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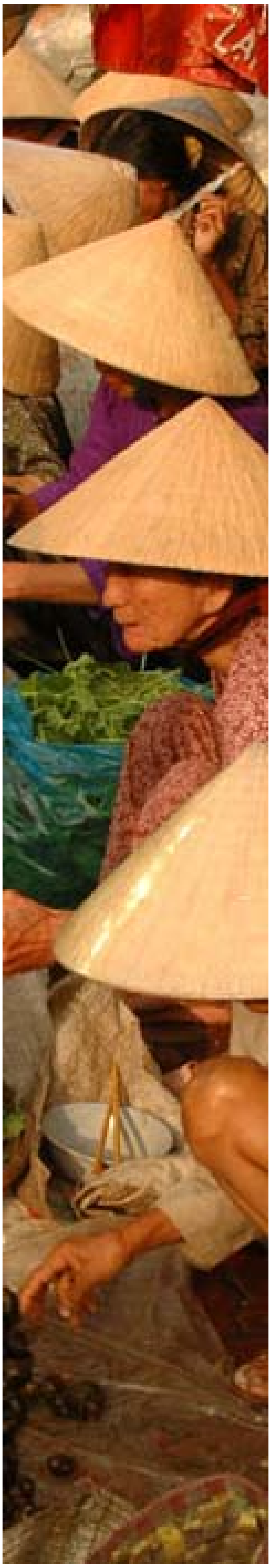

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Abstract:

The study of innovation and technological upgrading experienced a significant interest in the academic literature, especially within the developing countries (Lall, 1998, 2001; Kim and Nelson, 2000; Ariffin and Figueiredo, 2004). The lack of involvement by developing countries in radical innovative capabilities (Rasiah, 1994; Hobday, 2005) and the interest of scholars in learning technological capability building and technological catch up processes has directed researchers to analyze various mechanisms or drivers that contribute to technological upgrading, especially in developing countries, more so in the manufacturing sector. This study aims to investigate the R&D activities and the internationalization of these activities undertaken by foreign firms within the Malaysian manufacturing sector. The study aims to provide answers to the following questions: 1. What is the status of the systems of innovation within the Malaysian manufacturing sector? 2. What is the role played by the agents of innovation, in particular TNCs or MNCs, in relation to R&D activities and its internationalization? and, 3. How is the Malaysian manufacturing (local and foreign) technological and R&D progress to date? This study confirms that the Malaysian manufacturing systems of innovation is weakly positioned but shows limited evidence of process innovation and not product innovation. However, evidence of innovation differs among states and sectors owing to differences in the systems of innovation. Although, Malaysia has not been chosen as a site for offshoring or outsorcing of R&D activities to a significant degree, it is found that one very important driver of innovation is the central role that multinational enterprises play in the Malaysian manufacturing systems of innovation. Process innovation is conducted by foreign subsidiaries and is on the rise in key the electronics industry. It is also found that technological learning by local firms is mainly through linkages, sub-contracting and technological transfer.

Keywords: *Malaysian Manufacturing Systems, R&D, Technological Upgrading*

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1. Introduction

The Malaysian Gross Domestic Product (GDP) grew at an average rate of 6.7% during 1971-1990, while during 1990-1999 and 2001-2005, it had recorded an average growth rate of 8.1% and 4.5% per annum, respectively (Malaysia, 1991, 2000, 2006). One major and notable strategy of the government to spur economic growth is by attracting foreign direct investment (FDI). Indeed, Malaysia was one of the most active among the ASEAN countries in liberalizing its investment regime in the manufacturing sector during the 1980s and 1990s. Significant progress was seen during the 1980s under the administration of the then Prime Minister Dr. Mahathir Mohammad, where various joint venture projects with state-owned enterprises were launched. With the advent of the Investment Act in 1986, Malaysia experienced a huge influx of FDI. This policy offered many incentives to foreign investors, such as pioneer status, tax holidays, expanded investment tax allowances for expansion projects, tax deduction for export promotions, the establishment of Free Trade Zones and other types of incentives. In fact, trade liberalization which was improved by relaxing the restrictions over capital ownership of foreign companies and the considerable decline of tariff rates over the years (Urata, 1994) helped to attract FDI into the country. This brought with them better technology and know-how.

