

Chapter 3

Linkages for Fostering Innovation Activities – Case Studies of Firms in E & E Sector of Penang Cluster - Malaysia

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Linkages for Fostering Innovation Activities – Case Studies of firms in E&E Sector of Penang Cluster - Malaysia

Avvari V. Mohan

Abstract

Penang, a small island state in the northern part of Malaysia adopted a strategy somewhat akin to industrial clustering in the 1970s and was been able to reap economic benefits. But recently, given the emergence of other low cost manufacturing locations within Asia that could attract these players, there has been a discussion of the need for ‘upgrading’ the Penang cluster needing the firms to go up the value chain and innovate in order to maintain competitiveness. Thus it was felt that a study on what are the linkages emerging between firms and institutions for supporting innovation is warranted – and the study was done based on case studies of firms located in the Penang Island of Malaysia. With the exception of MNCs and one Local firm, most of the Innovations taking place could be categorised as incremental. In the case of the SME/SME firms – the Innovation was designing products for differentiating or when seeking new material for cost competitiveness. Motivations for the Innovation seemed to more for gaining or maintaining strong market position and opening up new markets. There appears to be no explicit collaboration for innovation among most of the firms within the cluster – collaboration seems more with suppliers or customers. In the case of MNCs and some local firms with international presence there is extensive movement of engineers between their different global locations. Those firms with innovation for product differentiation seem to have stronger links with universities – within cluster and in other clusters. Overall Penang’s E&E sector can be seen as an internationally linked cluster. It’s a cluster that is based on supporting policies and institutions (actors) that provide support for innovation, both at the national level and the regional level and driven by foreign MNCs and now also local MNCs. In general interviewees all agree on (1) Human Capital (2) Low Costs (3) Entrepreneurial Culture and (4) Pro Industry Policy as key factors for the development of Innovation activities in the Penang region. Penang Skills Development Corporation (PSDC) is a unique institution developed for the cluster that has good links with the firms and plays an important role.

1. INTRODUCTION

Penang, a small island state in the northern part of Malaysia adopted a strategy somewhat akin to industrial clustering in the 1970s and was been able to reap much

economic benefits from its industrial cluster. It has been recognised as one of the top ten most unique industrial clusters in the world by the United Nations. Penang can be considered as an industrial cluster /agglomeration, particularly for the Electrical and Electronics (E&E) sector. This report seeks to understand the innovation activities that firms in Penang are involved in and also what are the linkages that these firms have with different actors in the regional (within Penang) / national innovation systems for supporting their move into Innovation related activities.

For this report the argument is that Innovation is not just a firm specific factor but requires support from several other factors and involves linkages a firm develops with various actors within a cluster and beyond. Known as Innovation systems – this concept states that there are actors at the Regional / National that help innovation related activities in firms (Lundvall 1992, Freeman 1995). These factors of an NIS/RIS include the Industrial base of the region, infrastructure, and availability of skilled workforce relationships between producers and purchasers, links with organisation external to the cluster, public support and community involvement, informal community networks.industrial base of the state (Lye King and Avvari 2010). Similarly the other factors within the national and innovation system that have been outlined are considered important for the firm to move up the value chain into innovation related activities. This concept of Innovation systems - forms the basis for the study. Penang cluster can be seen as an innovation system and in this study we aim to understand the linkages firms are making within the cluster and beyond to support their move into innovation related activities.

1.1. Overview of the development of Penang E&E Industry Cluster

The growth of the E&E in Penang as an agglomeration / cluster can be summarized in different phases – first phase was in the 70s when it started off with the adoption of export-oriented manufacturing following the Investment Incentives Act of 1968 and the

FTZ Act of 1971. With the formal opening of export processing zones since 1972 export-oriented firms began to relocate in large numbers here. In addition to the small domestic market, the promotional role of UNIDO and World Bank which encouraged developing economies to take advantage of the dispersal efforts of multinationals was also important (Rasiah 2002). In addition promotional efforts by the Malaysian Government along with financial incentives being offered also helped to attract MNCs to set up manufacturing base in Penang. Apart from providing an attractive investment climate through the establishment of Free Trade Zones (now known as Free Industrial Zones) and Licensed Manufacturing Warehouses (LMWs), the government also offered a special 10-year pioneer status incentive to investors in the electronics industry.

After some growth there were problems and then in mid 80s which can be considered as the second phase of development for Penang started when the first Industrial Master Plan (IMP) was launched and the export processing zones regained active promotion from the government. Then in the later part of 1990s, particularly after the Asian crisis, some of the TNCs closed shop and moved out of the cluster. During this time the government intervened again with incentives and programmes to retain many of the MNCs (some had moved out of Penang during the crisis) and more recently in the 9th Malaysia plan there seems to be conscious / focussed efforts in developing specific cluster based planning for the rejuvenation of the industry

The island region having gone through four decades of development (which included the Asian Financial Crisis and competition from China and other regional players) and has come to be recognized as having a strong bases of Electronics and Electrical (E&E) manufacturing companies. The roles of the government, several policies and institutions have been identified as playing an important role in the development of an E&E agglomeration in Penang. But recently, in order to be competitive given the emergence of other low cost manufacturing locations within Asia that could attract these players, there has been a discussion of the need for ‘upgrading’

the Penang cluster needing the firms to go up the value chain and innovate. Formal cluster oriented policies have also been announced to help maintain Penang's (including the E&E sector's) competitiveness.

Given all of this i.e. the development of institutions at the national and regional level to help in upgrading of cluster - it was felt a field study is warranted to understand what kind of innovation related activities the firms are involved in, identify who are the actors in the Penang cluster (innovation system) that the firms are developing links with for their innovation. The main aim of this report is to identify (1) what kind of innovation activities are developing among the firms selected for the case studies in Penang (2) understand and map what are the linkages these businesses have or are developing for their innovation activities (3) derive policy implications.

2. AGGLOMERATION AND PRODUCTION NETWORKS FOR UPGRADING AND INNOVATION

In this section it is attempted to give a general picture of Penang Economic indicators, some Malaysian trade and labour situation. In addition an overview of the E&E sector in Malaysia, followed by some information on the production networks and S&T indicators in Malaysia are presented. In addition some information about Penang Agglomeration /Cluster specific aspects are also outlined.

The first table (1) provides an overview of the GDP of Penang from 2001 to 2005 – generally it can be observed that there is steady growth in the GDP. The manufacturing sector had with negative growth in 2001 but has been growing since then – with some ups and downs. Capital investments have been growing steadily and while foreign investments have been growing more steadily – domestic investments have shown a drop over the five year period.

Table 1 Penang: Economic Indicators

Year	2001	2002	2003	2004	2005
GDP (RM-Million)	16,773	17,501	18,788	20,032	21,128
GDP (%)	-2.5	4.3	4.2	6.6	5.5
Agriculture	17.6	3.6	3.4	4.5	2.7
Mining	5.9	-3.1	-4.6	-7.4	-3.0
Manufacturing	-11.9	4.5	4.1	9.6	5.9
Construction	-3.1	-8.8	3.3	-11.1	-1.3
Services	5.4	5.0	4.5	5.4	5.6
Total Capital Investment (RM-Million)	3,837	2,398	1,923	2,030	4,808
Domestic Investment (RM-Million)	260	411	467	1,014	717
Foreign Investment (RM-Million)	3,578	1,987	1,456	1,016	4,090

Source: Penang State Government, SERI (<http://www.penang.gov.my/index.php?ch=16&pg=44&lang=eng> accessed on Jan. 22nd 2010).

2.1. Some general Malaysian Trade and Labour issues

For the first three quarters of 2009, total exports recorded decrease of 23% to RM394.3 billion, while total imports contracted by 23.5% to RM 308.4 billion as compared with the same reference period of 2008. During January to September 2009, Malaysia's total trade was valued at RM 702.8 billion, a drop of 23.2% from the same corresponding period of 2008. External Trade balance recorded a surplus of RM 85.9 billion, decreased by 21.4% as against RM as against RM 109.2 billion during the period under study.

Electrical and Electronics, Malaysia's leading export earner contributed RM159.9 billion or 40.5% of total exports during the first nine months of 2009. It decreased by 19.3% from RM 198.1 billion as compared with last year. The major component namely electronic integrated circuits, which accounted RM65.5 billion or 41% of total exports of E&E products, decreased by 6.8% from the corresponding period of 2008.

2.2. Labor Force and Employed - Malaysia 2003-2008

Overall the labor force in Malaysia has increased 7.7 per cent from 10.24 million in 2003 to 11.028 million in 2008. Number of employed persons rose by 8 per cent in 2008 to 10.7 million compared to 9.87 million in 2003 (sourced from Industrial Census. Labor Force Statistics – Malaysia, 2008)

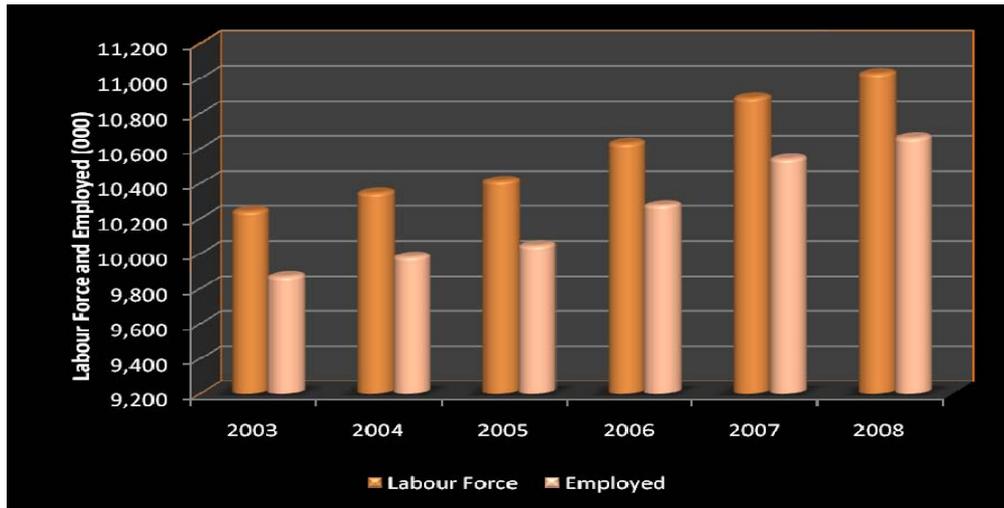


Figure 1 Labour Force in Malaysia from 2003- 2008

Source: Industrial Census. Labor Force Statistics – Malaysia, 2008.

Statistics from Immigration department of Malaysia shows that the trend of foreign workers working in Malaysia continued to increase from 2001 to 2008. The number of foreign workers recorded in 2008 were 2.01 million a decrease of 1.7 per cent compared to 2007(2.045 million) and increase of 34.47 per cent compared to 2003 (1.34 million). These workers include both lower skilled workers and also higher skilled workers (engineers, managers) and it's generally understood that significantly large portion of the foreign workers are in the lower skilled category.

2.3. Electrical and Electronics (E&E) Manufacturing Sector in Malaysia

The formative years of the electronics industry in Malaysia can be traced to the early 1970s when the Government shifted from an import-substitution to an

export-oriented strategy to promote industrial development. It was also during this period that offshore operations in emerging economies started mushrooming as a result of structural changes in the production networks of developed economies. Intense competition among MNCs for global market share and lower production costs were among the main factors that led to US, European and Japanese MNCs relocating some of their manufacturing operations overseas. Malaysia, which was moving ahead with its export-led industrial programme in the 1970s was a major beneficiary of such a move by the global MNCs. The table (2) below gives an idea of the subsectors of the E&E industry in Malaysia.

Table 2 Structure of the E&E Industry

Sectors	Sub-Sectors	Examples of Products
Electrical	Electrical	Panels and Consoles, Switching Apparatus, lamps, air conditioners, vacuum cleaners, ovens, transformers, cables & wires, primary cells & batteries, solar cells and modules.
Electronics	Components	Semiconductors, passive components, printed circuit boards, metal stamped parts and precision plastic parts.
	Consumer	Audio visual products such as television receivers, portable multimedia players (PMP), speakers, cameras and electronic games.
	Industrial	Multimedia and information technology products such as computers and computer peripherals, telecommunications equipment and office equipment.

Source: MIDA Reports (www.mida.com.my accessed on Jan. 22nd 2010).

The E&E industry continues to be the leading sector in manufacturing sector in Malaysia. As of 31st Dec. 2008, Malaysia has more than 1800 companies producing E&E related products.

Table 3 Investments in Approved Manufacturing Projects in E&E Industry, Malaysia 2008

Employment	Domestic Investment (RM million)	Foreign Investment (RM million)	Total Capital Investment (RM million)
34,196	440.9	17,332.1	17,773.0

Source: MIDA Reports (www.mida.com.my accessed on Jan. 22nd 2010).

