5] Of course, there are many products showing an increase in density consistently since 1995.[6] However, these items tend to be located farther away from the origin. Among more than 300 commodities in which the density is increasing, the closest to the origin was "7761: traditional television picture tubes," hardly a cutting-edge product (see Table 8).

Table 8: Top 20 commodities whose density is increasing

SITC4	Short description	invdensity	Lall Class	exporting
7761	Television picture tubes, cathode ray	6.5	HT1	1
8710	Optical instruments and apparatus	6.9	HT2	1
8841	Lenses and other optical elements of any material	7.2	MT3	1
5826	Epoxide resins	7.5	MT2	1
7643	Television, radio-broadcasting; transmitters, etc	7.7	HT1	1
5112	Cyclic hydrocarbons	8.3	RB2	1
7523	Complete digital central processing units; digital processors	8.5	HT1	1
5827	Silicones	8.7	MT2	1
4233	Cotton seed oil	8.7	RB1	0
7131	Internal combustion piston engines, for aircraft, and parts, nes	8.8	MT3	1
3415	Coal gas, water gas and similar gases	8.8	PP	0
7243	Sewing machines, furniture, needles etc, and parts thereof, nes	8.8	MT3	1
5137	Monocarboxylic acids and their derivatives	9.0	MT2	1
7263	Machinery, accessories for type-setting, for printing blocks, etc	9.1	MT3	1
7757	Domestic electro-mechanical appliances; and parts thereof, nes	9.2	MT3	1
1221	Cigars, cheroots: cigarillos	9.2	RB1	1
8442	Under garments of textile fabrics, not knitted or crocheted; mens, boys under garments; other than shirts	9.3	LT1	1
5233	Salts of metallic acids; compounds of precious metals	9.4	RB2	1
8952	Pens, pencils and, fountain pens	9.6	LT2	1
6514	Yarn 85% of synthetic fibres, not for retail; monofil, strip, etc	9.6	LT1	1
5154	Organo-sulphur compounds	9.7	RB2	1
2671	Regenerated fibre suitable for spinning	9.7	MT2	0

Note: PP: Primary Products, RB1: Agro-Based, RB2: Other Resource-Based, LT1: Textile, garment & footwear, LT2: Other, Low-Technology, MT1: Automotive, MT2: Process, MT3: Engineering, HT1: Electronic & Electrical, and HT2: Other, High-Technology.
Source: authors' calculation

[5] It was also the case for the commodity "8811", but Penang had revealed comparative advantage in this product in 2007.
[6] That is, the density increases from 1995 to 2000, and from 2000 to 2007.

Diversification Opportunities

The previous section focused mainly on the upgrading opportunities for Penang. In this section, the focus of the discussion is on the diversification opportunities. The first step is to see what kind of new products entered the export basket, by combing through the export data set. Between 1995 and 2000, Penang added 43 new products to its export basket (see Table 15). Among these 43 items, 6 are classified as high-tech. Between 2000 and 2007, Penang added further 26 products to its export mix, although only one was classified as high-tech (see Table 16). These new products are aircraft parts, power plant parts, and some medical related products.[7] There is scope for further diversification into biomedical products. In 2006, Penang accounted for 70 percent of all medical devices produced in Malaysia, some by MNCs such as B. Braun, Ambu, and Cardinal Health (Rajah 2007).[8] The entry of firms such as AlphaBiologics is a good start.[9]

Other opportunities for diversification, by and large, involve non-electronic products which have been increasing their share of Penang's export bundle. By 1995, Penang was already exporting most products in the 4-digit electronics classification and this has persisted through 2007 (see Figure 13 especially in comparison to Figure 1). The analytic approach employed here and the findings reported in Yusuf and Nabeshima 2008, suggest that for Penang and Malaysia as a whole, the more promising opportunities for diversification as distinct from upgrading are in primary products, agro-based products, and other resource-based products (see Figure 14 and Figure 15).

These product groups are aligned more closely with Malaysia's evolving technological capabilities and offer better opportunities for deepening and earning profits than products or services in the life sciences or IT which are high-tech, but could be beyond the reach of current and medium term capabilities. Even for those products identified as promising diversification possibility, it will not be easy. From 1995 to 2007,

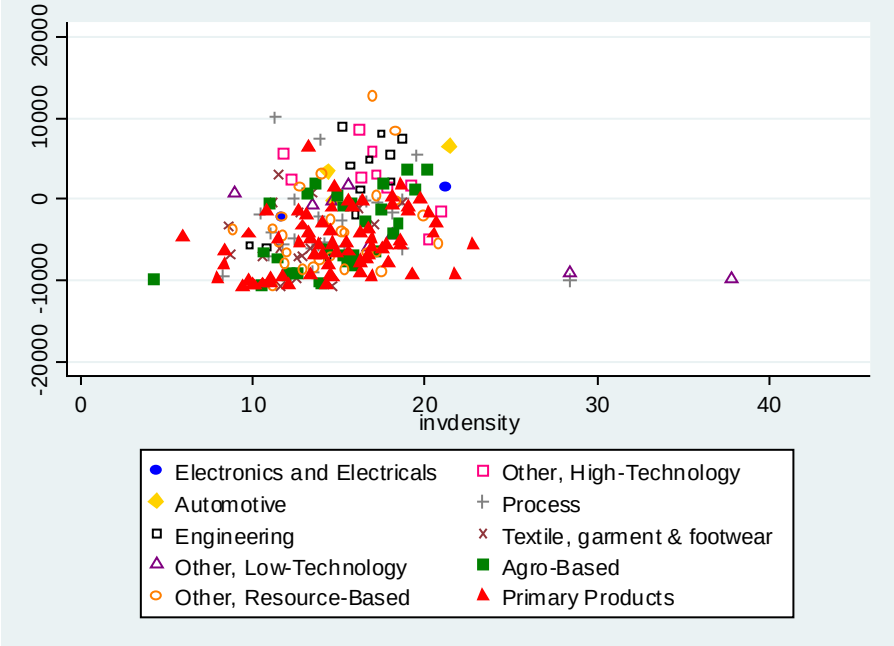
[7] Already, there are several biomedical firms in Penang such as Straits Orthopaedics (a producer of kits for joint replacement surgeries), Vigilenz Medical Devices (a producer of sutures), and AlphaBiologics.

[8] Like the electronics industry, the medical device industry started with foreign direct investment, by B. Braun in 1972 (Rajah 2007). 70 percent of the medical device exports are medical gloves and contraceptives.

[9] Symmetry Medical, orthopedic manufacturer based in the United States, is also considering establishing a subsidiary in Penang.

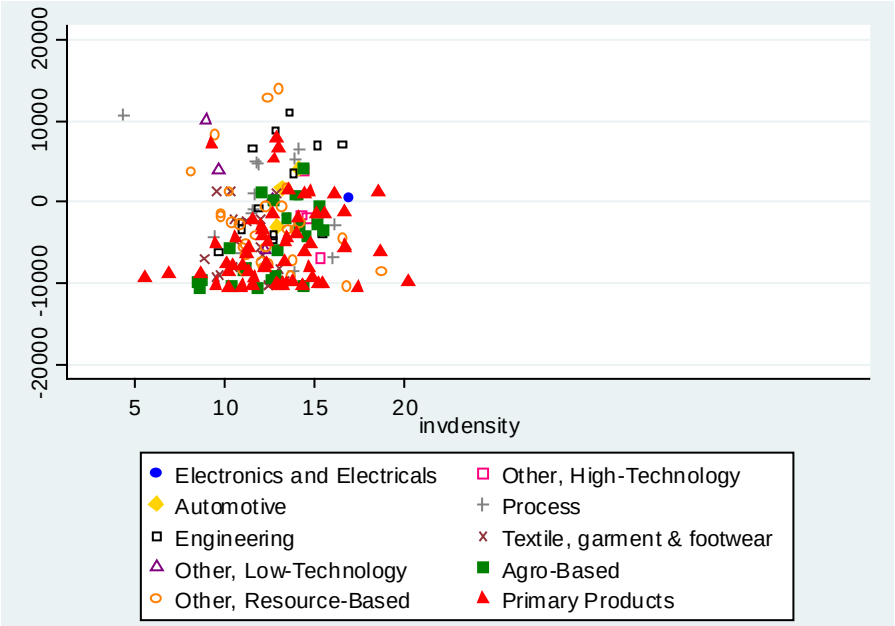
the distribution of those products not exported by Penang is becoming tighter. However, it is not moving towards the origin, suggesting that Penang is apparently not acquiring capabilities to export these products. The analysis presented here can only point to the options for diversification based on a specific methodology, but can not provide guidance on how to accumulate the capabilities. The next section will explore some of the possible ways in which to enhance the scope for diversification.

Figure 13: Product Space for Products Not Exported by Penang, 1995



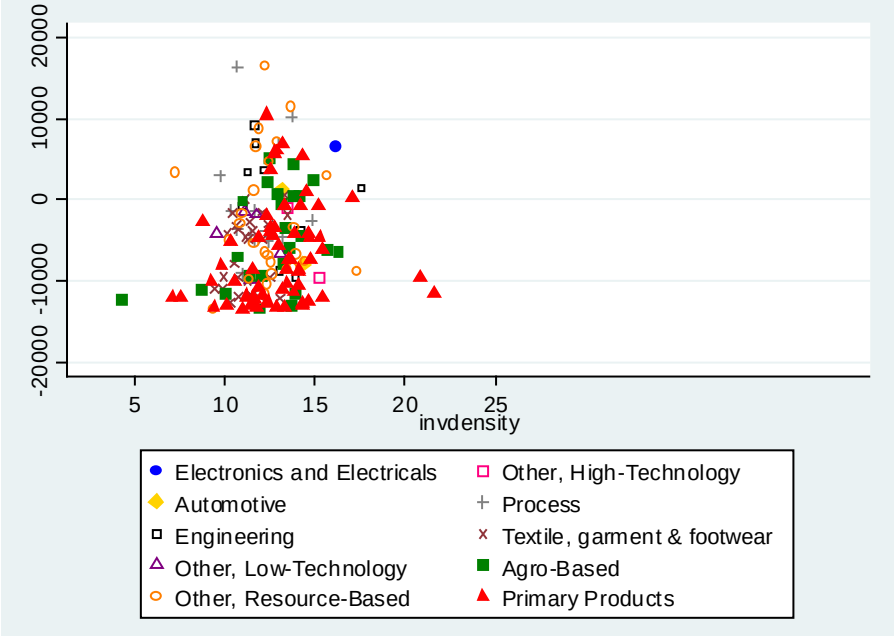
Source: authors' calculation

Figure 14: Product Space for Products Not Exported by Penang, 2000



Source: authors' calculation

Figure 15: Product Space for Products Not Exported by Penang, 2007



Source: authors' calculation

III. Industrial Upgrading and Diversification

It is desirable to note at the outset that industrial deepening and diversification into higher technology activities will be constrained by four factors: the sparseness of agglomeration economics because of Penang's size;[10] the absence of a research base grounded in local universities and research institutions; the quality of the technical workforce; and the absence of Malaysian firms that can take the lead in pushing the local economy upstream.