It is notable that the dynamic Malaysian economy has become more competitive across a broad range of manufactured goods and has also managed to switch to higher value-added manufacturing products (Wilson, 2000). The outward oriented economic strategies have somehow progressed well in establishing the manufacturing sector, namely the electronic and electrical sectors. The success of the Malaysian manufacturing sector can be partly attributed to its trade and the liberalization of FDI. Since the late 1970s the manufacturing sector has contributed significantly to the growth of the Malaysian economy. Its contribution to the export earnings accounted for 80.5% of the total export earning and nearly 31.4% of Malaysia's GDP in 2005 (Malaysia, 2006). This suggests that a decline in export competitiveness could adversely affect the Malaysian economy. Moreover, it is widely recognized that innovation is a key factor in sustaining Malaysia's competitiveness in the face of rapid globalization. However, studies concerning innovation in Malaysia are limited. While there have been few studies on innovation (Hobday,1996; Rasiah, 2003; Narayanan and Wah, 2000) and internationalization of R&D activities (Ariffin and Figueiredo, 2004) in Malaysia, less attention has been paid to analyzing the issue as a system hence providing little evidence for any significant policy directions. Therefore, the purpose of this study is to shed further light on the development of the manufacturing systems of innovation. This is done by examining the systems of innovation at national, sectorial as well as firm level. The next section gives a brief review of the current stage of R&D activities by examining the available innovation indicators. Subsequently, an in-depth analysis of the current state of the manufacturing systems of innovation in Malaysia is presented, followed by a review of literature of innovation studies in Malaysia and the current technological progress made by Malaysian manufacturing firms (local and foreign).

2. Snapshot of R&D Activities and its Related Indicators of Innovation in Malaysia Introduction

In this section, the current level of R&D indicators (inputs and outputs) is used to explore the systems of innovation in Malaysia. The indicators were compared with those of other developing and developed nations. Technological effort is vital to

Malaysia, even though it is clear that it is not "innovating" at the frontier. So far, Malaysia has only learned to use imported new technology and equipment from the more advanced countries. However, it is time to upgrade Malaysia from the assembly stage to manufacturing, design and development of new products. Comparing the R&D expenditure (Table 1) it is clear that Malaysia is still behind many other nations such as Korea, Singapore, India and China (see footnote of Table 1). The performance scoreboard indicates that compared to the average standard (even among Asian countries), Malaysia is still lagging behind even after intense measures have been undertaken to promote innovation.[1] Given the intense competition (from low cost producing countries e.g. China, Vietnam), the trend records weaknesses in the National Innovation Systems and if left unattended would further erode the nation's industrial competitiveness since many other countries are catching up fast especially in terms of technological progress. Therefore, the government would have to focus on shaping the national system of innovation, and provide more proactive R&D infrastructure to enable the progress to an innovative society.

Apart from R&D investments, the availability of human resources in the science and technology fields is a crucial determinant of an innovative economy. Comparatively, Malaysia is far behind in terms of the number of scientists and engineers in R&D and researchers compared to Singapore, China and Vietnam except for S&E enrollment relative to first degree enrolment and post-graduate enrolment (Table 1). This shortage is made worse due to the 'brain drain' problem. Therefore, the innovation policy should take into account both the demand side (e.g. tax credit for R&D and research grants) and supply side (e.g. supply of qualified researchers, scientists and engineers) to enhance the discovery and innovation process. In addition, opportunities should be given to the best available resources, where it may promise a better outcome.

Table 1: R&D Performance Scoreboard, 2002 & 2004

Indicator	Year 2004	Year 2002	Average /Selected OECD
Overall R&D Intensity	0.63	0.69	2.33 [1]
Industry R&D expenditure as % of GERD	71.5	65.3	>62 [2]
Total R&D Personnel (headcount)	30983	24937	>100000 [3]
Researchers per 10,000 labor force	21.3	18	61 [4]
Total FTE per researcher	0.55	0.4	0.74 [5]
Science and engineering enrolment as % of total first degree enrolment	48.2	51.8	44.6 [6]
Science and engineering enrolment as % of total post-graduate enrolment	40.6	44.2	32.4 [7]
Proportion of postgraduate enrolment to undergraduate enrolment	01:06.6	01:08.4	1:11.6 [8]
Women researchers as proportion of total researchers (%)	35.8	33.7	27 [9]

[1] Average OECD, however, countries like Korea and Nordic countries report higher values
[2] Average OECD, Japan(75)
[3] Many OECD countries have more than 100,000 researchers .For example Korea has 210 000 researchers in 2004
[4] Average OECD

[1] For a detailed discussion on incentives and other forms of assistance for innovation given by the government, see Jomo, 2007.