The E&E sector constitutes a significant part of the country's manufacturing output (29.3 per cent), exports (55.9 per cent) and employment (28.8 per cent). In 2008, gross output of the industry totalled RM167.2 billion (US\$53.9 billion), exports amounted to RM233.8 billion (US\$75.4 billion) and the industry created employment opportunities for 296,870 people. (Source Invest Penang Website). From the Table 3 above, as of 2008, it can be seen that the E&E sector in Malaysia has significant foreign investments rather than domestic investments. This is supported by data gleaned from Penang government website (Table 4 below) showing investments for the first quarter 2008 – but this time by state. What is interesting is that though it's the second smallest state in the country – Penang is third in terms of number of projects and second in terms of investments received.

Table 4 Approved Manufacturing Projects by State, Jan-Mar, 2008

State	Number	Employment	Domestic Investment (RM)	Foreign Investment (RM)	Total Capital Investment (RM)
Sarawak	10	3,243	461,566,450	12,538,888,124	13,000,454,574
Pulau Pinang	29	5,244	4,234,202,777	462,000,501	4,696,203,278
Selangor	58	3,721	313,768,700	1,413,535,179	1,727,303,879
Johor	34	5,294	592,950,413	406,917,768	999,868,181
Perak	13	637	86,906,692	622,715,775	709,622,467
Sabah	13	1,749	274,737,534	229,014,947	503,752,481
Terengganu	2	0	472,500,000	27,500,000	500,000,000
Kedah	12	792	94,369,636	62,307,733	156,677,369
Perlis	1	303	0	91,250,000	91,250,000
Pahang	5	136	69,503,970	21,091,030	90,595,000
Melaka	10	539	21,754,164	51,422,500	73,176,664
Negeri Sembilan	3	225	31,798,123	5,355,568	37,153,691
W.P. – Kuala Lumpur	2	311	6,057,000	14,038,750	20,095,750
Total	192	22,194	6,660,115,460	15,946,037,874	22,606,153,334

Source: www.penang.gov.my (accessed in January 2010).

Table 5 PENANG: APPROVED MANUFACTURING PROJECTS

Overall Industry and E&E Sector 2003-2005	No. of Projects			Investment (RM Million)		
	2003	2004	2005	2003	2004	2005
<i>Electrical & Electronic</i>	57	54	61	1,385.4	1,258.6	3,771.30
Total in Penang	137	144	148	1,923.0	2,030.3	4,808.18

Source: MIDA Penang.

After seeing a drop in 2004, 2005 shows overall growth in the numbers of project and investments in the sector within Penang cluster. Discussions with some of the stakeholders indicate that in 2009 – 2010, while demand for exports has slowed, the investments in the sector – within existing firms and also new firms is increasing. In addition to the above section where one gets an overall idea of the E&E sector in Penang. There are several indicators that are considered for getting an idea of the current level of innovating capability. R&D expenditures, Education aspects, sources of innovation, are some of them – in the following section attempts to provide some idea of innovation capacity in terms of Investments and other aspects of R&D in Malaysia.

2.4. Investments and Other aspects of Research and Development/Innovation

While there has been some investment in R&D in particular in E&E sector – the macro indicators of R&D expenditures and numbers of researchers or scientists are important to get an idea of support for innovation.

When we look at Research and development (R&D) expenditures as % of GDP for the period between 1996-2000 in comparison to some of the neighbours – Malaysia's R&D expenditures as a percentage of GDP is 0.4 % - this is lower than most of its competitors/neighbours except Hong Kong which is at (0.4%)Singapore (1.9%); Korea (2.4%); Malaysia (0.4%); Thailand (0.1%); China (1%) and India (1.2%) all have higher R&D Expenditures as a % of GDP. On the indicator of Number of researchers per 10,000 labor force, Malaysia's was 15.6 (in the year 2000) where as for its is 83.5 for

Singapore (2000); 60 for Korea (1998); Scientist and engineers in R&D (per million people between 1996-2000) is 4,140 for Singapore; 2,319 for Korea; 160 for Malaysia; 74 for Thailand; 156 for Philippines; 545 for China and 274 for Vietnam (*Source UNDP, Human Development Report, 2003 reported in Chandran et al 2009*).

In general the total R&D expenditures for the private sector are supposed to have been steady and consistent according to report of the MOSTI. In 2004 private R&D expenditures was about RM 2.03 billion (National R&D Survey 2006 – MOSTI). As of 31st December 2008, the manufacturing sector in Malaysia has a total of 101 R&D projects involving investments of RM 1.4 billion have been granted PS/ITA incentives. Foreign Investments in these R&D projects amounted to RM928.4 million while domestic investments totaled RM 432.1 million. Out of these investments, the E&E industry has secured majority of investment. For a total of 35 R&D projects in E&E industry amounted to RM 685.3 million.

2.5. Education Indicators to support Innovation

Another indicator that is important for innovation is the number of student enrollments in Master's and Doctoral programmes in Science and Technology related areas. As can be seen in Appendix B – the proportion of student enrollments in master's and doctoral programmes is considerably low when compared to those in Arts fields at graduate and doctoral levels.

2.6. Sources of and Type of Innovation among Firms (in general)

One of the important indicators for Innovation, be it in from the 'Innovation Systems view or the more recently popular 'Open Innovation' framework is sources external to the firm. Be it links with customer or suppliers, other institutions and variety of sources of information are important for Innovation to take place within an organisation. Overall the more prevalent forms of innovation, as indicated by the firms

participating in the survey, improvements in products or process developments – and while for process developments there are factors outside the firm as sources – both new product developments and product improvements seem to be based on sources within the firms.

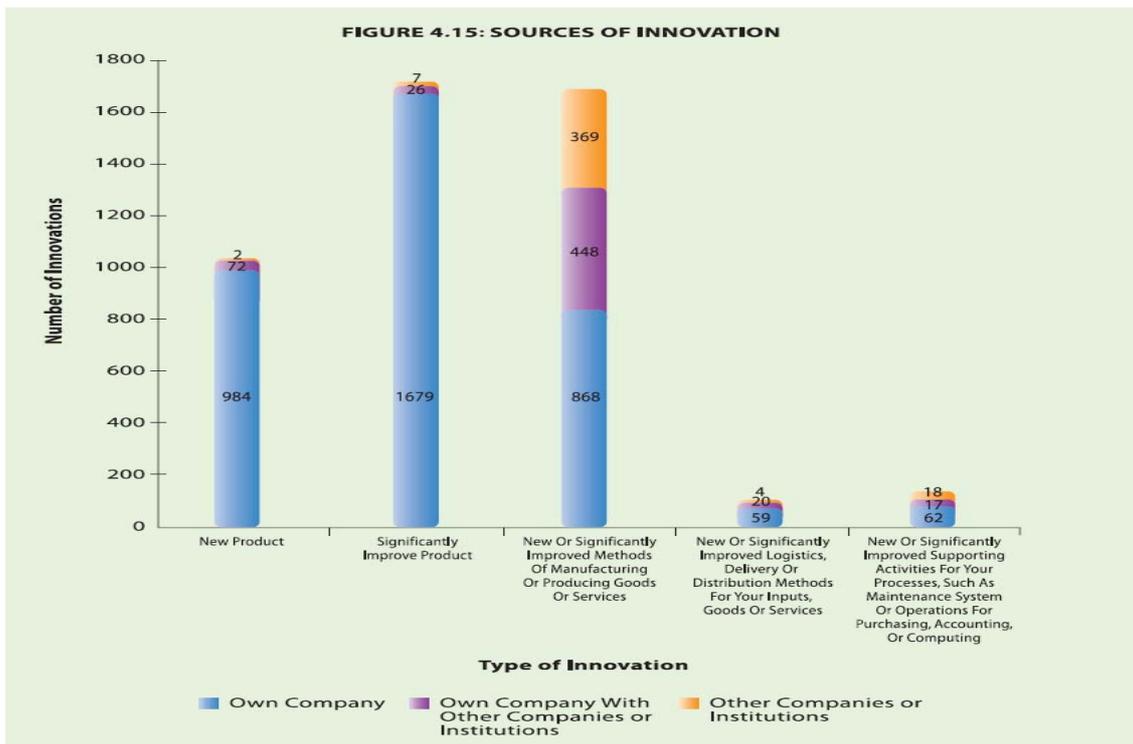


Figure 2 Sources and Type of Innovation among Malaysian Firms in general

Source: National Survey of Innovation Report 2002-2004 (MOSTI) www.mastic.gov.my accessed on January 22nd 2010.

The Figure 2 above shows clearly different types of innovation that the firms are attempting or involved in. But what is of concern is that significant proportion of ideas for product innovations are from internal sources. It's only process innovations that seem to stem from relatively greater proportion of external sources.

2.7. Government Policy for Upgrading and Innovation

As mentioned earlier the beginning of the government policy for supporting the

development of an industry cluster was in November 1969, with the creation of the Penang Development Corporation (PDC) as the primary state development agency. In 1972, the 'Free Trade Zone' (FTZ) was created as country's first export processing zone to attract foreign electrical and electronics firms (Penang Development Corporation website). The next significant support came in 1989 – with the creation of Penang Skills Development Corporation (PSDC). PSDC is a joint effort of government, academia and industry. It was initiated by the State Government through the Penang Development Corporation (PDC) and is aided by academia, and the management and administration is left to the industry. PSDC operates as a non-profit society with its mission to pool resources amongst the 4 Free Trade Zones and 4 Industrial Estates in Penang.

In the 1990s competition from neighbouring countries led to creation of some high tech institutions to support and stimulate upgrading (at the national level) following the introduction of the Action Plan for Industrial Technology Development (APITD) in 1990 – including those such as the Human Resource Development Fund (HRDF) in 1993 Malaysian Technology Development Corporation (MTDC), the National Electricity Board, the Telecommunications Corporation and the Malaysian Microelectronics Systems (MIMOS) and the Private Universities Bill was enacted in 1995 so as to enable the development of human resource with greater role for markets. This is in addition to supportive policies from Ministry of International Trade and Industry (MITI) and also Ministry of Science Technology and Innovation (MOSTI) and promotional activities undertaken by Malaysian Industrial Development Authority.

More recently the 9th Malaysia Plan 2006-2010, placed high emphasis on the objective of upgrading manufacturing and related services (9th MP, MOSTI). Among the key policies initiated to achieve this objective is:

Upscale & value-add manufacturing and related services through knowledge & Innovation based activities in high-end E&E, petrochemicals, biotech and so forth.

The following are the major programmes launched to achieve the above objective.

1. Customized incentives to attract high-end FDI & domestic investment in strategic areas & soft infrastructure especially human capital development and R&D&C capability
2. Promoting innovation-driven SMEs to participate in global supply chains and strengthen linkages with GLCs & MNCs.
3. Encouraging new regional establishments especially in R&D, human resource and product development
4. Providing new industrial infrastructure-industrial estates, SMEs & technology parks as well as upgrading existing infrastructure

Under the 9th Malaysian Plan, one of the thrusts is to move the economy up the value chain. The E&E industry will be the main sector for industrial growth, innovation and shift towards higher value-added products and activities. Among the higher value-added products and activities identified are:

- Production of advanced electronic components such as metal-cam packages and the latest generation of integrated circuit packages, research and development (R&D), distribution and marketing.
- In order to make available a sufficient supply of high skilled and innovative workforce in the electronics sector the government had allocated RM36.2 million to upgrade existing institutions to provide microelectronics training.
- A total of RM23.7 million had been allocated to upgrade the Faculty of Electrical Engineering in USM to provide for the Collaborative Microelectronic Design Excellence Centre (CEDEC).
- A total of RM12.5 million had been allocated to set up the Malaysia Institute of Microsystems (MIMs).

To foster technological development, specific, general government and non-government agencies were established in Malaysia. The main role of these agencies is to act as coordinators or facilitators technology/technological development in the country. For this purpose, the Standards and industrial research institute (SIRIM), Malaysian Venture Capital (MAVCAP), and Malaysia Industrial Group for High

Technology (MIGHT) and ministries such as Ministry of Science, Ministry of Technology and Innovation were setup. SIRIM's primary objectives are to conduct R&D, contract research projects and to develop new innovations in product design and process development. MAVCAP helps companies to commercialization and finance their R&D projects, while MIGHT (non-profit organization) for promoting technology management and transfer.