There is no dependable recipe for technological upgrading and diversification, however, international experience points to four ingredients of relevance for Penang.

Spillovers from MNCs deserve priority because of the dominance of foreign producers in Penang's economy. These spillovers can arise from three main sources:

- Linkages which draw local producers into MNC networks and create channels for the transfer of hard and soft technologies from the MNCs to their local suppliers and clients;[11]
- The circulation of skilled and technical workers from MNCs to local companies that can serve as a transmission belt for new technologies, production skills, management techniques and entrepreneurship. There are a few cases of former Malaysian employees of MNCs starting firms in Penang which have thrived and grown.[12] But these cases are rare. Equally infrequent are instances of spin-offs from MNCs which have taken root and survived;

[10] Reviewing the evidence on agglomeration economies, Rosenthal and Strange (2004) find that with each doubling of the size of city, the urban GDP can increase by between 3 and 14 percent. Venables and Rice (2005) estimate that a doubling of the population of a city can raise productivity by 3.5 percent. Au and Henderson conclude from their assessment of the size and productivity of cities in China, that most are sub-optimal in size – i.e. below 5 million (Au and Henderson 2006) – and that productivity gains from an expansion would be about 4.1 percent if the city were 20 percent below optimal but as much as 35 percent if the city is half the optimal size (Henderson 2004; Rosenthal and Strange 2004). While evidence on urbanization economies (arising from industrial diversity) is mixed (and greater for some industries than others), that for diversity of high tech industries is much clearer. Overman and Venables (2005) find that a one standard deviation increase in the diversity index raises productivity by 60 percent (p.18). See also S. V. Lall, Shalizi and Deichmann (2004); Deichmann and others (2005); World Bank (2009); Fujita and Thisse (2002); and Quigley (2008).

[11] Eng Teknologi is the most successful case in Penang.

[12] These include Pentamaster, Globetronics, OptoElectronix, and Vigilenz Medical Devices.

- R&D by MNCs which trains local researchers and generates ideas which can induce local start-up activity.

Spillovers from MNCs

Thus far the evidence of significant technological spillovers leading to new starts in Penang is remarkably sparse although labor turnover at the MNCs has diffused knowledge and skills throughout the local economy. Many of the larger MNCs conduct design and development and some research, and some research capacity is beginning to emerge in Penang. And MNCs have forged backward linkages with local suppliers, mostly for relatively low tech products. However, the outcomes in terms of increased local value added, technological upgrading, new starts and a densifying of linkages have been disappointing. One factor inhibiting linkages and new starts is that MNCs are reluctant to cultivate local suppliers because the transaction costs for them can be high. They are also high for new suppliers which need to develop products, successfully market them to the MNCs, and if these are accepted, subject them to a lengthy certification process before they can be inducted into the MNCs supply chain. MNCs are keen to minimize the numbers of suppliers they deal with and strongly prefer that component manufacturers be able to support the MNCs operations globally. They also expect that the supplier should be able to muster the R&D capacity to contribute to the progressive upgrading of the design and performance of components and to whittle away at the costs. The bar was not as high in the 1980s through the early 1990s, however, it has risen since and Malaysian firms struggle to meet the requirements. They remain as second or third tier suppliers of the less sophisticated parts and components.

In sum, the experience of Penang reinforces the international empirical evidence which suggests that spillovers from FDI are modest at best, even the vertical spillovers from final assemblers to suppliers. The spillovers from MNCs to local firms can be a means of strengthening technological capabilities of local firms however, so far experience from other economies suggests that such spillovers rarely contribute to the nurturing of indigenous innovation capability in the host economy. At Penang's current stage of development, the likelihood of MNCs now serving as a vehicle for substantial technological upgrading of the electronics industry is fairly small. The continued

presence of MNCs in Penang, however, will be vital for the survival of export oriented electronics and for the emergence of other manufacturing activities associated with the life sciences.

Vehicles for Upgrading

If MNCs are unlikely to lead the technological upgrading and nurturing of innovation capacity of Penang's industry, then there remain only two other vehicles acting in concert – Malaysian firms in conjunction with local universities and research institutions.

Without exception, business firms do the bulk of R&D in industrialized countries and virtually all the commercial innovation (between two thirds and three quarters, see Jaruzelski and Dehoff 2007; Jaruzelski, Dehoff and Bordia 2005;2006). Moreover, large firms have the resources to conduct research and are responsible for most of the process and incremental product innovation (Baumol 2004). Firms, even the largest do not allocate more than fifth of their R&D expenditure to basic or applied research, instead they depend on other sources for upstream research and innovative ideas in particular new starts. Larger firms also turn to research institutions and research universities to fulfill this role. With research becoming a globalized activity, and global markets for innovation now operating, large firms are able to shop around the world for the technology which fits their requirements although local sources of the desired caliber are always more convenient and are preferred.

Where they have occurred, technological upgrading, innovation and industrial diversification appear to be the outcome of a sequence of actions by large firms operating internationally; new entrants which introduce innovative products or services; and a number of supporting intermediaries, and government which is a source of incentives, funding for R&D and demand for new products.

There are a number of Malaysian firms in the first category, such as Eng Teknologi[13] and Pentamaster,[14] but even these are small fry relative to players such as

[13] Eng Teknologi started operations in 1974 in Penang. It has emerged as one of the top five component suppliers for hard disk drives, producing base-plate and actuators among other components ("Corporate: EngTek" 2007). Actuators accounts for 25% of the sales of the firm ("Eng Teknologi counts" 2007). Eng Teknologi also has become an MNC with facilities in Dongguan (established in 1996), the Philippines (in

Samsung or LG or the Taiwanese electronics firms such as ACER or Asustek or Foxcon. New entry into electronics or the life sciences is no more than a trickle from the deal flow reported by venture capitalists. Detailed information from industrial censuses would cast more light but is unavailable. Thus the key part of Penang's innovation system – which is comprised of Malaysian business firms that do the actual upgrading, innovating and diversifying – is weak in numbers and in scale. Why this is so is hard to say.[15] It is not apparent that financial resources for expanding capacity or launching a new firm are scarcer than in say Shanghai or Guangzhou or Shenzhen. It is also not apparent that the binding constraint is the government incentive regime. Incentives and public venture capital in Malaysia are not less generous than those of comparators and interviews did not uncover concerns regarding the paucity of incentives. But no systematic evaluation of incentives has been conducted to identify shortcomings and improve its effectiveness.

Research Universities and University-Industry Linkages

Could intermediaries help drive the upgrading of technology and industrial diversification in Penang? There are three types of intermediaries which could contribute in this regard: research universities; research institutes;[16] and institutes offering training such as the Penang Skills Development Center,[17] extension and testing services. A growing importance is attached to universities, for two reasons. One is that the quality and skills of the workforce are major determinants of technological and innovative capacity. They also influence the supply of entrepreneurship and in particular, entry into

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1997) and Thailand (in 1998) (Hiratsuka 2006). All of Eng Teknologi's expansion seems to be occurring outside of Penang ("Eng Teknologi counts" 2007). In addition, the development of local suppliers in China is threatening the traditional suppliers based in Penang. While in the past, about 80% of the inputs used in actuator production came from other Penang-based firms, Eng Teknologi currently sources about 50% from Chinese suppliers. With the rapid development of suppliers in China, Eng Teknologi may source the majority of its inputs from China and the share of domestic components (mainly from Penang) may become as small as 20% ("As China Makes" 2007). Furthermore, Eng Teknologi is setting up two R&D centers: one in Senai, Malaysia and the other in Dongguan, China.

[14] Pentamaster spends 10% of its revenue on R&D with 40 workers dedicated to R&D, although up to 200 workers may be engaged in R&D related activities (P. K. Wong, Chang and Cheng 2007).

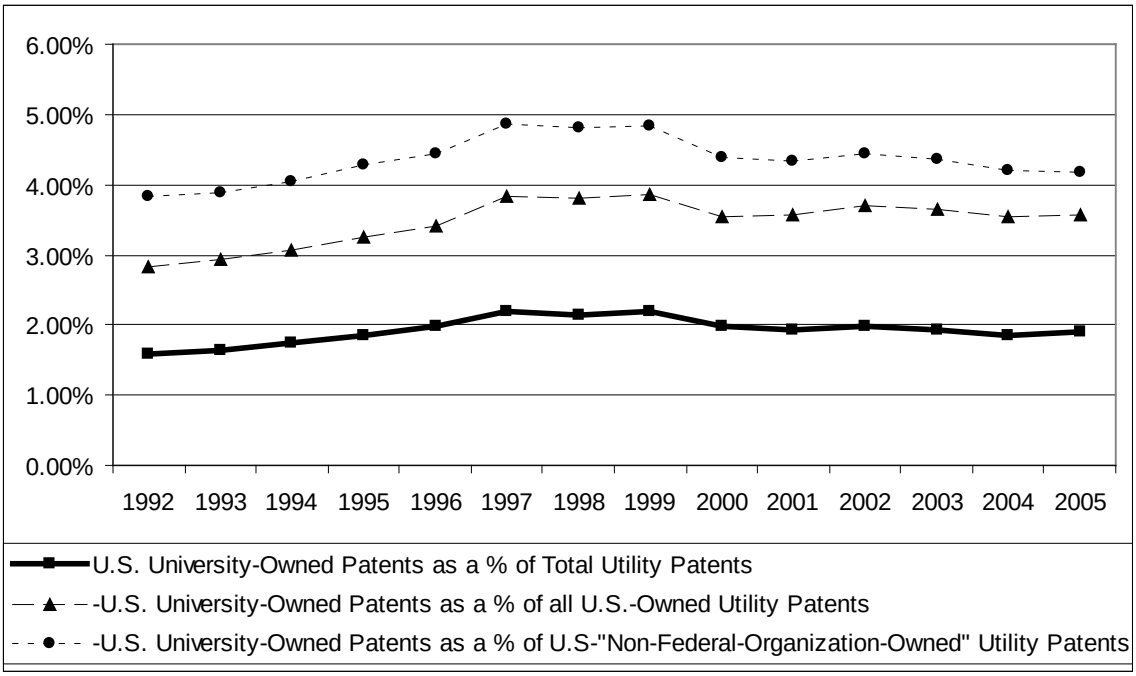
[15] One could argue that firms in Malaysia are still at an early stage of development. It took a long time for the emergence of innovative firms in Japan. Similarly, it is only recently that one find innovation-driven firms in Korea and Taiwan (China).