[5] Figure for Korea's researchers (2004)
[6,7,8] Figure on Korean Education from Korea Educational Development Institute(2005)
[9] Average value for EU/EFTA (UNESCO Institute for Statistics ,2006)

Research and development (R&D) expenditures as % of GDP 1996-2000: for Hong Kong (0.4%); Singapore (1.9%); Korea (2.4%); Malaysia (0.4%); Thailand (0.1%); China (1%) and India (1.2%), respectively. (UNDP, Human Development Report, 2003)
Number of researchers per 10,000 labor force is 83.5 for Singapore (2000); 60 for Korea (1998); 15.6 for Malaysia (2000); 5 for Thailand (2001).
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.

Education, training and dissemination of information are vital for the industrialization process, especially in developing innovative products and processes. Indeed, the continued search for productivity through education is a key factor in strengthening a firm's profit or even for the successful contribution of universities and research institutions with regard to innovation and commercialization of technology. For example, with the rapid expansion of competition, pricing power remains non-existent in many sectors, yet ever improving productivity has enabled firms to squeeze costs and rebuild their bottom line. Even the Corporate Sector Survey in 1998/1999 indicated that firms employing workers with higher levels of education are able to withstand the economic crises better than those who do not.

One essential policy issue would be building a well-defined infrastructure for education and the development of a science-oriented society in line with the needs of industry. Indeed recent studies suggest that the required skills of employees in the four main industrial clusters such as computers and semiconductor, telecommunication, instrumentation, and health and medical products are highly dependent on knowledge. The best contribution the government can make is to work on a knowledge producing agenda. Progressive measures in facilitating the creation of a knowledge-based economy through the information highway and smart schools should be given top priority for economic growth as well as for the development of an innovative society. Strengthening of the vocational and technical training schools should be emphasized to a great extent to facilitate the growth and development of innovation activities.

Malaysia has done fairly well in the adults and young literacy rate compared to other countries[2]. However, it is incorrect to say that Malaysia has the needed human resources to fulfill the needs of an innovative economy since a high literacy and enrolment rate does not reflect the quality of education that is available. Furthermore, the recent rapid expansion of new educational institutions (colleges, universities and training institutes) does not promise a great return if the quality of graduates deteriorates and if a large portion of the programs available in these institutions are focused towards non-science and non-technical subjects. Industrial institutions such as the German Malaysian Institute, the Japan-Malaysian Institute and the Malaysian France Institute and others should establish a network with the industries for better synergy, and to reduce the

[2] Due to the space constraint, the figures are not reported in this study. Figures can be requested from the author.

demand supply deficits of the high-tech industries in the future. For example, a study by Rasiah (2002) indicated that Penang and the Klang Valley failed to enjoy sufficient supplies of high-tech human capital because of ineffective coordination of supply and demand of high end human capital. Indeed, Malaysia is lagging behind in terms of tertiary level enrolment, especially in science and technology (ISIS, 2002; UNDP, 2002) and its ranking in terms of international innovativeness and competitiveness has deteriorated over the last few years. Building technological capability in Malaysia requires early nurturing of its human capital and a strong commitment by the government to support a new education system that fosters creativity, innovation and critical thinking. Malaysia has realized the importance of technology and has begun making large investments in this area. However, it is virtually impossible to gain without having a higher education system. In order to become a highly innovative economy, strategies and policies should focus urgently on the following four distinct areas:

1. Place greater emphasis on enrolment of tertiary students in science, mathematics and engineering and tertiary level curriculum should emphasize basic and applied science and technology
2. Enhance coordination and linkages between higher education institutions and industries
3. Expand the creation of knowledge workers by emphasizing the quality of education rather than quantity. This includes the quality of students, quality of teachers, learning aids, school/university facilities and others
4. Provide vocational and technical education and training with the motive to supplant industrial needs rather than for the purpose of encouragement

Given today's competitive environment, the development of new products and processes will be the lifeline of a nation. Opportunities should be created through academic research especially by encouraging partnerships between universities, research institutions and the private sector. Potential research projects in any of these institutions and inside firms should be identified and given the necessary support to facilitate the flow of innovation and new ideas. The direct outcome of innovation by research institutions and firm efforts would be in terms of patents, licensing and royalties.