Through MOSTI, the Malaysian Government has initiated funding for Innovation in manufacturing industry through several grants and Incentives. For E & E industry, these schemes include the Technology Acquisition Fund (TAF), the Commercialization of R& D Fund (CRDF), the Industry Grant Scheme (IGS), the Industrial Technical Assistance Fund (IATF), while the incentives include tax exemptions for the use of R&D services, construction of Industrial building for R&D. It is to be noted that, all these grants and incentives are given to encourage investment in R&D, but there is no formal requirement imposed on firms to undertake R & D activities. Table 6 shows the various Fiscal and Non-Fiscal Instruments that are available for manufacturing industry in Malaysia.

Table 6 Structure and Content of Innovation Policy – Malaysia

Fiscal Instruments		Non-Fiscal Instruments
Tax Incentives for R&D	Research Grants	
There are nine different types of tax incentives	Industry R&D Grant Scheme (IGS)	Not Clearly Articulated
	Technology Acquisition Fund (TAF)	
	Multimedia R&D Grant Scheme (MGS)	
	Intensification of Research in Priority Areas	
	Commercialization of R&D Fund (CRDF)	

Note: A brief description about various Research Grants schemes is in Appendix A.

In addition to grants there are tax incentives provided by Malaysian Government to firms to encourage them to take R&D activities include:

- Investment tax allowance on the capital expenditure incurred in in-house R&D
- Exemption of import duty on machinery and equipment, materials, raw-materials, components and samples used for R&D purposes
- Double deduction of expenses incurred in approved research projects.

Overall there seems to be in place a substantial set of incentives be it grants, tax incentives, special status type of benefits in place for encouraging Innovation from the government. But what is more important is how much of this support is being utilized and leading to innovation or at least a move towards innovation activities / efforts in the industry. What is interesting is the at crucial points in time the S&T policy has been changing to address changing needs, albeit reactive, of the industry.

In this section a descriptive account of some indicators of the manufacturing and investment activity in Penang and to a small extent in the E&E sector were outlined. Aspect of S&T manpower in terms of education were presented and support in terms of policy and incentives from the government of Malaysia were gleaned from the relevant ministry documents were presented. In the next section the cases developed from the field study are presented.

3. CASE STUDIES

The main research question what are the linkages between firms and other actors / institutions for supporting innovation activities in Penang's E&E sector? The report is to be based on ten case studies (9 completed one more to be done) of firms located in the Penang Island of Malaysia. The cases studied for this report can be classified into the following groups:

1. Multinational or Transnational Corporations (MNCs/TNCs)
2. Large Local Firms (with specific/formal R&D units)
3. Small and Medium Sized Local Firms

Despite many follow-up calls it was not possible to get access to the only visible joint-venture firm in the cluster's E&E sector. The following passages present the case studies of the firms in the Penang region. The cases are structured to have some background information of the firm, key factors of the Penang region important for being located, linkages / collaborations with different actors in the innovation system and conclusions.

3.1. Case #1 - German Automotive Electronics MNC (GAE-MNC)

This case is of a German GAE MNC which has been present in Malaysia since the 1920s. It currently has offices located in Selangor, Perak and Penang. The GAE MNC is a public listed company in Malaysia and is responsible for the sales and distribution of automotive original equipment, automotive aftermarket products, power tools and security systems in Malaysia. The automotive aftermarket and original equipment sales divisions as well as car-multimedia division in Malaysia are part of the GAE MNCs automotive technology business. Automotive technology is one of the biggest business divisions in this group. In 2008, sales were recorded at 26.5 billion Euros. GAE-MNC in Penang currently has a staff strength of about 700 and sales turnover of about RM600 million (approximately 180-190 million US\$) in 2008. The unit here produces car multimedia products such as car radios, rear seat entertainment systems and navigation systems as well as electronic components and actuator motors for original equipment manufacturers (OEMs).

3.1.1. Factors Attractive in Penang for Manufacturing

In addition to the factor of low costs, the altruistic nature of the firm was to set up manufacturing plants developing economies to help them through employment opportunities and gain the benefit of low cost locations. Main motivation to start in Penang (in the 70s) was the efforts of the then Chief Minister – to promoting and

developing certain factors conducive for setting up of manufacturing plants – the location factors including availability of cheap labour and supportive policies of the federal government and good infrastructure. Starting as a manufacturing unit for exports, GAE Penang moved into R&D (product development) and now is an independent subsidiary responsible for design, manufacturing and marketing car multimedia and navigation products under its umbrella.

3.1.2. Types of and Motivations for Innovation

Product Innovations are to cater to the local markets ie ASEAN markets. Most of the innovations are for introducing new products more to avoid competition and process innovations to support the manufacturing of the new products and also to reduce costs. Process innovations include those to cut input costs – sourcing for new materials. The product innovations include new to the markets of the firm and also new to the firm in Penang.

3.1.3. Key Drivers and Support for Innovation

There are several sources / support factor for innovation at the GAE. Key institutions that have been supportive for the setting up for the facility are MIDA and MITI at the national level. MIDA provides grants for R&D activities in addition to other support like tax incentives etc. At the regional level, the state government, PSDC, the cluster university and FrePenCa are key institutions. A critical driver seems to be the support from within the organisation. The organisation has 280 locations linked in a network. Bosch has several R&D centres around the world with varying competencies offering in-house source of information. Information is available through internet and also through corporate magazines / news letters.

The following diagram provides an overview of the linkages GAE MNC in Penang has for Innovation

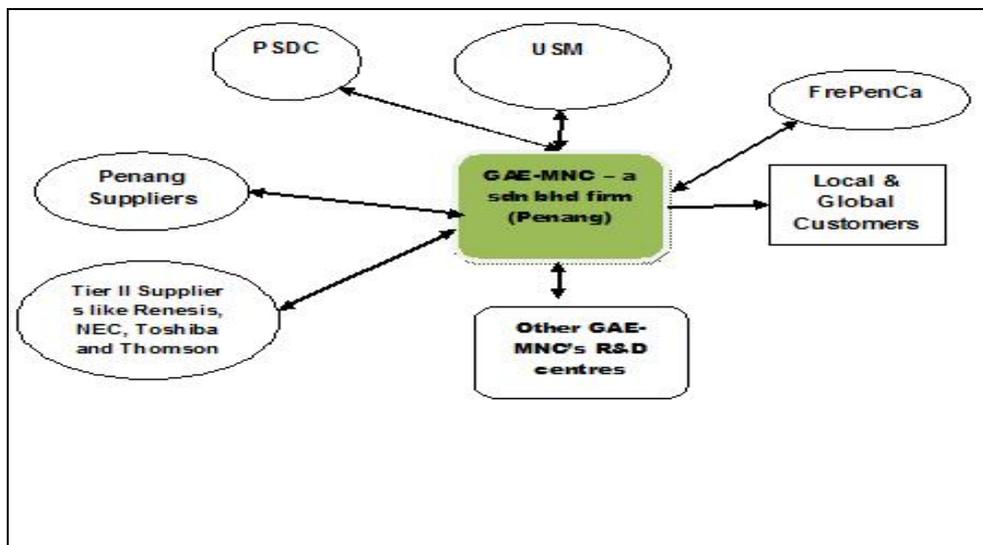


Figure 3 Diagram of Firms Linkages of the GAE MNC in Penang

3.1.4. Linkages or Collaborations

In general the external collaborations are short term. There appears to be almost no formal firm to firm linkages within Penang cluster or out of cluster also. There are linkages with suppliers within cluster and in other locations are considered very strong. Other actors with which Bosch has strong linkages include USM (the cluster university) and PSDC.

The GAE in Penang has strong linkages with suppliers within the cluster. Among the key reasons for continuing and extending the value chain activities in Penang include the presence of a large supplier base in the E&E sector. In addition the GAE-MNC has strong links with what it calls tier-2 suppliers in Japan and France – this collaboration is for joint product development and also to build capacity of these suppliers. One of these suppliers has a presence in Penang also.

The linkage with cluster university (USM) is fairly strong – the university's laboratory facilities are used for testing and also the firm uses the knowledge of the faculty in the mathematical and statistics faculties for various analysis works.

Linkage with Other Cluster Actors The firm has strong links with PSDC – where it has availed substantial training assistance of the skilled work force in the production plant. More recently PSDC is also increasing its role in training higher skills human resources to support the Design and Development function also. FrePenCa is another actor in the region that the GAE-MNC has active links with – the Free Industrial Zone, Penang Companies’ Association. FrePenCa helps in maintaining communications and relationships amongst its members in matters of mutual interest as well as with the Government and its agencies – and also help in negotiating with the government and its agencies for any help needed in the Innovation and other activities of the firm.

3.1.5. Issues in Policies related to Innovation

Overall the government policies, both at the national and state level, are considered to be favourable and supportive for Innovation – be it in terms of grants, infrastructure provision, policies like tax rebated etc. But an issue is that recently there is more focus on supporting ‘future’ oriented projects / areas rather than policies to help existing industries to climb up the value chain. This has led to some lacunae in the emergence of support firms / suppliers in the cluster – instead there is a mushrooming of firms in the ‘new’ focus areas that are being supported.

3.1.6. Conclusion

From the GAE MNC perspective the key issues in Penang cluster that are helpful for going up the value chain from manufacturing to design and innovation activities are – availability of highly skilled human capital, good infrastructure, presence of large base of suppliers, conducive policies and incentives, presence of cluster institutions. At the national level, institutions like MIDA which provide the incentives and benefits created by the MOSTI and MITI ministries and in general the stable political situation are deemed as useful. A more focused policy and incentives to further develop the cluster

(along with the focus on future areas) are considered as critical for the further development of E&E sector in Penang.

3.2. Case # 2 - Intel Malaysia

Intel Malaysia Sdn. Bhd. founded as a subsidiary of Intel Corporation, USA started its operations in Penang in 1972 has now grown into the largest, most mature manufacturing facility outside of the United States. Intel Malaysia now comprises three campuses and employs more than 8,500 people. Intel Penang is a key assembly and testing site with capabilities in assembly technology development, VLSI design, failure analysis, device physics, test tooling, technology development and marketing. Known for its world-class safety standards in the global semiconductor industry, Intel Malaysia is also a two-time winner of the Prime Minister's Quality Award, a symbol of excellence honoured to public and private organizations that implement outstanding total-quality management programs and contribute significantly to the country's economy and community.

3.2.1. Factors Attractive in Penang

Main motivation to start in Penang (in the 70s) was the efforts of the then Chief Minister – to promoting and developing certain factors conducive for setting up of manufacturing plants – the location factors including availability of cheap labour and supportive policies of the federal government and good infrastructure. Beginning as a manufacturing centre, Intel Malaysia is now a major R&D centre in the global operations of Intel. Key factors in the cluster that helped Intel include human capital, support from national and state level governments – through policies and incentives.

3.2.2. Innovations at Intel Penang

More than 70% of the global design and development work at Intel is at the Penang

facility. Among the more recent innovation is the Pine Trail platform, the next version of the company's successful Atom line, which reduced the number of chips in the Atom chipset down to two from three. Intel will start production of its 32-nanometre process technology under the 2010 Roadmap, with the 32-nanometre Westmere processors designed to deliver higher integration and energy-efficient performance.

Intel Malaysia Sdn. Bhd - Products and Services

- Manufacture and sale of semiconductor chips; and development of integrated digital technology platforms for the computing and communications industries.
- Microprocessor products, including dual-core microprocessors, quad-core microprocessors, 32-bit architecture microprocessors, and 64-bit architecture microprocessors, which are used in computer systems, as well as in embedded designs, such as industrial equipment, point-of-sale systems, panel PCs, automotive information/entertainment systems, and medical equipment.
- Chipset products that send data between the microprocessor and the input, display, and storage devices, such as keyboards, mouse, monitors, hard drives, and CD or DVD drives; and motherboards for use in the desktop, server, and workstation platforms.
- NOR and NAND flash memory products, such as wireless memory for mobile phone designs, set-top boxes, networking products, DVD players, and DSL and cable modems;
- Communications infrastructure products, including network processors, communications boards, and optical transponders; and networked storage products for use in a range of Internet devices.
- It serves original equipment manufacturers, original design manufacturers, PC and network communications products users, and other manufacturers.

Source: Bernama Times website

(http://www.btimes.com.my/Current_News/BTIMES/articles/20091125174808/Article/index.html accessed on January 25th 2010) and Interview).

3.2.3. Support for Innovation

The main sources for Innovation at Intel are their own laboratories around the world and also several consultants that Intel hires on project to project basis. Key

institutions that are supportive to Intel for Innovation include the MIDA and MOSTI at the national level and PSDC and to a smaller extent USM, the cluster university.

3.2.4. Linkages and Collaborations

Overall the linkages developed by Intel-Penang are of a short term nature. There is not much firm to firm - within Penang cluster – collaboration, at least formally. The linkages are strong with suppliers with Penang and outside Penang. There is some linkage with the Cluster University and PSDC.