[16] There are only two research institutes in Penang: the Fishery Research Institute and the Malaysian Institute of Pharmaceuticals and Nutraceuticals at USM

[17] PSDC actively engages with the industries to design and conduct training to enhance the relevance of its programs.

high tech activities (Berry and Glaeser 2005). A second reason is the comparative advantage universities can acquire to conduct basic and applied research. However, it should be noted that even in the United States, universities account for only about 5 percent of all patents, and although they have a larger share of the invention patents, in the areas of applied research and innovation, their role is small (see Figure 16).

Figure 16: Share of US Utility Patents Granted to US Universities and Colleges



Source: US Patent and Trademark Office

Whether a strong push to raise the quality and relevance of instruction in tertiary institutions in Penang and to build research capacity can accelerate the industrial transition in Penang is an open question. How quickly success in this regard would affect the local industry is another question. However, what we do see from international experience is that successful industrial clusters benefit from proximity to high quality universities. Firms interviewed in Penang indicated that their R&D, or product / process development efforts were being impeded by shortages of specialized skills. MNCs hire some technical personnel to work on design, testing and product development[18] but as

[18] AMD employs 30 workers mainly on process innovation rather than contributing to the design of AMD chips, although 80% of AMD's chips are produced in Penang. Motorola assigns 1,000 engineers for

Rasiah (2006, p. 22) has pointed out, "in Penang, the supply of R&D engineers and technicians is too small for the [MNCs] to upgrade further into R&D activities."[19] While firms find the quality of students graduating from local public universities to be adequate (see Table 9), they would welcome improvement in the level of skills.

Table 9: Assessment of quality of students graduating from local public universities in Penang

Assessment	Number of Firms	%
very poor	0	0.0
poor	5	7.3
fairly good	50	72.5
very good	14	20.3

Source: Authors' calculations based on investment climate survey data

Few Malaysian firms – whether in Penang or elsewhere - have thus far sought to cement university industry linkages for the purposes of product upgrading and innovation.[20] The interaction is limited to consulting arrangements and troubleshooting contracts. This is not unusual for three reasons. First, firms, especially small and medium sized ones, conduct a minimal amount of R&D and when they outsource, seldom seek assistance from universities. Second, for larger firms also, universities are ranked low as sources of technology. Third, most firms are specialized in electronics and electrical engineering, which are research intensive fields but not ones noted for university industry collaboration. Few universities anywhere in the world, do much downstream applied research in electronics, and USM is no exception. Fourth, USM has limited research capacity and is not in a position to significantly assist firms even if the demand were there.[21] The absence of major research institutions whether affiliated with

product designs. Agilent employs 500 R&D engineers in Penang, mainly on development work. Many of the MNCs identified the low number of engineering and science Ph.D. and MA produced by universities as a significant bottleneck. Shortages also contribute to the high turnover among experienced engineers (currently 16 percent annually) working for MNCs.

[19] In 2000, there were more than 5,000 scientists and engineers in R&D per one million people in Japan. The comparable number for China was 545 (in 2000) and 160 in Malaysia (in 1998) (Fan and Watanabe 2006).

[20] One exception is Hovid Pharmaceutical that has an R&D center located in USM.

[21] USM was granted 10 patents between 1995 and 2005. Its R&D spending is concentrated in biochemistry, energy technology, and process technology and engineering (Yusuf and Nabeshima 2008).

the university or independent ones, also is a factor.[22] By and large, the comparative of the best research universities is in basic research and in early stage development. Second tier provincial universities, are less likely to engage in applied research and have fewer incentives to market their findings to the business community. Most often they have commercializable findings to offer and their faculties rarely enjoy the incentives to go beyond conceptual research which can be published in scientific journals, or at best to do early stage development[23].

The preferences of firms in Penang – much like firms in the UK and the United States – to seek technology from sources other than universities are underscored by the results from the latest round of the investment climate survey[24], and our interviews with firms. Firms in Penang acquire technology mainly through purchase of new vintage of machinery, especially the imported ones.[25] Only a handful of firms regard universities as a source of technology (see Table 10)[26].

Even when the technologies were developed locally, firms do not regard universities and research institutes as their main collaborators. Instead, they identified other firms as the preferred collaborators (Table 11).[27] On a more positive note, the few firms which collaborate with universities in Penang or elsewhere in Malaysia generally regard their services to be satisfactory, especially in identifying new technologies, in modifying existing technologies, and conducting R&D in technologies closer to the frontier. The problem lies in the small number of firms in Penang that regularly collaborate with universities and research institutes in general.

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[22] USM is trying to change this with the establishment of the Malaysia Institute of Pharmaceuticals and Nutraceuticals in 2006. The focus of the institute is to identify local compounds used in traditional medicine and explore the utility and effectiveness of such compounds as medicine. Currently there are 10 Ph.D.s and 10 MA students working at the Institute. Overall, there are only 350 Ph.D. in Malaysia with specialization in the life sciences. USM produces about 150 Ph.D.s a year, of which 50-75 are in the life sciences.

[23] See Wright and others (2008).

[24] The second round of the investment climate survey was conducted in Malaysia in 2007/2008. For the results on the first round, please see World Bank (2005).

[25] Among the firms in Penang which purchased new machinery, more than half purchased imported machinery while about one third purchased domestic equipment. Only few purchased second-hand machinery regardless of the origin.

[26] See Hughes (2007).

[27] In the last three years, only 12% of firms surveyed in Penang have collaborated with universities or research institutes when upgrading or acquiring new technologies. The propensity to work with universities and research institutes in Penang is actually lower than the national average of 16%.

Table 10: General Sources of Technologies for firms in Penang

	most important		second most important		third most important	
	Number of firms	%	Number of firms	%	Number of firms	%
Embodied in new local machinery or equipment	29	21.32	12	10.17	7	6.73
Embodied in new Imported machinery or equipment	30	22.06	29	24.58	8	7.69
By hiring key personnel	15	11.03	16	13.56	21	20.19
Licensing or turnkey operations from international sources	6	4.41	4	3.39	3	2.88
Licensing or turnkey operations from domestic sources	2	1.47	1	0.85	5	4.81
Developed or adapted within the establishment locally	11	8.09	13	11.02	10	9.62
Transferred from parent company	14	10.29	2	1.69	2	1.92
Developed in cooperation with client firms	13	9.56	14	11.86	11	10.58
Developed with equipment or machinery supplier	8	5.88	12	10.17	12	11.54
From a business or industry association	3	2.21	6	5.08	10	9.62
Consultants	3	2.21	6	5.08	10	9.62
From universities, public institutions	0	0	1	0.85	4	3.85
Mergers and acquisitions	1	0.74	1	0.85	1	0.96
Other	1	0.74	1	0.85	0	0

Source: Authors' calculations based on investment climate survey data

Table 11: Collaboration partners when developing technologies locally

	Yes	No
with Other firms	52	86
	37.7%	62.3%
with Universities	22	116
	15.9%	84.1%
with Research institutions	30	108
	21.7%	78.3%

Source: Authors' calculations based on investment climate survey data

Among those firms that have not collaborated with universities and research institutes in recent years, the major reasons seems to be that firms do not feel that universities and research institutes can render services that are relevant to their operations. This compounded by a lack of knowledge of these institutions, the services they offer, and the people to contact (see Table 12). The lack of knowledge by firms on

the services and the appropriate person to contact can be mitigated by establishing an intermediary organization which facilitates matchmaking between the university and the firm. There are a number of different options depending on scope of the intermediary organization. For example, universities can set up technology licensing offices and other university-affiliated organizations. One well-known example is UCSD Connect which has facilitated UILs between UC San Diego and the local business community.[28] In other countries, a municipality (or a group of municipalities) sometimes act together to promote university-industry linkages with diverse memberships to stimulate local economy.[29] However, such efforts are unlikely to lead to major shift in the demand for university based research. From a longer term standpoint, the most effective approach to building UILs would be one that gradually improves the quality of teaching and research capacity and carves out a reputation for scientific excellence. With regard international reputation, Malaysian universities have improved their ranking, but it is still low (see Table 13).[30] They are among the top 200 to 300 universities in the world among the top 30 to 50 universities in the East Asia region.

Table 12: Reasons for not collaborating with universities and research institutes

	Most important		Second most important		Third most important	
	Number of firms	%	Number of firms	%	Number of firms	%
Haven't heard of them	33	26.8	8	7.7	8	8.6
Their services are not relevant to your firm's needs	51	41.5	26	25.0	7	7.5
Don't know anyone there to make a first point of contact	20	16.3	23	22.1	22	23.7
Application process too cumbersome	7	5.7	12	11.5	18	19.4
Lack of technical capability in-house to interact with institutions	1	0.8	22	21.2	15	16.1
Afraid of in-firm technical knowledge leaking out by collaborating	3	2.4	6	5.8	12	12.9
Tried it before and was not a fruitful experience	3	2.4	5	4.8	9	9.7
Others	5	4.1	2	1.9	2	2.2

[28] See Smilor and others (2005) for the detail on UCSDConnect.

[29] One such organization is TAMA Association near Tokyo. The association includes universities, local small- and medium-sized firms, and financial institutions (T. Kodama 2008). Apart from promoting the diffusion of technology, TAMA also assists firms in accessing lab and testing facilities and obtaining certification for their products.

[30] There was no Malaysian university ranked in the ranking published by Shanghai Jiao Tong University.