Table 2: Patents, Royalties and License Fees for Selected Countries

Country	Patents granted to residents (per million people)	Receipts of royalties and license fees (US$ per person)
	1999	2001
Hong Kong, China	4	16.0
Singapore	12	..

Korea, Rep. of	931	14.6
Malaysia	..	0.9
Thailand	..	0.1
China	2	0.1
India	1	0.1

Source:UNDP, Human Development Report, 2003

It is evident that Korea and Singapore (high patent grants and royalties) have an understanding of the relationship between the outcome of research and economic growth (Table 2).

Table 3: Other Selected Indicators of Innovation, Malaysia and OECD

Indicator	Year 2004	Year 2002	Average /Selected OECD
% of public R&D financed by industry /external funds	2	n/a	>10 [1]
Total number of publication in ISI-indexed journals (1981-2005)	1179	938	16628 [2]
Total Citation (2001-2005)	1360	2716	37 502 [3]
No of patents applied (Malaysian)	522	322	>10 000 [4]
No of patents granted (Malaysian)	24	32	>6300 [5]
No of USPTO patent per million population	3.6	2.5	152 [6]

[1] Average of selected OECD
[2,3] Average no of ISI papers for Australia ,Korea and Finland (NSIOD,2006)
[4,5] Average value for figure for Germany ,France, UK (OECD)
[6] Weighted average OECD
[7,8,9] Figure from IMD World Competitiveness Report 2006.

It is also evident that Malaysia is weakly positioned in this aspect. Thus, Malaysia must spring to the mind of investors as the center for technology venture capital. Malaysia should be able to attract much investment capital into technological startups. One move towards encouraging venture capital into Malaysia will be to improve the law that will safeguard intellectual property. Russia, for instance, has experienced little investment in high technology despite having skilled technical talent and supply of unemployed engineers. The reason for this can be attributed to Russian law, which does not safeguard intellectual property.

To boost the expected outcome from research, Malaysia would have to direct its efforts towards:

1. Improving intellectual property rights
2. Encouraging more collaborative efforts between research organizations and industries
3. Providing more funding for technology commercialization
4. Redirecting some of the academia's efforts merely from consultation work to market-oriented product and process development
5. Improving the mobility of personnel
6. Establishing strong links to leading international R&D organizations
7. Creating higher intensities of R&D and research application

Apart from the indicators mentioned above, firm-level activities in high technology intensive industries may shed some light on the technological progress made by the nation. Porter (1998) suggested that locating critical masses of linked industries and institutions in one place helps firms to enjoy competitive success. Clustering benefits the industry by providing efficient concentration of suppliers, efficient access for information and knowledge, close relationships and coordination, enhanced diffusion of knowledge on best practices and stimulates innovation.

However, the adoption of cluster based industrial development does not show a significant concomitant growth of the supporting industries that will fuel the engine of growth for the economy. Although Malaysia has successfully moved to the export of high technology industries (57% of Malaysia's export in 2001 is in high technology industries) (Chandran & Veera, 2003; Chandran, Deviga & Karunagaran,2004), it is found that Malaysia is still largely dependent on foreign technology. The impressive export of high technology industries are largely due to foreign participation. Therefore, the spillover effect from the MNCs has not greatly promoted indigenous technological capabilities. The following reasons could significantly be the contributing factors:

1. Malaysia is basically engaging only in the assembly stage of manufacturing
2. Failure in attracting MNC headquarters to be located in Malaysia (HQs significantly contribute to research and development activities)
3. Lack of skilled professionals in supplementing the industries
4. Lack of an entrepreneurship and innovative culture among Malaysians