3.2.5. Issues in Linkages / Collaboration

Strongest links are with Intel Labs around the world. There is regular movement of technology personnel from Penang facility to various Intel facilities for training and collaborative work. There are also strong links with suppliers – and Intel has helped in developing several suppliers (some of whom have become independent large local players).

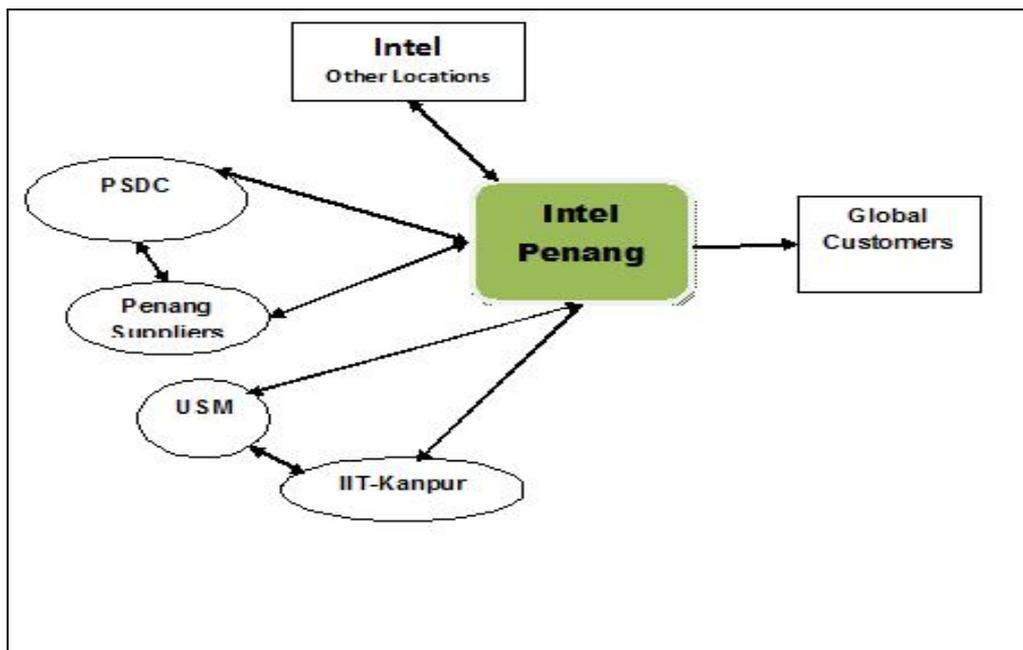


Figure 4 Diagram of Intel-Penang's Linkages

One of the distinguishing aspects of collaboration is how Intel supports the local university USM. Intel had identified the Indian Institute of Technology at Kanpur (IIT-K) in India as one of important research centres in the region for its area of focus, and helped in USM to forge links with IIT-K to enhance USM's research capabilities. This collaboration involves research and development in engineering and computer science and also lecturers from IIT sharing their expertise in R&D at USM. A more recent example of a linkage with customer is Intel's partnership with Packet One Networks for the deployment of the first nationwide 802.16e WiMAX network -

3.2.6. Conclusion

The key factors for the R&D activities at Intel Penang are the critical mass of engineering manpower available in the cluster (trained internally over decades) and also supportive national and state government - the support being in terms of incentives (tax rebates, grants and other non-financial support). The presence of suppliers within the region is another critical factor. The critical link is internal with the various laboratories firm located all around the world and the movement of the engineers between these labs.

3.3. Case #3 - Eng Teknologi Holdings Bhd

Engtek Group is a home-grown Malaysian primarily involved in precision engineering and manufacturing. The Engtek Group currently comprises seven key operating subsidiaries of which three are based in Malaysia, and one each in the Philippines, China, Singapore and Thailand. The Group has an annual sales in excess of RM240 million and its cumulative investments over the years have exceeded RM200 million. It started operations in 1974 in Penang and is considered amongst the top

precision engineering and manufacturing supply chain players for the electronics industry in the Asia Pacific region. Eng Teknologi Holdings Bhd (ETHB), the Group's parent company, is located in Penang and serves as the regional headquarters. It is listed under the technology section on the Main Board of the Kuala Lumpur Stock Exchange (KLSE). Eng Teknologi's Integrated Engineering Centre has manufacturing facilities of more than 75,000 sq. metres with approximately 1,000 units of CNC machines – which are strategically located throughout Asia Pacific Region, enabling it to meet its customers' specific requirements. This case is focused on Eng Tekhnologi's business encompassing the design & manufacturing of quality precision components and assemblies which are categorized into the global Data Storage Group (DSG).

3.3.1. Factors Attractive in Penang for Manufacturing and Design and Development

The firms attributes Malaysian government's (both at the national and state level) effort to promote the growth of small and medium enterprises in the country as the primary factor. The other key contributing factors include the various incentives granted through MITI and MOSTE, and the availability of a skilled management and operating workforce.

3.3.2. Types and Motivations for Innovation

There are both product and process innovation activities in the firm. While the product is not new to the world, it's a new to the firm innovation. Most of the product innovations are for introducing new products more to avoid competition and to cater to the ASEAN market. One of the main product development efforts has been co-designing (with different customers) of the 'actuator' or E-Block product. The process innovations follow to support the manufacturing of these new products and also to reduce costs. Process innovations include those to cut input costs – sourcing for new materials.

3.3.3. Key Drivers and Support for Innovation

There are several sources / support factors for innovation at Engtek. Key institutions that have been supportive for the setting up for the facility are MITI and MIDA at the national level. With MIDA providing grants (from MITI and MOSTE) for R&D activities in addition to other support like tax incentives etc. At the regional level, the state government support has been, PSDC, the cluster university (USM) and FrePenCa are key institutions. Another factor supporting innovation seems to be the support from within the organisation. One hand it's the mission of the organisation to be a TNC and have in-house design and development capabilities. In addition, the organisation has a few locations around ASEAN near to their regional customers and there is flow of knowledge from customers in these locations to the Penang facility – through meetings and also movement of engineers. Information from customers serving as a driver for innovation – the firm has inter-group meetings (conferences or seminars) for exchange of technology information.

3.3.4. Linkages or Collaborations

There appears to be almost no formal firm to firm linkages within Penang cluster or out of cluster also. The firm attributes support for innovation due to the availability of and having strong linkages with suppliers, sub-contractors within Penang. There appears to be a very weak link with Cluster University. There is strong link with PSDC.

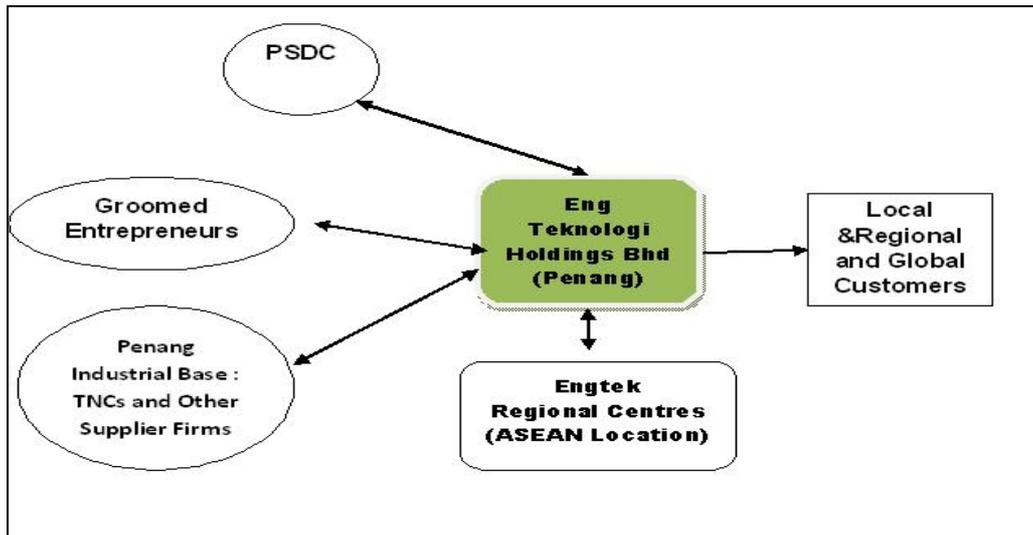


Figure 5 Diagram of Firms Linkages of Engtek Penang

An interesting set of ‘actors’ that are linked to Engtek are entrepreneur groomed by Engtek – to become suppliers / co-developers (also known as Intra-preneurship). Engtek themselves have had the experience of getting support from TNCs located in Penang – in terms of being a customer and also training in technology related and other areas – based on this experience they have also groomed some of their employees to start up firms in Penang to support Engtek and also be independent – there is a case where Engtek has even bought out one such ‘groomed entrepreneurial venture’.

3.3.5. Issues in Policies related to Innovation

Overall the government policies, both at the national and state level, are considered to be favourable and supportive for Innovation – be it in terms of grants, infrastructure provision, policies like tax rebated etc.

3.3.6. Conclusion

Overall the main support factor for innovation are skilled manpower base in Penang, a strong industrial base - with a mix of TNCs and local firms – offering support as

customers and also as suppliers. Support from governments is in terms grants, tax reliefs, and development of infrastructure. Key actors in the region/cluster include TNCs, PSDC and the government. Although they have had experience in a joint venture (with Adventist of Japan in mid 90s) they prefer to 'go it alone' in upgrading their activities from manufacturing to design and development.

3.4. Case #4 - Creative Bliss Sdn. Bhd.

Creative Bliss Sdn. Bhd. was officially incorporated in August, 1994, and is principally involved in producing and supplying of high quality customized metal stamping parts/components as well as undertake the entire process of tools and dies design making by its associates. Creative Bliss Sdn. Bhd is involved in design engineering and undertakes customized stamping for a very wide range of products and currently manufactures precision metal parts for multi-national corporate and other industries such as Audio & visual industries, Electrical & Electronic, Office automation equipment and also for Furniture accessories, Automobile parts firms.

3.4.1. Types and Motivations for Innovation

Over the years of operations, Creative Bliss established excellent practices and procedures in their production processes that helped them to achieve 'excellent' quality in their products. To meet the standards and expectations set by its customers, Creative Bliss started innovating in their production, process innovations to reduce the overall time in production (eg. One of them being reduction from four processes to one process). Process innovations include those to cut input costs – sourcing for new materials. Some innovations are for improving existing products mainly to reduce costs. Information available through internet, from interactions with lead customers and regional trade exhibitions has helped Creative Bliss to achieve their innovation objectives.

3.4.2. Key Drivers and Support For Innovation

Though the key driver appears to be from the owner's philosophy ie. from within the organisation. Conservative quality oriented of the main partner /CEO and training in Japanese continuous improvement philosophy seems to be the key. There are other support factors for innovation at Creative Bliss. Key institutions that have been supportive for the setting up for the facility include MITI through MIDA – through the provision of grants for R&D activities in addition to other support like tax incentives given under programmes for development of SMEs. At the regional level, PSDC and JAICA provide support in training and other advisory services. But the most important factor is its lead customer, Sony, - being the important factor in the string of the firm – the TNC also sends their engineers for providing training to Creative Bliss technical staff on new technology/design issues.

3.4.3. Linkages of Innovation

Usually collaborations with other firms are short term. Creative Bliss has a firm to firm linkage within Penang cluster with Sony's Penang unit. The firm does not have linkages with suppliers in other locations. Other actors with which Creative Bliss has strong linkages include PSDC and JAICA.