Source: Authors' calculations based on investment climate survey data

Table 13: Ranking of Selected Universities in East Asia

2008	2007	2008 regional rank	School Name	Economy
19	17	1	University of TOKYO	Japan
25	25	2	KYOTO University	Japan
26	18	3	University of HONG KONG	Hong Kong (China)
30	33	4	National University of SINGAPORE(NUS)	Singapore
39	53	5	HONG KONG University of Science & Techno...	Hong Kong (China)
42	38	6	The CHINESE University of Hong Kong	Hong Kong (China)
44	46	7	OSAKA University	Japan
50	36	8	PEKING University	China
50	51	9	SEOUL National University	Korea
56	40	10	TSINGHUA University	China
166	223	23	CHULALONGKORN University	Thailand
230	246	33	Universiti MALAYA (UM)	**Malaysia**
250	309	35	Universiti Kebangsaan MALAYSIA (UKM)	**Malaysia**
313	307	43	Universiti Sains MALAYSIA (USM)	**Malaysia**
320	364	46	Universiti Putra MALAYSIA (UPM)	**Malaysia**
356	401-500	51	Universiti Teknologi MALAYSIA (UTM)	**Malaysia**

Source: Times Higher Education Supplement
(http://www.topuniversities.com/university_rankings/results/2008/overall_rankings/fullrankings/)

How frequently and how closely universities and firms might eventually interact with each other will also depend upon the future composition of Penang's industry. This is because scientific content differs among industrial subsectors, as noted earlier. Using Japanese patent data, F. Kodama and Suzuki (2007) find that biotechnology has the highest scientific content (measured by citation to academic papers rather than patents), followed by nano-technology, IT, and environment related technologies. Patents in these technology areas contain more citations to academic papers and more frequent incidence of citing academic papers. Universities in the United States also tend to patent more in biotechnology related fields (see Table 14). Similar to the difference in R&D intensity by industrial subsector (van Pottelsberghe de la Potterie 2008), the propensity to cite (or utilize) research findings from universities and research institutes differs among industrial subsectors. If this is the case, then the degree of linkages between universities and firms are dependent on the industrial composition. Given the current concentration of

electronics and machinery industry in Penang, one would expect to see little collaboration with universities.

Table 14: Distribution of US Patents Granted to Universities by Technology Class, 1969-2005

Class	Class Title	Total	%
424	Drug, Bio-Affecting and Body Treating Compositions (includes Class 514)	8,123	16.7%
435	Chemistry: Molecular Biology and Microbiology	6,991	14.4%
532	Organic Compounds (includes Classes 532-570)	3,331	6.9%
128	Surgery (includes Class 600)	1,692	3.5%
530	Chemistry: Natural Resins or Derivatives; Peptides or Proteins; Lignins or Reaction Products Thereof	1,361	2.8%
520	Synthetic Resins or Natural Rubbers (includes Classes 520-528)	1,275	2.6%
250	Radiant Energy	1,060	2.2%
73	Measuring and Testing	886	1.8%
324	Electricity: Measuring and Testing	740	1.5%
800	Multicellular Living Organisms and Unmodified Parts Thereof and Related Processes	730	1.5%

Source: Authors' calculations

To summarize, under the circumstances, USM can assist over the medium term by:

- Improving the quality of education particularly in science and engineering disciplines, by enhancing soft skills and enlarging the supply of technical workers. Communication, team working, and analytic skills are the ones which many employers feel students lack. [31]
- Initiating post doctoral programs in key areas so as to deepen the culture of research and to position the university to generate knowledge in new areas some of which could have commercial potential.
- Encouraging entrepreneurship with the help of training and specialized services provided through incubators and a science park.[32]
- Engaging in exploratory research and internship programs with local companies with government funding serving as a catalyst.

[31] Over 60 percent of the 167 electric-electronics firms surveyed in Penang and Johor in 2005 reported that university curricula in Malaysia lack interface with firms activities thereby forcing them to invest in longer training periods for new recruits (Rasiah 2008)

[32] The National University of Singapore has initiated some programs that offer useful pointers (P.-K. Wong 2008).

The university's ability to attract more students into its S&T graduate programs and to raise quality will be strongly influenced by the demand for high level skills reflected in better entry level salaries and career prospects for graduates and Ph.D. holders. Although employers complain of shortages and of turnover, it is not apparent that the salaries of the most highly skilled workers and particularly of researchers have risen sufficiently to elicit the desired supply response.

Diversifying into Linked Services

Improving the quality of instruction provided by USM and expanding graduate and doctoral programs would start the process of enhancing USM's reputation in Malaysia and abroad. This would begin drawing more foreign students to Penang which would contribute to the heterogeneity of the student body and could be a welcome source of earnings for the university as well as for local providers of services to the school. Elite universities are important exporters of services and can be significant revenue generators for the local economy.[33] University teaching and research in the life sciences has the potential to generate synergies with Penang's hospital sector, itself a growing exporter of medical services, mainly to visitors from Indonesia although there is ample scope for diversification.[34]

Medical services providers, like universities can be significant revenue earners for the local economy but too often universities and hospitals remain as island sectors in the urban economy with few linkages and low employment multipliers (Florida, Mellander and Stolarick 2008). It is when these sectors connect with the real sector as in the case of Boston and San Francisco that the multiplier effects start to grow (see Figure 17). The backward linkages from medical services can be to bio-informatics, to IT based firms, to producers of diagnostic and imaging equipment, medical implants, and to the pharmaceutical industry supplying hospitals with medications and using their services to

[33] See for instance Appleseed (2003) on the economic impact of research universities in the Boston area; Appleseed (2004) on Harvard; CBRE consulting (2008) on the University of California-San Diego; Wisconsin Technology Council (2004) on the University of Wisconsin-Madison; and Econsult Corporation (2006) on the University of Pennsylvania.

[34] Nearly 200,000 foreign visitors used Penang's hospital facilities in 2006 for everything from routine physical exams to heart related procedures to hip and knee replacement. Each visitor spent approximately 2.5 days in a hospital (not including any additional time spent in Penang or other resorts to convalesce) and was accompanied by at least one additional person who generated revenues for local merchants and hotels.

conduct drug trials. Universities can be the source of ideas and entrepreneurship which contribute to the ranks of firms supporting the medical services sector. However, it is exceedingly rare for a manufacturing-cum-services cluster to emerge spontaneously even if each of the component parts is present as they are to a degree in Penang. The electronics and bio-pharma industries in Penang could evolve to serve the hospital sector with USM and local entrepreneurs providing some of the impetus. But the likelihood of this happening without the government, local industrial associations, and the university jointly and effectively coordinating the process is small. Even with coordination and the provision of patient risk capital to promising new starts and mezzanine financing for growing firms, the probability that a dynamic cluster might emerge is not high, but it is in the realm of possibility. This kind of a nexus between electronics / IT/ bio-pharma, USM and the hospital sector is one possible pathway to growth via technological upgrading which harnesses several key drivers. There may be others as well but a cross-sectoral effort will call for coordinating mechanisms to assist market forces because these latter are not taking Penang where it wants to go.

IV. Future Directions and Constraints

A strategic vision that translates via incentives and policies into a coordinated effort to encourage the development of a few mutually reinforcing activities would be necessary for Penang to transition to a more knowledge intensive economy with sound growth prospects. As noted above, the electronics industry and the nascent bio-pharma subsector could serve as the foundation of future development. The university and research sector can provide inputs to accelerate the process of upgrading and diversification. And the medical services industry could become an additional driver if it builds linkages to other parts of the local economy. The time horizon for such a transition cannot be less than 5-8 years. And the chances that Penang could move to a GDP growth path of about 7-8 percent per annum are no more than even. There are seven reasons for tempering expectations.

First, Penang is a medium-size city with limited urbanization economies to trigger diversification and support upgrading.

Second, although the RCA suggests that electronics has emerged as the city's strong suit, this is belied by the weak evidence of industrial deepening and rising value added in electronics. Furthermore, the product space analysis does not support the case for high-tech development other than in electronics.

Third, the absence of local firms that could play a lead role – or of several promising new starts in medium and high-tech areas – does not augur well for the future.

Fourth, the local innovation system is weak. USM is years away from becoming a research university of even a regional stature. Significant research capabilities emerge gradually and depend on the ability and experience of key researchers. Pouring money into expanding enrollment and research can yield results but slowly once talent begins to thicken.

Fifth, there is little demand from local companies for 'innovation.' Until firms build up their own R&D, they will not aggressively seek technology from other sources, such as universities.

Sixth, current salaries and lifetime earnings for researchers are not high enough to attract the best and the brightest into applied research in electrical engineering, bio-technology and drug development, for example.

Seventh, innovation in electronics generally requires large research teams led by experienced research managers which neither USM nor local Malaysian firms can easily mobilize. Biotech, bio-engineering and bioinformatics research is usually done by smaller teams, and in principle, the entry barriers for a mid-sized research university are lower. However, the returns to biopharmaceuticals are highly uncertain, and an investment can take between 10 and 15 years to pay off, if it yields a return at all.

The global economic crisis that commenced in 2008 injects additional uncertainty into Penang's future prospects. If the recession persists, there could very well be a substantial geographical reduction of capacity and a shake-out of the export-oriented industrial systems across East Asia. Many MNCs could scale back and consolidate their operations and local firms could go out of business. Depending on how long growth slows, firms will shelf their plans for upgrading and save on research expenditures. This is a time for governments to think strategically to provide the private sector with guidance and both to conserve viable manufacturing capabilities and also to take steps

that will enable Penang's industry to benefit from a rebound in international economic activity, whenever it comes.