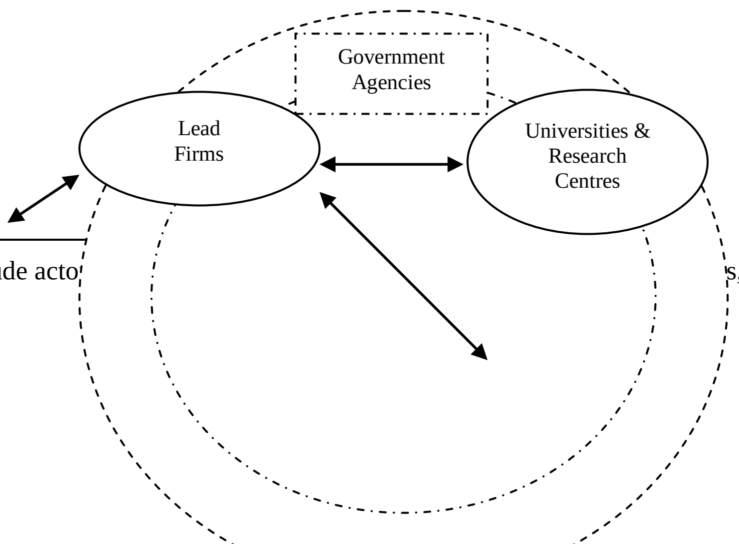
As a whole, the national level indicators show weaknesses in the technological progress efforts. The country's weak position in terms of research and development and innovative capability poses major challenges. The analysis suggests that Malaysia should further improve its fundamental agenda in its efforts to be a knowledge and technology driven economy. The research has indeed provided some insights on policy improvements as the tool to foster innovation in Malaysia. Although a number of key indicators such as technology diffusion and high technology industries to some extent support the movement of the Malaysian economy towards an innovation focus, further improvements are vital, especially within education, research and development, and human resources development. Thus, the undeniable importance for Malaysia is to become a knowledge-based economy through the creation and adoption of national policies to complement the emergence of innovative activities. Malaysia should take a pro-active approach concerning policy developments.

In the following, we will provide meso- and micro-level evidence by examining the manufacturing innovation systems. This will allow us to track the innovation activities of firms at a more disaggregated level, which is crucial for policy implementation.

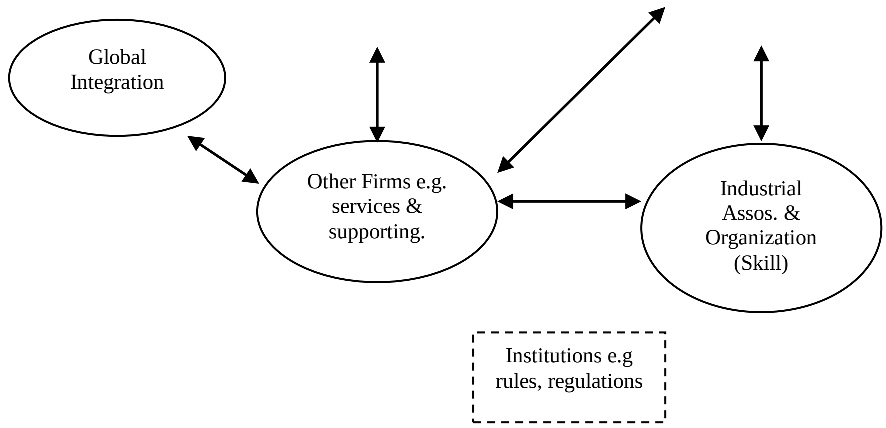
3. Malaysian Manufacturing System of Innovation

Given that innovation and technological upgrading does not work in isolation, the National Innovation System (NIS) framework (Lundvall, 1985; Freeman, 1987, 1993; Dosi, Freeman, Nelson, Silverberg and Soete, 1988; Nelson, 1993), since its development in the 1980s, provides significant insights into understanding the technological progress of nations (Patel and Pavitt, 1994), region (regional systems of innovation) as well as firms. Within the NIS framework, scholars have taken different approaches when analyzing the innovation environment. While Lundvall, (1985, 1988) supports the institutional approach, others, Dosi et. al. (1988) and Freeman (1987) take the evolutionary approach. Broadly, two distinct categories of actors are involved in the NIS framework, namely the organization and institution. The NIS incorporates and analyses the interrelationship between the organization and the institution. Organization refers to the formal structure that is created to facilitate innovation activities or for diffusing knowledge. They include firms[3], universities, government agencies, science parks and skills development agencies. Institution refers to the sets of practices, rules and regulations including the infrastructure that governs innovation activities. In the same contention, the ***manufacturing systems of innovation*** can be viewed as the interaction between the actors which mainly consists of physical, human resources and knowledge flows. The interactions can be viewed as systems that contribute to the differences in technological progress and innovation between the actors within the manufacturing industries. Therefore, we developed the ***Malaysian manufacturing Systems of Innovation*** (MSI) by incorporating the key actors in the systems (Figure 1). Additionally, we included 'global integration' in the system, due to the growing importance of global integration for technological upgrading in the Malaysian manufacturing sector. This provides a more complete systems view in analyzing the state of Malaysian manufacturing innovation systems.