The following diagram provides an overview of the linkages Creative Bliss in Penang has for Innovation

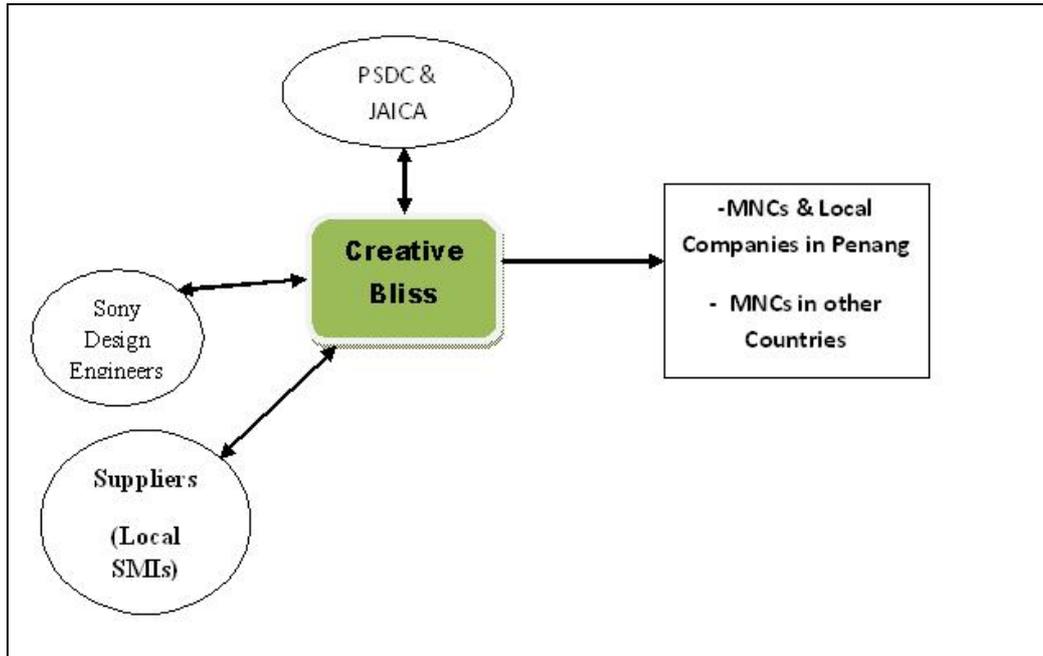


Figure 6 Diagram of Creative Bliss' Linkages

3.4.4. Issues in Policies related to Innovation

Though the government policies, both at the national and state level, are considered to be supportive for Innovation – be it in terms of grants, infrastructure provision, policies like tax rebated etc, the firm is not aware of many options available and hence has not sought help from any of these incentives/policy passed benefits. Hence, for most of the innovations at Creative Bliss are self financed/funded

3.4.5. Conclusions

From the Creative Bliss perspective the key issues in Penang cluster that are helpful for going up the value chain from manufacturing to design and innovation activities are – availability of highly skilled human capital, presence of large base of local suppliers, presence of its major customer and cluster institutions. At the national level, provisions made by the MITI ministry and in general the stable political environment are deemed as useful. Reducing procedural delays to utilize existing grants and more incentives to

further develop the cluster are considered as critical for the further development of E&E sector in Penang.

3.5. Case #5 - Kontran (Kontron Manufacturing Services (Malaysia) Sdn Bhd)

Kontran Malaysia has its manufacturing and R&D centres in Penang. Kontron Malaysia, while being a part of the Kontran – a German company listed in the Luxemburg stock exchange, is a private limited company. Kontron ranks as one of the world's largest manufacturers of embedded computer technology (ECT) and supplies leading OEMs, system integrators and application providers. Some of the products that Kontron offer include Boards & Mezzanines, Computer on Modules (COM), HMIs and Displays. In 2008, Kontron sales were recorded at 497 million Euros (about US\$ 697 million). Kontron in Penang currently has a staff strength of about 500 with principal operations in the facility are manufacturing of integrated circuits boards (ICB) for technology applications in the areas of energy, medial, aerospace, transportation, telecom, gaming, automation and military and research and development activities.

3.5.1. Factors Attractive in Penang for Manufacturing

Kontron Malaysia started in as UNICO, a Malaysian firm setup operating in Penang from 1996, used to be the largest supplier of ICBs to Intel. Later it was successful in building a strong supplier system in the cluster through Rozatanet. UNICO was acquired by an American firm first and later on acquired by Kontron, a German MNC (which spun out of BMW). Availability of highly skilled engineers is the critical factor along with a local CEO supportive of R&D activities for Kontron to move up from manufacturing to design and development activities. In addition generally low cost of doing business, availability of cheap labour (for manufacturing), the presence of its key customers and strong supplier network in the cluster have made Kontron to continue its manufacturing operations in Penang. Supportive policies of the federal government and

good infrastructure have also played role for Kontron to continue and expand its manufacturing and R & D (product development).

3.5.2. Types of Innovation and Motivations for Innovation

Through its continuous/incremental research and development process, Kontron main motivation for Innovation is to create major competitive advantage for customers through a significant reduction of time to market and costs. Most of the innovations are to both improving the existing products and developing new products for its global customers. The product innovations include to access new markets for the firm. Process innovations such as those adhering to the ROHS (EU standards for use of hazardous materials) have also helped in innovation involving new materials. Process innovations include those to cut operation costs – developing new business processes.

3.5.3. Key Drivers and Support For Innovation

A significant driver for Innovation at Kontron is the support from within the organisation a supportive CEO for R&D activities is attributed. Specific requirements unique to its global customers and compliance to new regulatory systems (such as ROHS) in counties are other important source. At the regional level, PSDC, the cluster university USM and its involvement with Rozattanet organisation are key institutions that have helped in move up from manufacturing to design activities. Kontron has more than 1000 engineers across its R&D centres around the world with varying competencies offering in-house capabilities and this link to its group R&D facilities around the world is another important support element. Global customers and local suppliers in the cluster are significant source of information for new design ideas at Kontron.

3.5.4. Linkages or Collaborations

Kontron has healthy inter firm linkages within the group companies located outside the Penang cluster. Design Engineers from other locations of Kontron visit Penang periodically to share/contribute to new product ideas. Kontran also has strong firm to firm linkages with its global customers both within and outside Penang cluster. Though these customers do not invest in product innovation at Kontron, they participate in a co-development model in new product development and they are rewarded with a royalty fees once the product is commercialized. At the regional institutional level the firm has a strong link with PSDC which arranges suppliers from within the cluster. The firm also has strong linkages with Rozattanet which helped it to build strong supplier network within the cluster. Links with USM (the cluster university) appears to be weak as they occasionally provide few students as interns for a maximum of 6 months duration.

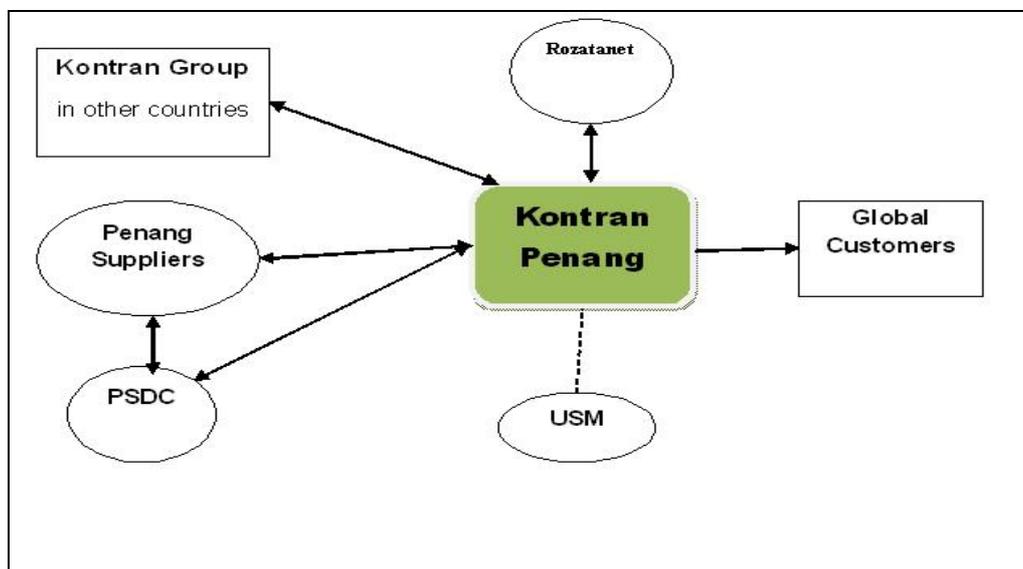


Figure 7 Diagram of linkages for Kontron (Penang)

3.5.5. Issues in Policies related to Innovation

Availability of surplus cash reserves made Kontron all its innovations self financed.

The absence of a centralized body/institute to promote innovation across all manufacturing firms in the cluster is making innovation a firm specific activity –due to reasons such as specific requirements from the customers, expansion/growth plans of the firm and so forth. Reducing procedural delays to utilize existing grants and providing more incentives will further develop the innovation. Creating increased awareness programs about various grants and incentives available through government policies, both at the state and national level to all the manufacturing firms can significantly boost the innovation.

3.5.6. Conclusion

From the Kontron perspective current market situation is encouraging with stable volumes across all its products and about 15% growth is expected in technologies catering to automation and telecom industries. Key issues in Penang cluster that are helpful for innovation activities are – participation of its global customers and local suppliers in their innovation activities, and availability of highly skilled human capital, and good infrastructure. At the national level, provisions made by the MITI and MIDA ministries and in general the stable political situation is deemed useful.

3.6. Case #6 - XYZ (in SDD Sector)

XYZ (SDD Sector) designs, develops, manufactures and markets custom and open-standard memory solutions based on Flash memory and DRAM technologies, and external storage solutions. The company was founded in 1990 as XXX Technology and changed its name in 2001. Further, it changed its name to XYZ (SDD Sector), Inc. in March 2007. The firm is headquartered in Santa Ana, California and set-up first South-East Asian manufacturing site in Penang, Malaysia in 2006.

XYZ (SDD TECH.) Penang has a new facility built on 10.5 acres of land, of which 6 acres are currently utilized. The plant currently has a built-up area of 210,000 sq feet

which houses manufacturing cells and SMT lines, as well as an R&D laboratory, offices, and other amenities including a multiple conference rooms equipped with full video conferencing facilities to manage the global integration of XYZ (SDD TECH.)'s business. XYZ (SDD TECH.) is currently experiencing growth and evidenced through recruiting additional engineers and manufacturing-based employees to support the company's production ramp. XYZ (SDD TECH.) is also hiring R&D engineers to complement the existing R&D team in Penang. The R&D team in Penang is engaged in advanced ASIC & firmware Design and Implementation as well as New Product Prototyping. The team also performs Product Level Testing.

3.6.1. Product and Services

XYZ (SDD TECH.) flash products include Solid State Drives which are designed to meet the data storage requirements of a range of industries, including defense and aerospace, automotive and transportation, industrial, and communications industries. They also offer Compact Flash Memory cards, Flash Disk Modules, Secure Digital Memory cards, MMCPlus Memory cards, USB Flash Drives and Single Chip Drives.

3.6.2. Drivers and Support for Innovation

The main Innovation is product and the product is a new to the world (SDD technology). Ensuing process innovation activities would hence also exist. The main support for Innovation (in this case for being able to start up the new firm in a new technology area) comes (1) at the national level supportive policies from MITI and MOSTE – MITI for supportive policies in general and for the issue related to imports of equipments etc and certain grants made available. MOSTI for the supporting with incentives and grants for the R&D activities.

3.6.3. Linkages and Collaborations

Collaborations are ‘need’ based – being a new technology are the firm prefers to go at it alone and so most linkages are of short term. There appears to be almost no formal firm to firm linkages within Penang cluster or out of cluster also. There are linkages with suppliers within cluster and in other locations which are considered very strong. Several of the suppliers groups are in Korea and Taiwan.

Some interesting linkages have been developed – with what we can term as technology free-lancers – who are based in the EU for helping in technology development and in addition it has strong links with its US office – which is close to customers in that region and to other technology players.

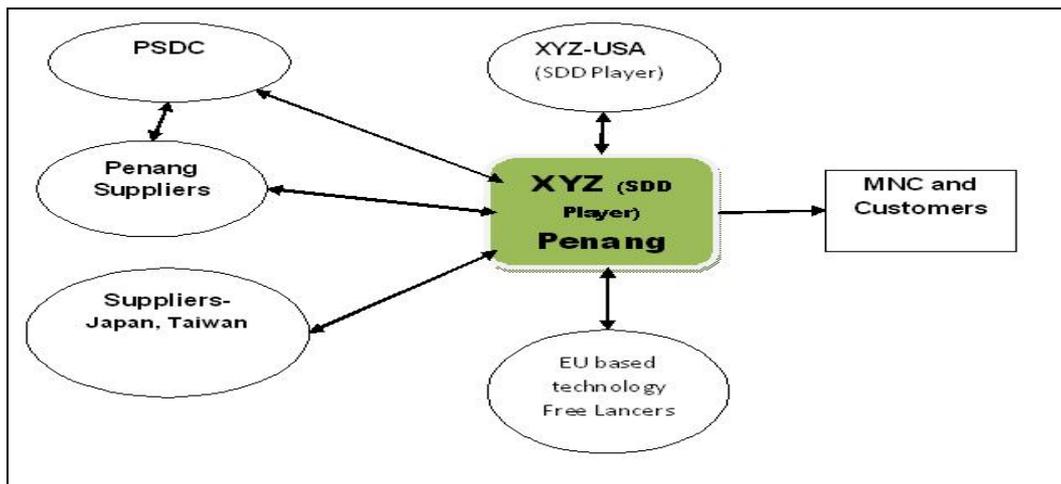


Figure 8 Diagram of XYZ (SDD TECH.) - Penang Linkages

3.6.4. Issues in Collaboration and policies for Supporting Innovation

Overall XYZ (SDD) sees collaborations particularly joint ventures as not so vital for R&D based innovation activities – it sees any collaboration as short term activity for specific problem solving and actively seeks out to develop links (as it does with freelancers in the EU for technology development) – constantly referring to the R=G metaphor. XYZ (SDD) sees the software development as an integral part of R&D in the electronics sector – and would like to have benefits that the ICT sector receives – but

this requires the application for the 'MSC' (Multimedia Super Corridor project) status to get the benefits accorded to ICT firms

3.6.5. Conclusion

For XYZ the critical factor for supporting the firm and innovation activities in Penang is the availability of highly skilled (experience in TNCs) human capital – particularly what it termed as the 30 year of pooled talent in the region. In addition the mobility of the human capital is an important point. The strong industrial base in Penang and supportive policies - from the national and state governments has been instrumental for being located in Penang.