Table 15: New exports in 2000

sitc4	Short description	Trade Value in mill. RM (2000)	Lall Class	PRODY (2000)
8974	Other articles of precious metals or rolled precious metals, nes	117.89	LT2	9,341.52
5138	Polycarboxylic acids and their derivatives	55.00	MT2	8,589.99
230	Butter	6.48	RB1	7,161.24
5852	Other artificial plastic materials, nes	4.07	MT2	8,808.99
7928	Aircraft, nes and associated equipment	2.72	HT2	16,258.83
2731	Building and monumental (dimension) stone, roughly squared, split	0.93	PP	4,934.87
440	Maize, unmilled	0.90	PP	4,342.21
2927	Cut flowers and foliage	0.87	PP	3,220.65
6713	Iron and steel powders, shot or sponge	0.61	MT2	7,596.55
5837	Polyvinyl acetate	0.59	MT2	13,069.26
5155	Other organo-inorganic compounds	0.58	RB2	17,458.86
6519	Yarn of textile fibres, nes	0.52	LT1	5,993.72
8946	Non-military arms and ammunition therefor	0.44	LT2	9,066.43
5415	Hormones, natural, or reproduce by synthesis, in bulk	0.35	HT2	22,278.11
8821	Chemical products and flashlight materials for use in photografy	0.34	MT2	22,355.58
7251	Machinery for making, finishing cellulose pulp, paper or paperboard	0.31	MT3	21,619.18
2815	Iron ore and concentrates, not agglomerated	0.30	RB2	1,860.65
5241	Radio-active chemical elements, isotopes etc	0.25	HT2	6,391.74
2332	Reclaimed rubber, waste, scrap of unhardened rubber	0.20	RB1	1,860.14
5112	Cyclic hydrocarbons	0.19	RB2	11,887.15
142	Sausages and the like, of meat, meat offal or animal blood	0.19	RB1	9,448.93
7924	Aircraft of an unladen weight exceeding 15000 kg	0.15	HT2	12,259.33
7421	Reciprocating pumps (other than those of heading 74281)	0.09	MT3	12,279.00
8935	Articles of electric lighting of plastic	0.09	LT2	11,599.48
2519	Other cellulosic pulps	0.09	RB1	14,636.56
343	Fish fillets, fresh or chilled	0.09	PP	8,676.17
5122	Cyclic alcohols, and their derivatives	0.07	MT2	8,088.34
6572	Bonded fibre fabrics, etc, whether or not impregnated or coated	0.07	LT1	19,886.88
7841	Chassis fitted with engines, for vehicles of headings 722, 781-783	0.04	MT1	12,387.86
2873	Aluminium ores and concentrates (including alumina)	0.04	RB2	2,303.33
812	Bran, sharps and other residues derives of cereals	0.03	PP	2,283.90
6539	Pile and chenille fabrics, woven, of man-made fibres	0.03	MT2	8,814.38
5414	Vegetable alkaloids and derivatives, not put up as medicaments	0.03	HT2	13,579.64
7129	Parts, nes of steam power units	0.02	HT2	10,279.27
6543	Fabrics, woven, of sheep's or lambs' wool or of fine hair, nes	0.02	LT1	16,139.21
2667	Discontinuous synthetic fibres, carded or combed	0.01	MT2	4,423.50
7423	Rotary pumps (other than those of heading 74281)	0.01	MT3	16,401.75
6647	Safety glass consisting of toughened or laminated glass, cut or not	0.01	RB2	21,664.65
5622	Mineral or chemical fertilizers, phosphatic	0.01	MT2	3,366.82
2733	Sands, excluding metal-bearing sands	0.01	PP	5,282.50
5623	Mineral or chemical fertilizer, potassic	0.01	MT2	3,443.69
2239	Flour or meals of oil seeds or oleaginous fruit, non-defatted	0.01	PP	1,392.47

Note: PP: Primary Products, RB1: Agro-Based, RB2: Other Resource-Based, LT1: Textile, garment & footwear, LT2: Other, Low-Technology, MT1: Automotive, MT2: Process, MT3: Engineering, HT1: Electronic & Electrical, and HT2: Other, High-Technology.
Source: Authors' calculation

Table 16: New exports in 2007

sitc4	Short description	Trade Value in mill. RM (2007)	Lall Class	PRODY (2006)
6899	Base metals, nes and cermets, unwrought (including waste and scrap)	9.63	RB2	11,492.50
2786	Slag, scalings, dross and similar waste, nes	5.11	PP	10,572.04
7923	Aircraft of an unladen weight from 2000 kg to 15000 kg	4.27	HT2	9,061.12
240	Cheese and curd	2.19	RB1	13,470.20
6975	Base metal indoors sanitary ware, and parts thereof, nes	1.56	LT2	13,829.75
2922	Natural gums, resins, lacs and balsams	0.45	PP	764.04
7213	Dairy machinery, nes (including milking machines), and parts nes	0.40	MT3	18,444.62
7938	Tugs, special purpose vessels and floating structures	0.36	MT3	5,878.79
118	Other fresh, chilled or frozen meat or edible meat offal	0.19	PP	12,045.39
2112	Calf skins, raw, whether or not split	0.18	PP	2,644.78
3354	Petroleum bitumen, petroleum coke and bituminous mixtures, nes	0.18	RB2	7,794.08
7131	Internal combustion piston engines, for aircraft, and parts, nes	0.14	MT3	4,749.05
7842	Bodies, for vehicles of headings 722, 781-783	0.11	MT1	11,688.27
4113	Animals oils, fats and greases, nes	0.11	RB2	11,921.18
611	Sugars, beet and cane, raw, solid	0.10	RB1	2,462.11
2613	Raw silk (not thrown)	0.05	PP	4,263.63
430	Barley, unmilled	0.05	PP	7,652.19
2111	Bovine and equine hides, raw, whether or not split	0.04	PP	7,299.51
2481	Railway or tramway sleepers (ties) of wood	0.04	RB1	3,027.00
616	Natural honey	0.04	RB1	6,207.73
421	Rice in the husk or husked, but not farther prepared	0.03	PP	2,375.16
6594	Carpets, rugs, mats, of wool or fine animal hair	0.02	LT1	7,759.34
7126	Steam power units (mobile engines but not steam tractors, etc)	0.02	HT2	16,290.06
2682	Wool degreased, uncombed of sheep or lambs	0.02	PP	11,988.34
7911	Rail locomotives, electric	0.02	MT2	8,547.08
571	Oranges, mandarins, etc, fresh or dried	0.01	PP	7,843.32
3413	Petroleum gases and other gaseous hydrocarbons, nes, liquefied	0.00	PP	8,748.64

Note: PP: Primary Products, RB1: Agro-Based, RB2: Other Resource-Based, LT1: Textile, garment & footwear, LT2: Other, Low-Technology, MT1: Automotive, MT2: Process, MT3: Engineering, HT1: Electronic & Electrical, and HT2: Other, High-Technology.
Source: Authors' calculation

Table 17: Upgrading Opportunities for Penang, 1995

sitc4	short description	haveRCA	exporting	invdensity	Lall Class
8811	Photographic cameras, flashlight apparatus, parts, accessories, nes	0	1	2.837	HT2
7762	Other electronic valves and tubes	0	1	2.912	HT1
9510	Armoured fighting vehicles, war firearms, ammunition, parts, nes	0	1	2.969	MT3
452	Oats, unmilled	0	1	3.026	PP
344	Fish fillets, frozen	0	1	3.039	PP
7528	Off-line data processing equipment, nes	0	1	3.054	HT1
7648	Telecommunications equipment, nes	0	1	3.058	HT1
6841	Aluminium and aluminium alloys, unwrought	0	1	3.061	PP
5982	Anti-knock preparation, anti-corrosive; viscosity improvers; etc	0	1	3.085	MT2
7415	Air conditioning machines and parts thereof, nes	0	1	3.090	MT3
6413	Kraft paper and paperboard, in rolls or sheets	0	1	3.097	RB1
6671	Pearls, not mounted, set or strung	0	1	3.109	RB2
8852	Clocks, clock movements and parts	0	1	3.127	MT3
2331	Synthetic rubber, latex; factice derived from oils	0	1	3.155	RB1
7523	Complete digital central processing units; digital processors	0	1	3.161	HT1
2881	Ash and residues, nes	0	1	3.199	RB2
5849	Other chemical derivatives of cellulose; vulcanized fibre	0	1	3.209	MT2
5161	Ethers, epoxides, acetals	0	1	3.213	RB2
7149	Parts, nes of the engines and motors of group 714 and item 71888	0	1	3.221	MT3
113	Pig meat fresh, chilled or frozen	0	1	3.235	PP

Note: PP: Primary Products, RB1: Agro-Based, RB2: Other Resource-Based, LT1: Textile, garment & footwear, LT2: Other, Low-Technology, MT1: Automotive, MT2: Process, MT3: Engineering, HT1: Electronic & Electrical, and HT2: Other, High-Technology.
Source: Authors' calculation

Table 18: Upgrading Opportunities for Penang, 2000

sitc4	short description	haveRCA	exporting	invdensity	Lall Class
8811	Photographic cameras, flashlight apparatus, parts, accessories, nes	0	1	3.052	HT2
7928	Aircraft, nes and associated equipment	0	1	3.115	HT2
7525	Peripheral units, including control and adapting units	0	1	3.116	HT1
452	Oats, unmilled	0	1	3.160	PP
7518	Office machines, nes	0	1	3.177	HT1
8710	Optical instruments and apparatus	0	1	3.255	HT2
5161	Ethers, epoxides, acetals	0	1	3.270	RB2
7511	Typewriters; cheque-writing machines	0	1	3.271	HT1
2519	Other cellulosic pulps	0	1	3.292	RB1
8821	Chemical products and flashlight materials for use in photografy	0	1	3.299	MT2
7762	Other electronic valves and tubes	0	1	3.314	HT1
5112	Cyclic hydrocarbons	0	1	3.354	RB2
8852	Clocks, clock movements and parts	0	1	3.363	MT3
6411	Newsprint	0	1	3.364	RB1
7591	Parts, nes of and accessories for machines of headings 7511 or 7518	0	1	3.372	HT1
8851	Watches, watch movements and case	0	1	3.385	MT3
5827	Silicones	0	1	3.394	MT2
344	Fish fillets, frozen	0	1	3.404	PP
7523	Complete digital central processing units; digital processors	0	1	3.422	HT1
4111	Fat and oils of fish and marine mammals	0	1	3.431	RB2