Figure 1: Malaysian Manufacturing Systems of Innovation (MSI)



[3] Firms also include acto… s, suppliers, customers, etc.



Source: Authors, modified by identifying the main actors in Malaysian manufacturing sector with the guide of NIS concepts and literature.

Using MSI as the framework, the next section evaluates the current status and the role played by the different agents - organization and institution.

3.1 The MSI actors

We limit the analysis to the six main components of the MSI namely universities and public research institutes, industrial associates and other organizations (e.g. skill development), firms (both lead firms and the supporting firms, which are vertically and horizontally linked), the institutions (e.g. government policies and rules, grants), government agencies, and global players.

3.1.1 Universities and research organizations

Universities and research institutions play an important role in the NIS[4] (Laredo and Mustar, 2001), particularly in the US and other developed countries (Rosenberg and Nelson, 1994; Mowery, Nelson, Sampat and Ziedonis, 2001). Research on innovation widely recognizes that linkages play a prominent role in the success of commercialization and knowledge transfer between research organizations and industries (Acs, Audretsch and Feldman, 1994; Hagedoorn and Vonortas, 2000; Sveiby and Simons, 2002; Cohen, Nelson and Walsh, 2002; Meyer-Krahmer and Schmoch, 1998; Arundel and Geuna, 2004). Additionally, national innovation systems are significantly influenced by the collaborative research programs especially by creating and strengthening networks, which are essential for breeding innovation clusters (Liyanage, 1995). However, the current level of university and industrial linkages in Malaysia is still poor. Very limited evidence is available on collaborative work, which leads to pre seed funding by industries, joint ventures, and other forms of industrial alliances. The National Innovation Survey (MOSTI, 2006a), indicated that important sources of information for innovation among the manufacturing firms are internal sources, suppliers of equipments, materials, components, other firms from the same industry and competitors. University and private R&D institutes are rated to be the less

[4] The current framework in the analysis of the role of universities in NIS include the Triple Helix (see Gunasekara, 2006)

important sources of innovation. In Malaysia, their roles are limited in providing consultancy and basic research (Chandran, Veera and Farha, 2008).

Additionally, the commercialization of university results is also limited, hence the active role of universities in innovation outcomes is insignificant within the context of the manufacturing systems of innovation. Creation of start-ups, technological licensing and other forms of commercialization of research findings is very limited. Although the major share of government R&D funding is allocated to the universities and research institutions (via Intensification of Research in Priority Areas), a survey of 5232 projects implemented by the public research institutions and universities during the Sixth and Seventh Malaysia Plans revealed that 14.1 per cent of these projects were identified as potential candidates for commercialization whereas only 5.1 per cent was commercialized (Malaysia, 2001). Despite the traditional roles of the research organizations, the government has focused very little attention on identifying and overcoming the challenges and barriers faced by these research organizations in commercialization. Lack of industrial collaboration, poor financing, improper structure of technology commercialization offices, poor information process, lack of demand oriented research and weak intellectual property management serve as the major impediments to technology commercialization (Chandran et. al., 2008).

3.1.2 Industrial Associates and Skill Development Organizations

Industrial associates and skills development organizations play a crucial role in supporting the manufacturing innovation ecosystem. Knowledge sharing and skill transformation is vital for the progress of innovation systems. At present, the active roles of these organizations are limited to Penang, where the role of the Penang Skills Development Centre (PSDC) is highlighted. Although each state has its own skills development organization, the contribution of these organizations is limited due to erroneous implementation and lack of drive of these organizations to upgrade or teach skills that are relevant to the industry. For instance, the Johor Skills Development Corporation is merely a provider of skills, but lacks the coordination with industry to provide for the specific skills and knowledge that a firm needs. On the contrary, the PSDC has established a close relationship with the industries and have relevant industrial machinery to contribute to skills formation. PSDC works closely with the industrial personnel to design the curriculum and gets them to run their courses. The smart partnership between the PSDC and transnational corporations, representatives from the State Government, Penang Development Corporation (PDC), Universiti Sains Malaysia (USM), SIRIM and the Ministry of Public Enterprises makes the curriculum relevant to industrial needs. Indeed, the partnership between PSDC and member companies provides the room to pool together resources to plan, design and conduct a wide range of training programs (training modules were contributed by Agilent Technology, Astec, Eng Teknologi, Robert Bosch, Fairchild Semiconductor, Komag, Intel, Motorola and Penang Seagate). It also helped PSDC equip itself with state of the art equipments, computer hardware and software relevant to industry. This is not apparent in many other states. Thus, the manufacturing sector still lacks the skills and knowledge in undertaking serious R&D work. Therefore some TNCs have established their own skill centers to provide training for their work force. Others, including the