3.7. Case #7 – ViTrox Corporation Bhd

ViTrox calls itself a solutions provider of innovative, advanced and cost effective automated vision inspection system & equipment for the semiconductor and electronic packaging industries. ViTrox team works closely with its customers to design, develop and implement inspection solutions to improve quality of their products & processes every day. At present, ViTrox is an award winning public listed company and worldwide leader of high speed machine vision inspection systems which has extensive customer base in Malaysia, Thailand, Philippines, India, China, Taiwan, Japan, Korea & USA.

ViTrox's AOI Division designs, manufactures and markets technological advanced and cost effective automated optical inspection (AOI) systems and related products, providing quality improvement solutions that are able to detect defects occurring during manufacturing process for printed circuit board (PCB) industry, flexible printed circuit board (FPC) industry and high density interconnect substrate (HDI) industry. Their newly launched AOI flagship products, Challenger and VF-10 have been successfully accepted customers in Penang and overseas markets.

3.7.1. Motivation and Drivers for Innovation

Most of the innovation is in products – 80% of innovation is in existing products for product differentiation. Being a new firm in the sector they seek this. About 20% of the innovations are for moving into new markets. Drivers for innovation are key customers (TNCs in Penang and in other clusters) and from information searches done by R&D personnel. The key sources of information for innovation include participating in technology conferences - organised by technology driving associations (like IEEE etc), research articles from academics (searched via internet).

3.7.2. Support For Innovation

The main support for Innovation (in this case being a relatively new firm) comes from (1) at the national level supportive policies from MITI and MOSTE – MITI for supportive policies in general and for the issue related to imports of equipments etc and certain grants made available. MOSTI for the supporting with incentives and grants for specifically R&D activities. In addition the availability of highly skilled manpower (from the TNCs) in Penang and a good supplier base are important.

3.7.3. Collaborations

Overall the linkages developed by ViTrox are of a short/medium term nature. There is not much firm to firm - within Penang cluster – with the exception of collaboration with Agilent Technologies. The firm started by taking over ownership of some of the products that Agilent in Penang wanted to spin out / sell out. And ViTrox maintains strong links with Agilent – formally and informally. The linkages are strong with suppliers within and outside Penang.

There is both direct through the PSDC linkage – for training facilities and indirect support also as PSDC provides training and skill development support for the local supplier base. There is some linkage with the cluster university. There is strong linkage

with a university (Multimedia University) located in the ICT cluster of Cyberjaya – joint projects with the faculty there and also student internships are the innovation supporting activities. This linkage has important implications for other such firms for supporting R&D in the E&E sector. There is also a link with a university in the USA for technology development (through the US office).

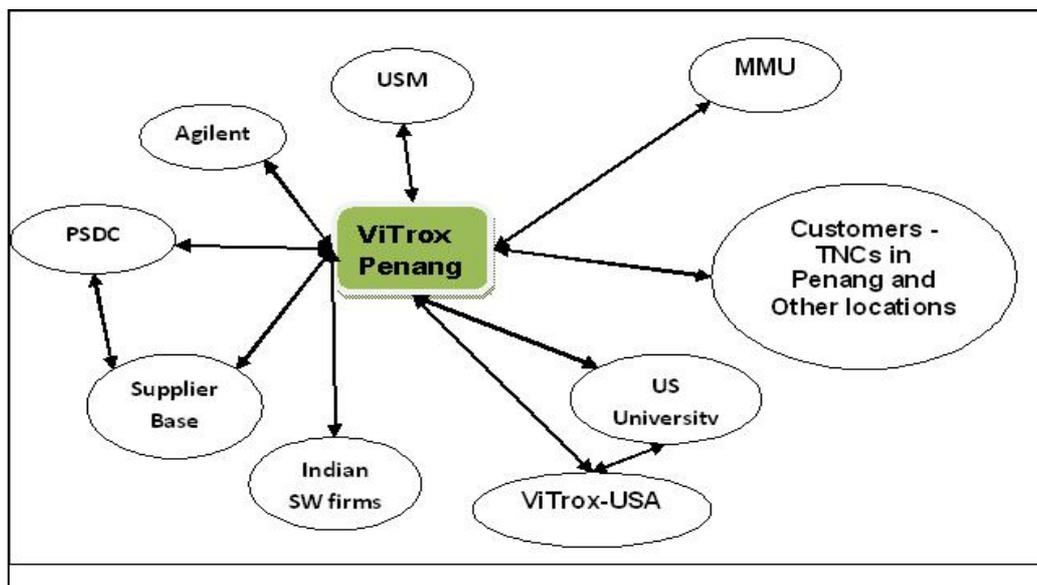


Figure 9 Diagram of ViTrox Linkages

3.7.4. Issues in Collaboration and Conclusions

Overall ViTrox sees collaborations – particularly with universities within the cluster and in other cluster as a critical aspect for supporting innovation activities. The strong industrial base in Penang and supportive policies - from the national stage governments has been instrumental for being located in Penang. ViTrox sees the need for collaboration in the ICT sector as software development is an integral part of the R&D in its area of operations (testing equipment) and has actively sought out links in different clusters – with a university and also with software developers – seeking information from the internet.

Clearly the strong TNC base in the industry, mobility of the skilled human capital and support from the governments has been key for supporting firm development and innovation. Linkages within and outside cluster are critical for the innovation activities.

Interestingly ViTrox is an MSC Status Company (gives it access to several more incentives from government under ICT sector schemes). "ViTrox also has won some awards included - the Silver Recognition at the Malaysia HR Awards 08-09 which covers the HR Development Strategy, Best Practises in HR, Continuous Learning and Training, Application of HR System and Technology and Recognition of HR as Strategic Resource in the growth of organization".

3.8. Case #8 - Mayang Manufacturing Sdn. Bhd.

Mayang Manufacturing (Mayang), a local SME/I, started its operations in Penang in 1995. Mayang is a private limited company in Malaysia with production facility only in Penang and is principally involved in producing and supplying customized metal stamping parts, electrical components and industrial electrical fans. Mayang operates from its own premises in Sunway Business Park of Perai Industrial area in Penang. Current staff strength at Mayang is about 50 and its sales turn over in 2008 is about RM 5 million (approximately 1.45 million USD). Mayang currently manufactures precision metal parts, electrical components and electrical fans for companies in Perak and Kedah states in Malaysia and multinational companies in Penang in Audio Visual, Automobile and Electrical & Electronic industries. Their MNC customers include Robert Bosch Malaysia, Sony Malaysia and Perodua the car manufacturer in Malaysia is its local customer.

3.8.1. Factors Attractive in Penang for Manufacturing

Mayang chose Penang to setup its manufacturing unit due to the availability of skilled technical staff and cheap labour, and low operation costs. Supportive policies of

the federal government and good infrastructure in Penang also helped Mayang to start its production quickly. The presence of a large TNC base as a market was a critical factor. Though the initial operations were mainly in manufacturing, later Mayang started distribution of laboratory and high-end technical equipment.

3.8.2. Types and Motivations for Innovation

Innovation at Mayang is driven by requirements from its customers. Majority of these innovations are aimed at improvements in products to meet the specific design requirements of customers and improving existing products to reduce the costs and hence achieve competitiveness in the market. Process innovations are aimed at both to reduce costs and the overall time in production

3.8.3. Support for Innovation

The main source for innovation at Mayang is their in-house design engineers. The in-house design team uses information from internet sources to enhance their design skills.. Key institutions that are supportive to Mayang for innovation include the MIDA and MOSTI at the national level. Mayang is successful in getting grants from both these ministries to procure special fabrication machinery. To a smaller extent, professors from the University Malaya (UM), helps Mayang to develop new designs for industrial electric fans.

3.8.4. Linkages of Innovation

Overall the linkages developed by Mayang are of a short term nature. Though the firm is successful in getting grants from national ministries MIDA and MOSTI – there appears to be no follow in terms of accessing newer funding options for encouraging R&D activities. Mayang has no firm to firm linkage within Penang cluster. The firm does not have any linkages with both suppliers and customers within cluster and in other

locations. Links with UM also appears weak.

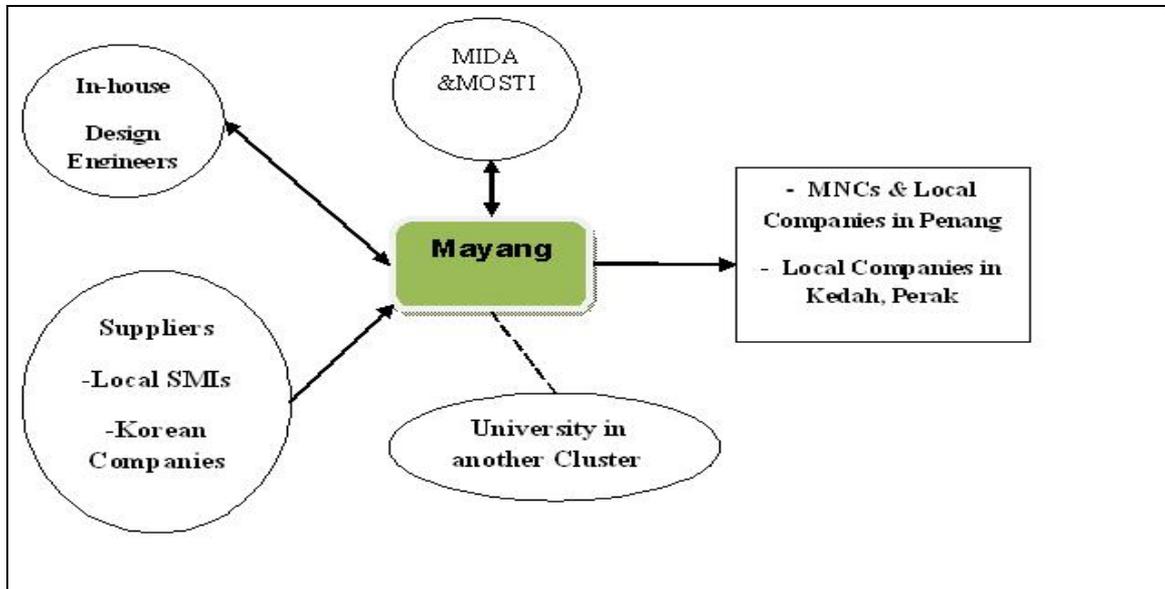


Figure 10 Diagram of Mayang Linkages

3.8.5. Issues in Linkages/Collaboration

The government policies, both at the national and state level, are considered to be favourable and supportive for innovation – be it in terms of grants, infrastructure provision, policies like tax rebated etc., Non participation of its suppliers and customers appears to be a major concern for Mayang.

3.8.6. Conclusion

From the Mayang perspective, the key factors in Penang cluster that are helpful in innovation activities are; TNC base as customers, availability of highly skilled engineering man power and good infrastructure. Both at the state and national level, provisions made by federal government and the national ministries and in general the stable political environment are seen as highly useful.

3.9. Case #9 - Motorola Malaysia

Founded in 1928 Globally Motorola is a leading TNC in the area of communications solutions in with more than 30 billion USD sales. Established in 1974, Motorola in Penang is now the company's largest manufacturing site for two-way radio products in Asia and the only design centre for two-way radios in the region. It is supposed to be as one of the key growth centres in Motorola's global operations. The R&D centre was started in 1976 with five local engineers to design and develop mission critical products and communications solutions. Today there are more than 1,000 R&D engineers employed in Motorola Penang. Motorola considers the Penang R&D Centre to play a strategic role as the 'Centre of Excellence' responsible for the entire product lifecycle activities including R&D, manufacturing, sales and distribution and customer support for regional and global markets for its digital two-way radios and advanced wireless broadband communications solutions. There is also a 24-hour Asia technical support centre. With its customer solution centre co-located with R&D, Motorola Penang also serves as a technology showcase highlighting both Made-in-Malaysia products and solutions indicating high level of engineering competencies in Malaysia. In addition, Motorola Penang has an Advanced Communications Laboratory that houses four key laboratories - an Electromagnetic Emissions (EME) Laboratory, a Type Approval (TA) Laboratory, an Engineering Laboratory, and an Electromagnetic Compatibility (EMC) Laboratory.