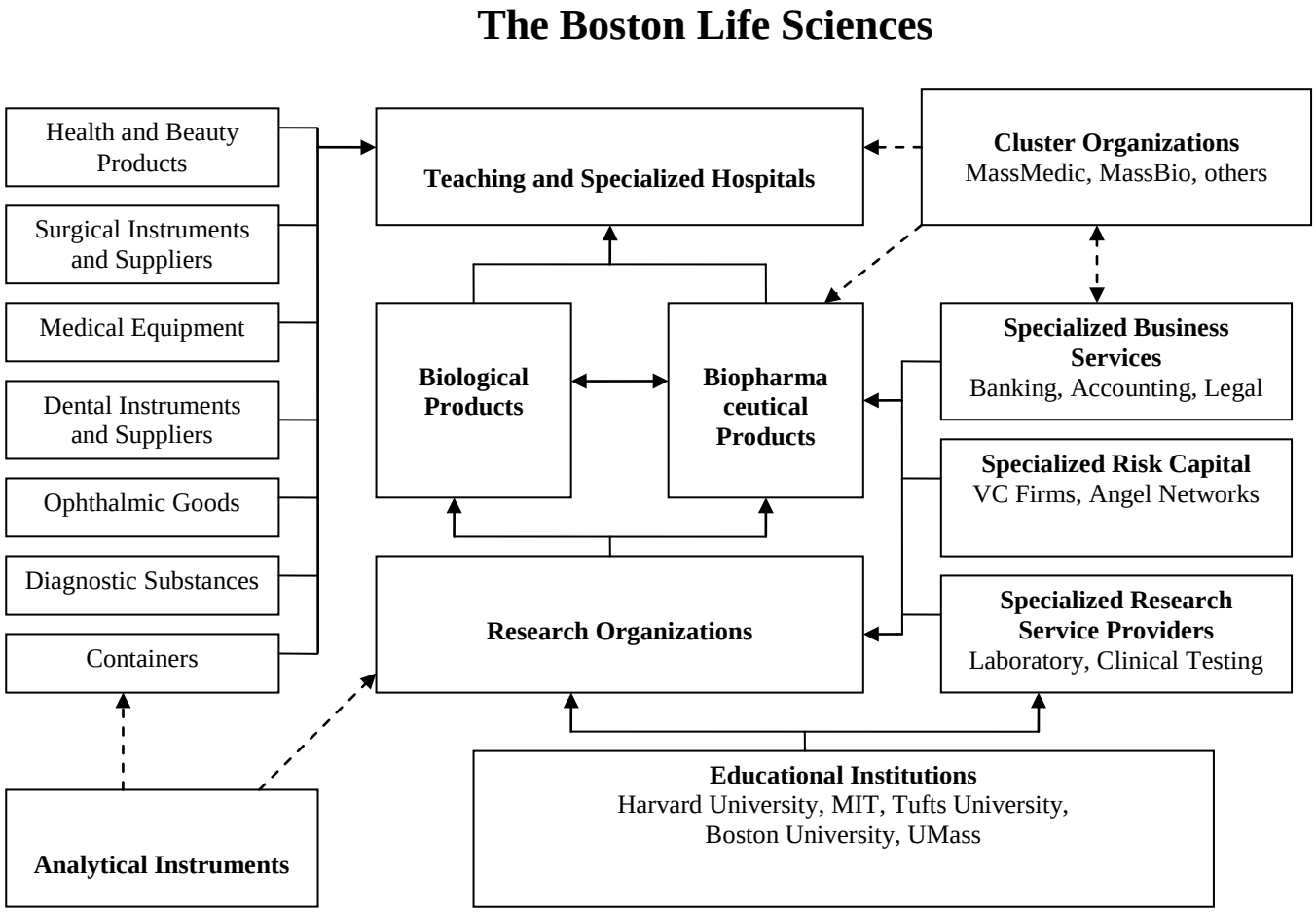
Note: PP: Primary Products, RB1: Agro-Based, RB2: Other Resource-Based, LT1: Textile, garment & footwear, LT2: Other, Low-Technology, MT1: Automotive, MT2: Process, MT3: Engineering, HT1: Electronic & Electrical, and HT2: Other, High-Technology.
Source: Authors' calculation

Table 19: Upgrading Opportunities for Penang, 2007

sitc4	short description	haveRCA	exporting	invdensity	Lall Class
7638	Other sound recording and reproducer, nes; video recorders	0	1	3.118	MT3
5112	Cyclic hydrocarbons	0	1	3.143	RB2
2519	Other cellulosic pulps	0	1	3.156	RB1
5161	Ethers, epoxides, acetals	0	1	3.184	RB2
5137	Monocarboxylic acids and their derivatives	0	1	3.266	MT2
8852	Clocks, clock movements and parts	0	1	3.274	MT3
7924	Aircraft of an unladen weight exceeding 15000 kg	0	1	3.289	HT2
7523	Complete digital central processing units; digital processors	0	1	3.322	HT1
5155	Other organo-inorganic compounds	0	1	3.326	RB2
7762	Other electronic valves and tubes	0	1	3.348	HT1
7643	Television, radio-broadcasting; transmitters, etc	0	1	3.351	HT1
7126	Steam power units (mobile engines but not steam tractors, etc)	0	1	3.368	HT2
8851	Watches, watch movements and case	0	1	3.378	MT3
5839	Other polymerization and copolymarization products	0	1	3.380	MT2
5415	Hormones, natural, or reproduce by synthesis, in bulk	0	1	3.380	HT2
5146	Oxygen-function amino-compounds	0	1	3.385	RB2
7612	Television receivers, monochrome	0	1	3.390	HT1
8821	Chemical products and flashlight materials for use in photografy	0	1	3.397	MT2
7649	Parts, nes of and accessories for apparatus falling in heading 76	0	1	3.410	HT1
141	Meat extracts and juices; fish extracts	0	1	3.411	RB1

Note: PP: Primary Products, RB1: Agro-Based, RB2: Other Resource-Based, LT1: Textile, garment & footwear, LT2: Other, Low-Technology, MT1: Automotive, MT2: Process, MT3: Engineering, HT1: Electronic & Electrical, and HT2: Other, High-Technology.
Source: Authors' calculation

Figure 17: Components of the Boston Life Sciences Cluster



Annex A: Financial Incentives for R&D, Technology Development, and Innovation in Chinese Firms

Table A.1: Fiscal Incentives for Innovation Offered in China

Fiscal Incentives for R&D and Related Activities	▪ The Chinese government provides import tariff exemption: ▪ To facilitate firms' technological renovation and product upgrading in existing state-owned enterprises. In addition, targeted industries such as those in the electronics sector were exempted from tariffs and import-related VAT on equipment during the 9th and 10th five-year periods. ▪ To promote technical transfer and commercialization. Foreign individuals, firms, R&D centers engaged in activities of consulting, and technical services related to technology transfer and technological development are exempted from corporate tax on their incomes.
Fiscal Incentives Given to Various Technology Development Zones	▪ Establishing economic zones, new and high-tech industrial zones (HTIZs), and economic and technological development zones is one of the key measures the Chinese government has adopted in facilitating acquisition of new and advanced technologies, promoting technological innovation, promoting the commercialization of S&T results, and enhancing China's industrial competitiveness. From the early 1980s, China began establishing special economic zones and, since the 1990s, high-tech industrial development zones. ▪ In 1991 China approved 21 national HTIZs, and by 2005 the total number countrywide had risen to 150, of which 53 are at the national level. These HTIZs have nursed 39,000 high-tech firms employing 4.5 million people. The total turnover of firms reached 2.7 trillion yuan in 2004, an increase of 31 percent over the previous year. The per capita profit was 33,000 yuan; per capita tax yield was 29,000 yuan, and the per capita foreign earnings were 157,320 yuan (US$19,000) ▪ In the national HTIZs a series of investor-friendly policies and measures have been introduced. These measures include tax reduction and exemption policies.
Fiscal Incentives Related to Income Tax	The Chinese government offers various tax holiday schemes to different types of firms. ▪ Foreign-invested enterprises can enjoy the preferential treatment of income tax exemption in the first two years after making profits and an income tax reduction (by half) in the following three years. ▪ Foreign-invested high-tech enterprises can enjoy income tax exemption in the first two years after making profits and an income tax reduction (by half) in the following six years. ▪ Sino-foreign joint ventures can enjoy income tax exemption in the first two years after making profits. ▪ Other firms are eligible for income tax exemption in the first two years when starting productive operation. ▪ Domestic firms in HTIZs are eligible for preferential treatment but with limits in terms of types of business activities (income earned from technology transfer or activities related to technology transfer, such as technical consulting service and training). A ceiling is imposed on how much they can benefit from income tax exemption (less than 300, 000 yuan). ▪ Income tax rate is set at 15 percent in these zones, which is much lower compared with the normal rate for those located outside the zones. Firms whose export share is above 70 percent of their annual production can enjoy further income tax reduction (10 percent).

	Turnover tax ▪ Foreign enterprises and foreign-invested enterprises are also exempted from the business tax on technology transfer. *Tariff and import duties* ▪ Tariff and import-stage VAT exemptions have been granted to foreign funded enterprises for their importation of equipment and technologies that are listed in the Catalogue of Encouragement *Accelerated depreciation* ▪ New and high-tech firms are granted accelerated depreciation for equipment and instruments (since 1991; see China's State Council Document [1991] No. 12).
Scholarships for Students Studying in Science and Engineering Fields in China and Abroad	The Chinese government has created an Overseas Study Fund to sponsor Chinese students and scholars to pursue their studies or training overseas. In 2004, the fund sponsored 3,630 people for advanced studies or research programs overseas. In line with China's development priorities, the fund identified seven disciplines or academic fields as its sponsorship priorities for 2004: ▪ Telecommunications and information technology ▪ High- and new technology in agricultural science ▪ Life science and population health ▪ Material science and new materials ▪ Energy and environment ▪ Engineering science ▪ Applied social science and subjects related to WTO issue
Incentives Given to Attract Overseas Chinese Back	▪ The *Chunhui* program has sponsored 8,000 Chinese scholars with PhDs obtained overseas to come back to carry out short-term work. The Yangtze River Fellowship program awarded 537 overseas Chinese scholars professional appointments in Chinese universities for curriculum building and teaching and for joint academic research.
Fiscal Incentives Given to Attract the Establishment of R&D Centers by MNCs	▪ The fiscal incentives offered include the following: ▪ Exemption from import duties and import-related VAT for imports of equipment, devices, and spare parts for R&D purposes (1997). ▪ Tariff and import-related VAT exemption for acquiring imported new and advanced technologies. Foreign-funded R&D centers receive the same fiscal benefits as foreign-funded high-tech firms and enjoy the same fiscal preferential treatments (November 2004). ▪ Exemption from corporate tax for revenue earned through the delivery of consulting or other technical services related to technology transfer, and technical development activities (1999; no. 273). ▪ Reduction in income tax payment for those R&D centers whose expenditures on R&D increased more than 10 percent annually.

Source: Yusuf, Wang and Nabeshima (2009)

Annex B: Financial Incentives for R&D Technology Development and Innovation in Thai Firms

Table B.1: Supporting Investment for the Development of Skills, Technology and Innovation

No.	Schemes	Organizations	Objectives	Details of the Scheme	Supporting Measures	Outcomes
1.	NSTDA Investment Centre (NIC)	NSTDA	To promote R&D spending by the private sectors in S&T with a focus on human resource development, capital funding and S&T management	1. NSTDA will co-invest in projects, which support the national S&T policy, such as projects which require advanced technology to create innovative products in order to reduce R&D risks of private firms. 2. The projects must have the potential to be commercialized and have reasonable returns on investment. 3. The projects must enhance value-added products in order to reduce imports. The projects also have to support the transfer of technology, as well as preserve the environment.	1. NSTDA will invest less than 50% of the total investment. 2. NSTDA will be part of the management team based on its share of investment in the project. 3. NSTDA will withdraw funding from the project if the project is determined to be ineffective or if its funding is no longer necessary.	
2.	Investment Development Policy for Enhancing Technology and Innovation	BOI	To stimulate and provide incentives for firms to improve their technology capabilities	To support direct S&T investment in potential industries: 1. Manufacturing of pharmaceutical and medical equipment. 2. Manufacturing of S&T equipment. 3. Manufacturing of aviation spare-parts. 4. Electronic designs. 5. R&D 6. S&T testing services 7. Calibration 8. Human resource development	1. Exemption of R&D machinery import duties. 2. Tax-based incentives: increase corporate tax holidays for 1 year but not more than 8 years in total.	

No.	Schemes	Organizations	Objectives	Details of the Scheme	Supporting Measures	Outcomes
3.	"Good Innovation – Zero-interest" Scheme	NIA	To provide investment opportunities for the private sector to innovate by co-absorbing risks	To provide soft loans for start-up firms in order to create prototype products or pilot projects.	1. The soft loans rates will be issued by the NIA and participating financial institutes. The maturity is less than 3 years. 2. The firms will be responsible for the collateral.	In 2005, a total of 22 projects were supported in the total amount of 23.65 million baht. The projects' cumulative as of 2005 value was 1,172.5 million baht.
4.	Technology Capitalization Scheme	NIA	To support the private sector in applying knowledge to create new products or patents	To provide grant support and carry out distinguished innovation projects with a high-degree of novelty.	1. The private sector has to invest not less than 25% of the total investment. 2. Grants amount not more than 75% of total investment and lesser than 5 million baht per project. 3. The maturity is less than 3 years.	In 2005, a total of 13 projects were supported in the total amount of 16.58 million baht. The projects' cumulative as of 2005 value was 54.38 million baht.
5.	Innovation Cluster Grants	NIA	To promote the private sector doing R&D as a cluster	To provide grants for potential clusters, such as manufacturing clusters and regional clusters ranging from pilot projects to commercialization.	1. Grant amount is less than 5 million baht per project. 2. The maturity is less than 3 years.	In 2005, a total of 6 projects were supported in the total amount of 9.04 million baht. The projects' cumulative as of 2005 value as 80.89 million baht.
6.	Venture Capital Scheme	NIA	To promote investments in industries with high potential	NIA and joint-venture institutes will invest in the project with a total amount of not more than 49% of the project's registered capital. The NIA will hold a smaller share than joint-venture institutes.	The total amount of the NIA's investment will not exceed 25 million baht.	Between 2004 and 2006, a total of 6 projects were supported in the amount of 39.5 million baht. The projects' cumulative as of 2006 value at 325 million baht.

Table B.2: Expanding Support Programs for Enhancing Technology in Industry

No.	Schemes	Organizations	Objectives	Details of the Scheme	Supporting Measures	Outcomes
1.	Industrial Technology Assistance Program: ITAP	NSTDA	Set up a mechanism to form linkages between technology providers and technology users by providing technical experts to assist in undertaking research and development, giving consultancy and solving problems at factory location including matching local demand in technology with external suppliers	1. Providing technology consultancy services in order to enhance levels of production and R&D that is provided by experts in the country and overseas 2. Organizing seminars in areas of technology that aim to enhance the capability of personnel in organizations 3. Searching for appropriate technology/information technology 4. Conducting quality assessments	1. Supporting the payment for experts in diagnosing general technical problems at full cost (100% of expert's costs incurred) 2. Supporting funding for hiring experts for the project on technology development at 50% of costs incurred but not over 500,000 baht and this provision can be given to only two projects/firm/year.	During 1992-2001, there were 630 projects from 562 firms/companies of which 346 projects (284 firms) were dealt with that diagnosed general technical problems and 319 projects (270 firms) that dealt with hiring experts.
2.	Company Directed for Technology Development: CD	NSTDA	Providing funds for R&D by the private sector (i.e. conducting R&D to improve products and production processes that are based on appropriate technology)	Soft loans for: 1. Conducting R&D and commercializing the findings 2. Improving technology or production processes and products 3. Setting up or upgrading research labs	1. Maximum loan is 30 million Baht and not over 75% of the project's total cost. 2. Interest rate is ½ of the general deposit rate in one year plus 2.25. 3. Payment period is 7 years (without principle payments in the first 2 years)	N/A
3.	Company Directed for Technology Development to Improve	Department of Industrial Promotion	1. To develop industry throughout the value chain i.e. from production processes, quality	Selecting 40 SMEs firms to join with consultants in 5 programs: 1. Developing and improving production processes 2. Improving standards	Providing financial support in part at 60% of consultancy costs but not exceed 9000,000 baht	In 2005, the amount of 40 million baht was allocated to the program that resulted in an increase in sales of

	Competitiveness Program: MDICP		assurance, R&D in products, financial management and marketing 2. To promote technology transfers from universities/research institutes to the private sector to enhance productivity at the firm level	and products so as to ally with ISO 9000 3. Enhancing capability on planning, technology management, strategic planning and marketing for competing in international markets		participating firms at 2,605.2 million baht.
4.	Consultancy Fund: CF	Department of industrial promotion	Providing consultancy services as to enhance productivity at the firm level	1. Hiring consultants to provide general supervision to the firms 2. Hiring consultants to provide technical diagnosis to the firms 3. Monitoring the firms	Providing funds for financial support in part i.e. 50% of consultancy costs but not exceeding 200,000 in the case of the procurement procedure is by bidding; and not exceed 100,000 baht in the case of the procedure is direct selection.	In 2006, the amount of 16.8 was allocated
5.	Knowledge Creation Fund	Office of the Higher Education Commission	To help support private sector and government agencies in R&D investment	Providing funds to the projects related to knowledge creation and knowledge application	-	The process of setting-up the Fund is underway.

Table B.3: Revising the Policy on Intellectual Property

No.	Schemes	Organizations	Objectives	Details of the Scheme	Supporting Measures	Outcomes
1.	Intellectual Property Services	NSTDA	1. To encourage private sector R&D 2. To protect Thai property rights	Providing services in PR related matters to the private sector	1. To give advice, consultations on the process of PR application and PR commercialization 2. To help coordinate in searching for PR information 3. To give specialist advice and consultations on legal-related matters 4. To provide training in and seminars on PR-related issues	During 1999-2005, the services provided to the private sector were follows: - PR: 46 cases; - Licenses: 55 cases; - Trademarks and other services: 31 cases
2.	Cooperation on implementation in the areas of innovation and intellectual property	-NSTDA -NIA -Department of Business Development -Export Promotion Department -Intellectual Property Department	1. To coordinate cooperation among government agencies involved in innovation creation, IP protection and IP commercialization; 2. To provide services in the areas of innovation, IP, and Thai-business promotion; 3. To cooperate on setting up measures/procedures/ mechanisms for start-up for innovation creation, IP protection and IP commercialization; 4. To sign a MOU that allows the flow of information and the creation of openness among the agencies.	A MOU has been signed by the five government agencies to demonstrate their commitment to working together.	Setting up a framework of cooperation in six areas: 1. Innovation creation and IP 2. PR protection 3. PR commercialization 4. PR enforcement 5. HRD in innovation and IP 6. Thai-business promotion	

Annex C: Malaysia's Incentive Policies to Improve Technological and Innovation Capabilities of Malaysian Firms

Table C.1: Malaysia's Incentive Policies

Policy	Agency/Programs	Objectives	Year	Outcomes
Business Climate and Technological Development	Malaysian Business Council (MBC) Malaysian Technology Development Corporation (MTDC) Malaysia Industry Government High Technology council (MIGHT)	Facilitate information exchange, business incubation, and investment management.	1993	Led to various initiatives to improve quantity and quality of R&D.
Human Resource Development Act (1992)	The HRD council was formed to control the grants for training under the Human Resource Development Fund (HRDF)	Provide incentives for employers to upgrade the capacities and capabilities of their employees.	1993	By 1997, dispersed RM 99 million to train 533,227 people. At the end of 2002, the total number of employers registered was 8172 of which 5797 was in manufacturing and 2375 in services. Between 1993 and 2002, electronics components, electrical machinery, apparatus appliances and supplies producers were the largest group of industries. Between 1995 and 2002, in the services sector, hotel, freight and computer were the top three. In 2006, a total of 608,962 employees were trained, involving financial assistance amounting to RM 2.89 billion.

				A total of 130,725 employees were trained in the areas of productivity and quality.
Higher Education: Student Support Mechanisms	National Higher Education Fund Corporation (NHEFC)	Offer subsidized loans to help students meet the high tuition fees charged by the newly established private higher education institutions	1997	Between 1997 and 2005, about RM 15.1 billion was committed to almost 800,000 students.
Tertiary Education: Quality Assurance	National Accreditation Board (LAN) Quality Assurance Division (QAD)		1997	
Stimulate skills-upgrading, technology acquisition and R&D	Technology Acquisition Fund (TAF) Intensification of Research in Priority Areas (IRPA)	help Malaysian firms seek strategic technology from foreign sources fund R&D in Malaysian R&D institutions		Public research institutes, such as the Malaysian Institute of Microelectronic Systems (MIMOS) and the Standards and Industrial Research Institute of Malaysia (SIRIM), promote basic and early-stage R&D in budding technology sectors and to supply development assistance to local firms.
Technology Transfer	Vendor Development Program (VDP)	Incentives for more technologically advanced firms, usually foreign MNCs, to provide local companies with guaranteed contracts and a free interchange of engineers and product specifications.	1993	
Domestic investment	Small and Medium Industry Development Corporation (SMIDEC)	Coordinate all incentives and assistance for the technological development of local firms.	1995	Provide 50 percent training grant to SMEs that send their employees for courses. Appoint 22 training providers to undertake the Skills Upgrading Program for SMEs.

Upgrade Technology: Second Industrial Master Plan (IMP2)	Multimedia Development Corporation (MDC) Multimedia Super Corridor (MSC)	Improving technological competitiveness by shifting focus towards higher value added activities, including efforts to promote and support industrial clusters.	1996/7	Venture capital fund, and the Multimedia University. Over 1,100 firms were located in the MSC.
Second Science and Technology Policy (STEP2)	Industry R&D Grant Scheme (IGS) Commercialization of R&D Fund (CRDF) Multimedia Super Corridor R&D Grant Scheme Demonstrator Application Grant Scheme	Encourage firms to adapt and create new technologies promote the commercialization of R&D results Promote the development of R&D clusters among MSC-status companies with at least 30 percent Malaysian equity. Encourage diffusion of ICT into the community	2003	13 initiatives in human resource development Aim to increase national R&D spending to at least 1.5 percent of GDP by 2010.
Liberalization of Manufacturing FDI (Tham 2004)	Ministry of International Trade and Industry	To achieve faster recovery from the crisis	1998/2003	Allowed 100% foreign equity ownership in the manufacturing sector for new and expansion/diversification projects that were applied by December 31, 2003 (except for metal stamping, metal fabrication, wire harness, printing, paper and plastic packing, plastic injection molded components, and steel service centers). It also removed export conditions.