Each of these laboratories perform specific stringent product tests ranging from transmissions levels and unwanted noise to product stress and durability levels to ensure that they are compliant within the industry's standard regulations requirements. Motorola is considered the leading communication vendor offering solutions compliant with two industry leading open standards – TETRA (TERrestrial Trunked RAdio) and APCO P25 (Association of Public-Safety Communications Officials Project 25). A large volume of Motorola's TETRA and APCO P25 systems, professional two-way radios

for both mission and business critical use, mobiles, accessories are designed and produced in Penang for the worldwide market. Motorola's prime focus is to strongly promote 'Made in Malaysia' (MIM) products and solutions designed and manufactured in Penang for the global markets and Malaysia.

3.9.1. Support for Innovation

The main support for Innovation comes from (1) at the national level supportive policies from MITI and MOSTE – MITI for supportive policies in general. MOSTI' supporting incentives and grants for specifically R&D activities. In addition the availability of highly skilled manpower in Penang and a good supplier base are considered important.

3.9.2. Linkages and Collaborations

There appears not much firm to firm linkage indicated within Penang cluster. The linkages are strong with suppliers within and outside Penang. PSDC links provides training and skill development support for the local supplier base. There is a strong linkage with the cluster university - USM. There is strong linkage with universities outside Penang - Multimedia University located in the ICT cluster of Cyberjaya and also IIU in Kuala Lumpur – joint projects with the faculty there and also student internships are the innovation supporting activities

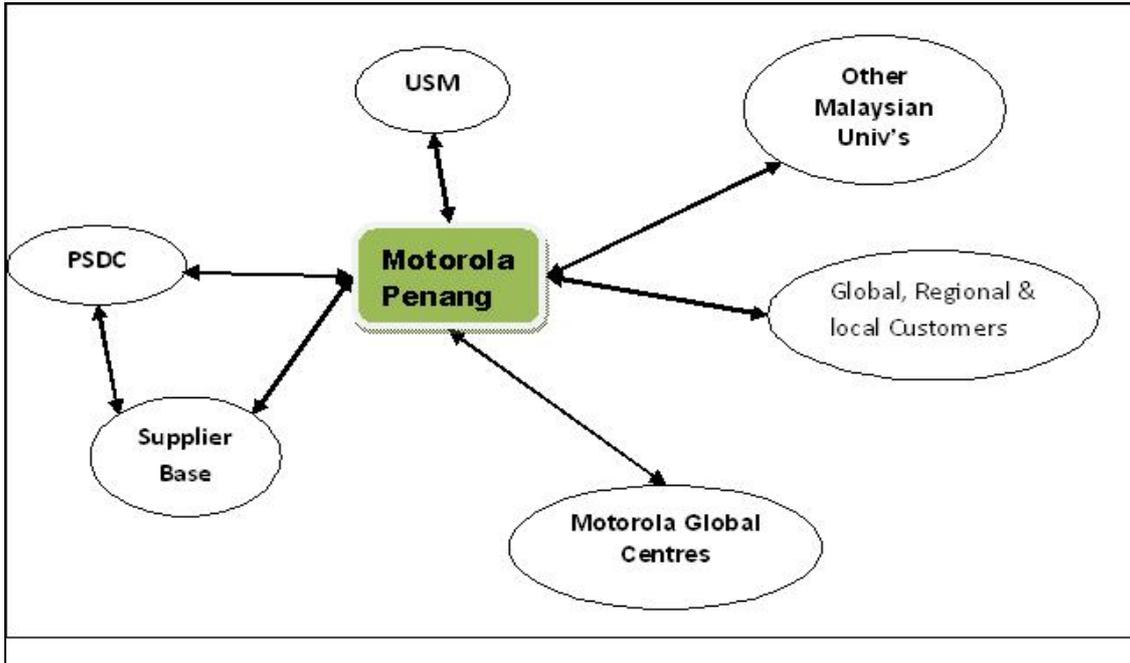


Figure 11 Diagram of Motorola Linkages

3.9.3. Conclusion

The strong industrial base in Penang and supportive policies - from the national and state governments has been instrumental for being located in Penang. In the case of Motorola it's a combination of internal factors particularly the support from heads of the subsidiary and support from the government of Malaysia – both at the national and state level.

Today, after more than 30 years in Malaysia, Motorola Technoplex in Penang houses the manufacturing facility, the Asia Design Centre and, the Center of Excellence for Terrestrial Trunk Radio (TETRA) and Integrated Enhanced Network (IDEN) worldwide under one roof. Interesting to note are Motorola Penang's capabilities and achievements being endorsed by the win of several awards including the Motorola CEO Quality Award for 1986 and 1989, The Malcolm Baldrige National Quality Award in 1989.

4. SUMMARY OF FINDINGS AND DISCUSSION ON CASE STUDIES

The key issues for the case studies included among others the types of Innovation Activities the firms were involved in and the motivations / drivers for such innovation. Linkages being developed with various ‘actors’ for fostering innovation and other related issues. The following are the findings from the case studies are presented in the following paragraphs

4.1. Innovation Activities and Motivations for Innovation

All the respondents in firms interviewed unanimously mentioned that although called R&D activities – there was no “R” done in Penang – it was mostly “D” viz. design and development activities that were taking place. With the exception of one MNC and one Local firm, most of the Innovations taking place could be categorised as Incremental. In the case of the SME/SME firms – the Innovation was designing products for customer requirements or co-designing with customers or when seeking new material for cost competitiveness. Motivations for the Innovation seemed to more for gaining or maintaining strong market position and in some cases opening up new markets. Both the MNCs mentioned that product innovation for strengthening market position and also for entering new markets. One of the local players said Innovation was for product differentiation.

4.2. Information For Innovation Activities

The MNCs had extensive internal sources of data – databases of key publications in their area of interest, participating in key conferences, intra-group meetings, links to universities at the HQ. Among the local firms - while all did use the internet in general – also checked out information on competitors’ as a source of information for innovation. One of them sought more information from the MNC within the cluster with whom it

co-develops products and also uses academic journals in the area of its research. A second local player had developed linkages with independent / free lance researchers in EU as its important source in addition to their office in USA being a base for information for innovation. One of local firms which has internationalized - has regular intra-group seminars / conferences. All the firms depend heavily on customers as the major source of information for driving innovation.

4.3. Collaborations /Cooperation Issues

There appears to be no explicit collaboration for innovation among most of the firms. Most of these are 'internal' R&D centre set up specifically – collaboration is more with suppliers or customers. One of the MNCs (A European one) mentions strong links with 4 key (Japanese and Taiwanese) suppliers – that they support and co-develop key components with these key partners. One of the large local firms mentioned that most of the design and development activity was not only for customer – but was also done as co-development with customers including signing deals for joint IP rights. Local firms talk about cooperation with suppliers or customers as they main collaborative activities.

4.4. Linkages (within Penang and outside Penang) for Innovation.

One of the key institutions in Penang with which all the firms have some form of association is the Penang Skills Development Corporation (PSDC) – which is credited for training operators needed for the manufacturing part of the firm and now training higher level skills personnel for the Design function also – and in addition providing some facilities for testing. Linkages with universities within / near the cluster are generally for student internships and they are seen as suppliers of manpower. An MNC (involved in consumer electronics) has stronger links with the University for accessing services (including testing and analysis work). Dispatching or acceptance of technical

personnel amongst the firms within the cluster is nonexistent – in the case of MNCs and local firms with international presence (one has manufacturing plants and design centre across the region and the others have a ‘US’ office) there is extensive movement of engineers between their different global locations.

4.5. Obstacles for Innovation

In general the main limitation for moving into innovation activities – particularly for ‘research’ part of the “R&D” – is the lack of enough competencies among the suppliers, lack of talent / human capital (particularly PhDs), lack of higher research capability of the local university (in their related areas). All the respondents discuss that they are open for collaboration within the cluster and also globally – but somehow this has never happened. All the R&D units have been developed as fully in-house independent units – with the exception of with formal links only with the group.

Another issue in Penang is the need for staff with administration, economy, social sciences and law qualifications is rising as there is a lack of talent in these sectors while there is no shortage of people with technical educational backgrounds. The presence of a skilled workforce in a region is a key requirement of any regional economy and technological system.

4.6. Public Policies Supporting Innovation Activities

Overall the current policies – be it related to infrastructure development, tax incentives, Grants etc are all considered critical for the moving up the value chain into design and development activities by the firms in Penang. Key institutions at the national level include the Ministries for Intl Trade and Industry (MITI) and Science, Tech. and Innovation (MOSTI), MIDA – the industry development authority. The policies that have attracted MNCs to have a major presence in the cluster are important – the MNCs play multiple roles – as a employers of qualified engineers, as large

customers, as developers of supplier firms, as developer of human capital (one of the local R&D firms calls it the ‘musical chair movement’ of high caliber engineers from MNCs to local firms).

4.7. Differences between TNCs Vs Local Firms

The case studies reveal there are differences in Innovation and support for Innovation activities between TNCs and local firms. TNCs move into Penang can be seen as a factor of both push and pull factors – pull factors in terms of supportive policy and attitudes of the both the national and state governments and the several incentives offered and also the conditions of TNC looking to restructure their operations around the globe to reduce costs. The TNCs linkages are essentially to the supplier base – in which they have a significant role in development also – through vendor development programmes. From this situation they now are in a position to leverage on human capital from different TNCs in the cluster.

In the case of local firms – their linkages to TNCs is a significant factor. Many of them started out as sub-contractors/supplier to the TNCs in the region and founders get their training from the TNCs – hence the TNCs themselves as an important factor in innovation system playing multiple roles.

4.8. Differences for Linkages for Product Differentiation Vs Cost Reductions

There is a difference in linkages for firms that seek innovation for product differentiation versus those making innovation efforts for cost reductions only – the product differentiation seeking firms develop more linkages ‘externally’ (outside the cluster) and with universities/research centers, their sources of information include research journals (and not just customers).

4.9. Cultural Factors

There are several cultural factors that can be helpful or be hindrance Innovation

related activities. An interesting aspect of Penang – is the cultural identity of the people – particularly the engineers in the manufacturing sector – be it electrical and electronics engineering or others also. There is a strong commitment of these people to the city/island and the respondents as well as other people interviewed state that overall Penang has a stable “population” and that while there is internal mobility ie people coming in – most of the people have been living there for a long time that has build a community and hence ‘learning’ has taken place in a context over a long period of time. There is also what has been mentioned as ‘Engineer Nobilities’ in this city. There is also an entrepreneurial culture emerging slowly with the incentives being provided by the government helping.

5. CONCLUSION AND RECOMMENDATIONS

Penang’s E&E sector can be seen as an internationally linked cluster. It’s a cluster that is based on supporting policies and institutions (actors) that provide support for innovation, both at the national level and the regional level and driven by foreign MNCs and now also local MNCs. In general interviewees all agree on (1) Human Capital (2) Low Costs (3) Entrepreneurial Culture) (4) Pro Industry Policy as key factors for the development of Innovation activities in the Penang region. In addition to national institutions the key actors in the Penang regional innovation system include the Penang Skills Development Corporation, the University (albeit at a lower level), Training Institutes, MNCs and presence of large supplier network. Intra-cluster firm linkages are very weak but global linkages within a firm are very strong. This strong orientation towards headquarters or research and development centre’s of multinational corporations and lead users in technologically advanced countries appears to yield pattern of linkages in which firms are able to 'leapfrog' firms in neighboring ASEAN countries.

A notable issue is the lack of joint ventures (JV) firms (there is one firm and the

author is trying to make contact) but most respondents feel negative towards JV type organisation for technological developments and there also appears to be so specific policy to support JV form of organisations (like in the MSC cluster). An interesting point is the role of MNCs in pushing the local university to collaborate and develop higher capacity for research. All these have implications and recommendation for policy.

Based on the cases and some additional interviews with certain ‘stakeholders’ including academics from the cluster university, an entrepreneur who has moved out of the E&E sector into retail and consultants the following recommendations are made for supporting innovation activities among firms in Penang.