Table C.2: List of Major Investment Incentives Available for Manufacturing Sector

Tax Incentives	Tax Concessions
Pioneer Status	An exemption of 70% of statutory income for five years with the balance of 30% of the statutory income taxable at current corporate tax rate. An exemption of 100% of statutory income for five years will given to pioneer companies located in promoted area (Sabah, Sarawak, Perlis, Labuan, Eastern Corridor of Peninsula Malaysia and high technology)
Investment Tax Allowance	An allowance of 60% (100% for Sabah, Sarawak, Perlis, Labuan and designated Eastern Corridor of Peninsula Malaysia) of qualifying capital expenditure incurred during the first five years. The allowance can be utilized to offset against the 70% of statutory income for each year of assessment.(100% for Sabah, Sarawak, Labuan, designated Eastern Corridor of Peninsula Malaysia and high technology)
Incentive for Industrial Adjustment	Not applicable anymore
Incentives to strengthen the Industrial Linkage Scheme Incentive for Large Companies - Incentives for Vendor	Tax deduction for expenditure incurred for training for employees, product development. Pioneer status or an ITA status for five years with 100% exemption on the statutory income.

Table C.3: Incentives Specifically for MSC Status Companies

Financial	Pioneer Status with a tax exemption of 100% of the statutory income for a period of 10 years or Investment Tax Allowance of 100% on the of 5 years to be offset against 100% of statutory income for each year of assessment.
	Eligibility for R&D grants (for majority Malaysian-owned MSC Status companies)
	Duty-free import of multimedia equipment
	Globally competitive telecommunication tariffs
	Freedom to source capital for MSC infrastructure globally and the right to borrow funds globally.
Other	Intellectual property protection and a comprehensive framework of cyberlaws
	No censorship of the Internet
	World-class physical and IT infrastructure
	Globally competitive telecommunication services
	Consultancy and assistance by the Multimedia Development Corporation to companies within the MSC
	High quality, planned urban development
	Excellent R&D facilities
	Green and protected environment
	Freedom of ownership.
	Unrestricted employment of local and foreign knowledge workers

Source: MIDA (http://www.mida.gov.my/beta/view.php?cat=3&scat=6&pg=129); Cyberport (http://www.cyberport.cc/download//MSC%20Cyberport%20Brochure.pdf and http://www.cyberport.cc/institute-incentives.php).

References

Appleseed. 2003. *Engines of Economic Growth: The Economic Impact of Boston's Eight Research Universities on the Metropolitan Boston Area*. Boston, MA: Appleseed.

____. 2004. "Innovation and Opportunities: Harvard University's Impact on the Boston Area Economy." Appleseed: New York.

"As China Makes More Components, Asian Neighbors Lose Out." 2007. International Herald Tribune, 10/23.

Au, Chung-Chung and J.Vernon Henderson. 2006. "How Immigration Restrictions Limit Agglomeration and Productivity in China." *Journal of Development Economics*, *80*(2): 350-88.

Baumol, William J. 2004. "Education for Innovation: Entrepreneurial Breakthroughs Vs. Corporate Incremental Improvements." NBER Working Paper 10578. National Bureau of Economic Research: Cambridge, MA.

Berry, Christopher and Edward L. Glaeser. 2005. "The Divergence of Human Capital Levels across Cities." NBER Working Paper 11617. National Bureau of Economic Research: Cambridge, MA.

Cbre Consulting. 2008. "A Study of the Economic Impact and Benefits of Uc San Diego." CBRE Consulting: San Francisco, CA.

"Corporate: Engtek Back on Growth Path." 2007. The Edge Malaysia, 12/03.

Deichmann, U., Kai Kaiser, Somik Lall and Zmarak Shalizi. 2005. "Agglomeration, Transport, and Regional Development in Indonesia." World Bank Policy Research Working Paper 3477. World Bank: Washington, DC.

Econsult Corporation. 2006. "The Economic and Fiscal Impact of the University of Pennsylvania:." Econsult Corporation: Philadelphia, PA.

"Eng Teknologi Counts on China Operations." 2007. The Star, 10/08.

Fan, Peilei and Chihiro Watanabe. 2006. "Promoting Industrial Development through Technology Policy: Lessons from Japan and China." *Technology in Society*, *28*(3): 303-20.

Florida, Richard, Charlotta Mellander and Kevin Stolarick. 2008. "Inside the Black Box of Regional Development: Human Capital, the Creative Class and Tolerance." *Journal of Economic Geography*, *8*(5): 615-49.

Fujita, Masahisa and Jacques-Francois Thisse. 2002. *Economics of Agglomeration: Cities, Industrial Location, and Regional Growth*. New York: Cambridge University Press.

Hausmann, Ricardo, Jason Hwang and Dani Rodrik. 2007. "What You Export Matters." *Journal of Economic Growth*, *12*(1): 1-25.

Henderson, J.Vernon. 2004. "Issues Concerning Urbanization in China." Prepared for the 11th Five Year Plan of China. World Bank: Washington, DC.

Hiratsuka, Daisuke. 2006. "Outward FDI from and Intraregional FDI in ASEAN: Trends and Drivers." Discussion Paper 77. Institute of Developing Economies: Chiba, Japan.

Hughes, Alan. 2007. "University-Industry Links and U.K. Science and Innovation Policy," In S. Yusuf and K. Nabeshima (eds.), *How Universities Promote Economic Growth.* Washington, DC: World Bank.

Jaruzelski, Barry and Kevin Dehoff. 2007. "The Booz Allen Hamilton Global Innovation 1000: The Customer Connection." *Strategy+Business*, *49*: 1-16.

Jaruzelski, Barry, Kevin Dehoff and Rakesh Bordia. 2005. "The Booz Allen Hamilton Global Innovation 1000: Money Isn't Everything." *Strategy+Business*, (41): 1-14.

____. 2006. "The Booz Allen Hamilton Global Innovation 1000: Smart Spenders." *Strategy+Business*, *45*: 46-61.

Kodama, Fumio and Jun Suzuki. 2007. "How Japanese Companies Have Used Scientific Advances to Restructure Their Business: The Receiver-Active National System of Innovation." *World Development*, *35*(6): 976-90.

Kodama, Toshihiro. 2008. "The Role of Intermediation and Absorptive Capacity in Facilitating University-Industry Linkages--an Empirical Study of Tama in Japan." *Research Policy*, *37*(8): 1224-40.

Lall, Sanjaya, John Weiss and Jinkang Zhang. 2006. "The "Sophistication" of Exports: A New Trade Measure." *World Development*, *34*(2): 222-37.

Lall, Somik V., Zmarak Shalizi and Uwe Deichmann. 2004. "Agglomeration Economies and Productivity in Indian Industry." *American Economic Review*, *73*(3): 643-73.

Overman, Henry G. and Anthony J. Venables. 2005. "Cities in the Developing World." CEPR Discussion Paper 0695. Centre for Economic Policy Research: London.

Quigley, John M. 2008. "Urbanization, Agglomeration, and Economic Development." Commission on Growth and Development Working Paper Series 19. World Bank: Washington, DC.

Rajah, Nawin. 2007. "An Overview of Medical Device Industry in Penang." *Penang Economic Monthly*, *10*(2): 1-13.

Rasiah, Rajah. 2006. "Explaining Malaysia's Export Expansion in Palm Oil and Related Products," In V. Chandra (ed.) *Technology, Adaptation, and Exports: How Some Developing Countries Got It Right.* Washington, DC: World Bank, 163-92.

____. 2008. "Malaysian Electric-Electronics Industry: Composition, Problems and Recommendations." processed. World Bank: Washington, DC.

Rosenthal, Stuart S. and William C. Strange. 2004. "Evidence on the Nature and Sources of Agglomeration Economics," In J. V. Henderson and J.-F. Thisse (eds.), *Handbook of Regional and Urban Economics.* North Holland, 2119-71.

Smilor, Raymond, Niall O'donnell, Gregory Stein and Robert Welborn. 2005. "The Research University and the Development of High Technology Centers in the U.S." Presented at the Conference on University Industry Linkages in Metropolitan Areas in Asia in Washington, DC on 11/17.

Tham, Siew-Yean. 2004. "Investment Regime: Malaysia." processed. Universiti Kebangsaan Malaysia: Kuala Lumpur.

Van Pottelsberghe De La Potterie, Bruno. 2008. "Europe's R&D: Missing the Wrong Targets?" Bruegel Policy Brief 2008/03.

Venables, A.J. and Patricia Rice. 2005. "Spatial Determinants of Productivity: Analysis for the Regions of Great Britain." CEPR Discussion Paper Centre for Economic Policy Research: London.

Wisconsin Technology Council. 2004. "The Economic Value of Academic Research and Development in Wisconsin." Wisconsin Technology Council: Madison, WI.
Wong, Poh Kam, Yii Tan Chang and Ming Yu Cheng. 2007. "Indigenous Innovative Companies in Malaysia." processed. World Bank: Washington, DC.
Wong, Poh-Kam. 2008. "Coping with Globalization of Production Networks and Digital Convergence: The Challenge of Ict Cluster Development in Singapore," In S. Yusuf, K. Nabeshima and S. Yamashita (eds.), *Growing Industrial Clusters in Asia, Serendipity and Science.* Washington D.C.: World Bank.
World Bank. 2005. "Malaysia: Firm Competitiveness, Investment Climate, and Growth." World Bank: Washington, DC.
____. 2009. *World Development Report 2009: Reshaping Economic Geography*. Washington, DC: World Bank.
Wright, Mike, Bart Clarysse, Andy Lockett and Mirjam Knockaert. 2008. "Mid-Range Universities' Linkages with Industry: Knowledge Types and the Role of Intermediaries." *Research Policy*, *37*(8): 1205-23.
Yusuf, Shahid and Kaoru Nabeshima. 2008. "Knowledge Deepening and Industrial Change in Malaysia." processed.
____. 2009. *Tiger Economies under Threat: Comparative Analysis of Malaysia's Industrial Prospects and Policy Options*. Washington, DC: World Bank.
Yusuf, Shahid, Shuilin Wang and Kaoru Nabeshima. 2009. "Fiscal Policies for Innovation," In Q. Fan, K. Li, D. Z. Zeng, Y. Dong and R. Peng (eds.), *Innovation for Development and the Role of Government: A Perspective from the East Asia and Pacific Region.* Washington, DC: World Bank, 149-80.