5.1. Targeted Policy for E&E Sector and Joint Venture

To improve the Industrial Base of Penang, we suggest that more efforts are made to improve the types of industry the Penang Cluster is serving. Penang has always been the hub for electrical and electronics manufacturing so an E&E industry specific policy and efforts to bring in firms in the E&E value chain is wanting:

- That relevant agency at the state and national level should target certain sub-sectors in the E&E sector and attract key ‘supplier’ firms which are located in East Asia (Taiwan, Japan or Korea).
- Some of the case respondents – both TNCs and larger local design firms mentioned the need for the development of a software developer group in Penang – as software development is an integral part of any product of process innovation in the E&E industry. This could be done through some co-ordination with the MSC project (ICT cluster project) or independently.

Consequently policy to encourage joint ventures type development is needed. this may help to bring in the ‘needed’ suppliers and also increase co-operation or

collaboration between firms in the cluster

5.2. Attracting Consultancy Firms into the cluster

Penang needs to be able to attract the best consulting firms to setup their firms in Penang to allow strategic planning consultancies to help move the firms in the Penang Cluster to a higher parts of the value chain. Penang also has to have market research companies operating in it to allow for market and product exploration and research. More innovative products with better market knowledge will make products made in Penang easily marketable to the world. Besides that, the presence of human capital and financial capital in Penang would encourage more high quality internal research and development to spur the firm's growth. The Penang government seems more focused on manufacturing – which is a good thing – but there is need to attract service firms to support the growth of the local firms and also TNCs to become independent subsidiaries in Penang

5.3. Promotion of Policy and Incentives Available for Innovation

Interviews with one of the (former) entrepreneurs in Penang and also from some respondents indicate that while there are several grants and incentives being offered by the government – particularly for R&D activities. The SMEs lacked information about these funds and incentives i.e., there is poor information flow on incentives and financial assistance provided by the government and other agencies. The relevant agencies like Invest Penang or MIDA need to have road shows or other forms of promotion.

(Recently the SMART (Small and Medium Enterprises Market Advisory Resource & Training) centre – was set up an initiative of the state government through investPenang to provide market intelligence, business advisory, information & resources, and Training service to SME in Penang.)

5.4. Entrepreneurial Culture for Innovation

Several papers and reports on Penang cluster and Innovation write that there is a lack of entrepreneurial culture in Penang. But based on the interview conducted and also from the respondents from the firms studied – the indication is that entrepreneurship is not the issue in the context of innovation – there seems to be a slow but steady growth of ‘local’ firms emerging from the supplier base – with human capital from the cluster firms eg. Kontron, VITROZ, Engtek etc. Some of these firms are acquisition targets for foreign firms also. The cultural impediment seems to be ‘satisfied with the current situation’ or conservative culture. So this has implications for education and S&T policy to create a risk taking culture among the entrepreneurs and also among the new graduates. The MSC project in Cyberjaya had interesting Technopreneur programme – supported by policies and incentives specific to SME/SMIs and also programmes that are collaborative and aimed to reduce risks to start ups and offers lessons for Penang to create a new pool of technology entrepreneurs.

Overall it can be said that Penang has the appropriate path created for possibility to move up the value chain from manufacturing to innovation – this move requires a different set of linkages to take place. The recommendations above would be the starting point and the key factor for supporting innovation is to have a culture of collaboration and sharing to be part of the region and this become the critical point to be addressed for the transformation of Penang.

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Rasiah, R. (2002). Systemic coordination and human capital development: Knowledge flows in Malaysia's MNC-driven electronics cluster. *The United Nations University Institute for New Technologies Discussion Paper 2002-7*.

All data /information related to Statistics about Penang and the E&E Manufacturing Sector were gleaned from the following websites (accessed during January 2010)

Malaysian Industrial Development Authority
www.mida.gov.my (accessed during January 2010)

Penang State Government Official Portal (Statistics Section)
<http://www.penang.gov.my/index.php?ch=16&pg=44&lang=eng>
(accessed during January 2010)

Information and Statistics related to S&T Indicators and R&D Activities were gleaned from the portal of Malaysian Science and Technology Information Centre
[www.mastic.gov .my](http://www.mastic.gov.my)

Appendix A

Science and Technology Incentives from Government of Malaysia.

www.mastic.gov.my website (accessed January 29th, 2010)

Research and development as well as technological innovations are essential in the Malaysian government's strategy of sustainable development and knowledge-based economy, or k-economy. Recognising these factors, the government has accorded a high priority to the scientific and the technological development of the country.

→ INDUSTRIAL AND R&D GRANTS

Since 1988, The Government has implemented a centralised grant system of financing science and technology (S&T) research in public institutions and research agencies. The Ministry of Science, Technology and Innovation (MOSTI) is charged with the responsibility of managing the fund and the implementation of S&T research and development (R&D) programmes in the country.

Some of the grants provided are explained below

IGS: Provides grants to support the usage and adoption of existing technologies or creation of new technologies by local companies in key technology areas such as advanced manufacturing, advanced materials, automation of processes, electrical & electronics, biotechnology, aerospace.

TAF: Provides partial grants to firms to acquire technologies through licensing, to enhance the design and production of existing and new products and processes.

MGS: Provides grants to encourage R&D in multimedia products and services among MSC status companies in Malaysia.

CRDF: Provides partial grants for qualified R&D projects to be commercialized.

→ LOAN & VENTURE CAPITAL

Over the years, the Malaysian government through various ministries and agencies, has helped the Small and Medium Industries (SMI) succeed from start-up through the many stages of growth. Financial assistance is offered to help start or expand these businesses and achieve success through business loans to entrepreneurs and business owners of specialised industries. These loans are made available through financial institutions such as Credit Guarantee Corporation Malaysia Berhad, Bank Pembangunan dan Infrastruktur Malaysia Berhad and Bank Industri dan Teknologi Malaysia Berhad to enable these entrepreneurs to obtain up to 100% loan and credit facilities to support their business aspirations. Venture Capital is an alternative form of financing. The Government has proven itself in the past to be very supportive of the VC industry and has continued to do so, providing adequate liquidity to meet the industry's needs.

→ S&T TAX INCENTIVES

The involvement of private companies in Research and Development (R&D) activities is crucial to the nation's industrialisation drive. To further encourage the involvement of the private sector in carrying out R&D, the government of Malaysia has made available various types of incentives for R&D activities. Most of the R&D deductions and allowances are provided for under the Income Tax Act, 1967. The category of incentives by way of Pioneer Status and Investment Tax Allowance are provided under the Promotion of Investments Act 1986. The following is the listing of tax incentives being provided.

- In-House Research
- R&D Company
- Contract R&D Co.
- Tax & Duty Exemption
- Double Deductions for Approved Research
- Double Deductions for Cash Contributions
- Double Deductions for Payments
- Software Promotion
- High Tech Co.
- Capital Allowance & Industrial Building Allowance Grant.
- Fulfillment of Definition

Two or these benefits for (1) in-house R&D and (2) R&D Company are provided below
In-house R&D

Under the Promotion of Investments Act, 1986, companies which carry out in-house research are eligible to apply for an Investment Tax Allowance of 50% on the qualifying capital expenditure incurred within a period of 10 years. This allowance will be offset against 70% of the statutory income for each year of assessment. An existing company undertaking reinvestments in in-house R&D (by way of additional expenditure for plant, machinery and building) is eligible for a second round of Investment Tax Allowance of 50%.

R&D Company

Under the Promotion of Investments Act, 1986, an R&D company which provides services both for its related companies or any other companies is eligible to apply for Investment Tax Allowance of 100% on the qualifying capital expenditure incurred within a period of 10 years. This allowance will be offset against 70% of the statutory income for each year of assessment. The related companies concerned will not enjoy double deductions for payments made to the R&D Company. However the R&D company may opt not to avail itself of the Investment Tax Allowance in which case, its related companies will enjoy double deductions incentive for payments made for R&D carried out by the R&D company. An existing R&D company

undertaking reinvestments D (by way of additional expenditure for plant, machinery and building) is eligible for a second round of Investment Tax Allowance of 100%.

→ [HCD FUNDS](#)

The Human Capital Development Fund Programme in S&T is an effort by the Government to strengthen the human capacity and capability for the enhancement of S&T in Malaysia. Among the objectives of this programme is to increase the critical mass of scientist and researchers of the country. It also aims at further strengthening the R&D functions in institutions of higher learning and public research institutions; and to enhance the country's competitiveness through the development of trained, innovative and creative human resource.

APPENDIX B

Statistics of Student Enrolment in Public and Private Educational Institutions

(MALAYSIAN SCIENCE AND TECHNOLOGY INDICATORS 2006 REPORT

EDUCATION IN SCIENCE AND TECHNOLOGY. www.mastic.gov.my accessed January 20th 2010)

Statistics of Enrolment and Graduation in Public Educational Institutions

Field of Study	Academic Year					
	Enrolment	Graduation	Enrolment	Graduation	Enrolment	Graduation
	2005/2006	2005/2006	2006/2007	2006/2007	2007/2008	2007/2008
First Degree	207,913	50,989	217,949	56,013	138,017	32,797
Master's Degree	31,518	6,785	27,242	7,622	30,383	8,499
Doctoral Degree	9,504	485	7,152	636	10,167	702
TOTAL	248,935	58,259	252,343	64,271	178,567	41,998

Enrolment and Graduation in First Degree Courses at Public Educational Institutions

Field of Study	Academic Year					
	Enrolment	Graduation	Enrolment	Graduation	Enrolment	Graduation
	2005/2006	2005/2006	2006/2007	2006/2007	2007/2008	2007/2008
1 - Art	93,633	25,974	100,802	27,576	138,017	32,797
2 - Science	69,490	17,089	70,250	18,005	55,721	14,954
3 - Technical	44,790	7,926	46,897	10,432	54,143	11,720
Other Fields	0	0	0	0	0	0
TOTAL	207,913	50,989	217,949	56,013	247,881	59,471

1. Covers the following subjects : Art and humanities, economics and business, law and others.
2. Covers the following subjects : Medical and dental, applied science, pure science and computer science.
3. Covers the following subjects : Engineering, architecture and planning, and others.

Enrolment and Graduation in Master's level Courses at Public Educational Institutions

Field of Study	Academic Year					
	Enrolment	Graduation	Enrolment	Graduation	Enrolment	Graduation
	2005/2006	2005/2006	2006/2007	2006/2007	2007/2008	2007/2008
Art	15,995	3,864	13,010	4,045	18,012	4,791
Science	11,065	1,830	9,207	2,216	8,411	2,622
Technical	4,458	1,091	5,025	1,361	3,960	1,086
Other Fields	0	0	0	0	0	0
TOTAL	31,518	6,785	27,242	7,622	30,383	8,499

Enrolment and Graduation in Doctoral level Courses at Public Educational Institutions

Field of Study	Academic Year					
	Enrolment	Graduation	Enrolment	Graduation	Enrolment	Graduation
	2005/2006	2005/2006	2006/2007	2006/2007	2007/2008	2007/2008
Art	4,827	231	4,445	366	5,409	295
Science	3,630	180	1,704	175	2,881	305
Technical	1,047	74	1,003	95	1,877	102
Other Fields	0	0	0	0	0	0
TOTAL	9,504	485	7,152	636	10,167	702

Enrolment and Graduation in First Degree Courses in Private Educational Institutions (as of 30th June 2007)

Field of Study	Academic Year					
	Enrolment	Graduation	Enrolment	Graduation	Enrolment	Graduation
	2005/2006	2005/2006	2006/2007	2006/2007	2007/2008	2007/2008
Art	61,724	8,873	70,387	13,495	88,418	5,040
Science	29,252	8,044	39,817	9,233	34,168	4,063
Technical	10,419	3,377	13,867	4,448	17,836	2,659
Other Fields	0	0	0	0	0	0
TOTAL	101,395	20,294	124,071	27,176	140,422	11,762

Enrolment and Graduation in Master's Degree Courses in Private Educational Institutions (as of 30th June 2007)

Field of Study	Academic Year					
	Enrolment	Graduation	Enrolment	Graduation	Enrolment	Graduation
	2005/2006	2005/2006	2006/2007	2006/2007	2007/2008	2007/2008
Art	3,173	832	4,173	1,036	4,479	298
Science	1,075	111	1,496	397	868	49
Technical	601	137	808	159	737	71
Other Fields	0	0	0	0	0	0
TOTAL	4,849	1,080	6,477	1,592	6,084	418

Enrolment and Graduation in Doctoral Degree Courses in Private Educational Institutions (as of 30th June 2007)

Field of Study	Academic Year					
	Enrolment	Graduation	Enrolment	Graduation	Enrolment	Graduation
	2005/2006	2005/2006	2006/2007	2006/2007	2007/2008	2007/2008
Art	360	23	465	25	693	6
Science	108	6	183	5	68	1
Technical	130	18	212	21	56	52
Other Fields	0	0	0	0	0	0
TOTAL	598	47	860	51	817	59

Source: Department of Higher Education Management, Ministry of Higher Education Malaysia.