Federation of Malaysian Manufacturing (FMM) and specific training institutions like the German-Malaysia Institute, Japan-Malaysia Technical Institute and France-Malaysia Institute contribute in terms of skills development. However, their effectiveness is unclear. Although there are no direct measurements of the effectiveness of these institutions, the common complaints from firms indicate that these institutions are still incapable of providing the necessary industry relevant skills. A survey by PDC (2002) indicated the additional required skills in the electronic sectors in Penang (Table 4). Topping the list are the growing requirements for technicians, electronic, mechanical and QC engineers.

Table 4: Additional Requirement for Manpower

	2000	2001
Electronics Engineers	361	372
Mechanical Engineers	299	240
Industrial Engineers	79	71
Chemical Engineers	31	27
QC Engineers	145	149
Engineers (Others)	103	90
System Analysts	86	94
Computer Programmers	39	41
Technicians	1151	1168
Tool & Die Makers	62	74

Source: PDC, 2002

With regard to industrial associates like electronics associates, company associations and the like, the sharing of knowledge and technical know-how is also limited. The main aims of these associations are mainly to facilitate and coordinate their activities with government agencies. They mainly focus on coordinating with the service providing agencies (electricity, water, transport etc.) and the government to improve the basic infrastructure.

The role of universities in skills development is also very much limited due to the mismatch in the curriculum and lack of industrial exposure among graduates[5]. Although limited, few initiatives were taken to improve collaboration between universities and industries. Moreover, large firms like Intel, Agilent and Altera have to some extent established recruitment and research linkages with the public universities. The USM-Intel cooperation is a leading example. The newly established private and public universities (e.g. University Perlis Malaysia, Multimedia University (MMU) and others) that provide more specialized courses are found to have positioned themselves better with the industries. For instance, Altera has created curriculum in collaboration with MMU to create graduates for their own needs. Altera has also transferred part of their know-how and equipment to MMU. Indeed, the personnel in charge of university-industry coordination monitor and coordinate these programs. This indeed reduces the gap between the industries and the education institutions. Likewise, University Perlis

[5] However, it is also found that recruitment of local university students for internship was rampant (e.g. Intel, Kobe, B Braun, Fairchild etc). This instead, provides the practical exposure to the students as well as future job opportunities. To what extent this contributes to the skills is not clear.

Malaysia has a close relationship with the industry and a better curriculum setting[6] which encourages firms to recruit a large number of graduates from this university[7]. Although certain cases obviously stand up in supporting the Malaysian manufacturing innovation systems, the overall system for skills development is insufficient to support the technological progress of the manufacturing sector.

3.1.3 Lead and Supporting Firms

Owing to the high foreign presence and the export-oriented industrial strategy, foreign ownership has traditionally contributed to technological development in the Malaysian manufacturing sector. Within the industrial clusters, the lead firms (normally foreign-based multinationals) have and continue to play a vital role in the technological upgrading of the local as well as the other supporting industries. Within the electrical and electronics and automotive clusters, a number of studies have highlighted the role of foreign MNCs (Rasiah, 1994, 1999, 2003; Hobday, 1996, 2003, 2005; Ismail, 1999; Leutert and Sudhoff, 1999).

Due to technological complexity, the importance of cooperation is recognized for knowledge resources and to build competences (Lundvall, 1988; Muller and Zenker, 2001). Further, research findings (Rasiah, 1994; Ariffin and Bell, 1999; Ariffin and Figueiredo, 2004; MOSTI, 2006a) have indicated that outsourcing activities and linkages between the MNCs or other customers and local firms is vital in developing the local manufacturing firms' technological trajectories. In the Malaysian manufacturing sector, however, the active role of other parties like the government, public R&D research institutes and universities in innovative activities of manufacturing firms is very limited. While analyzing the differences in cooperation between companies in Singapore and Penang, Malaysia, Berger and Diez (2006) identified that in Singapore, companies seek intense cooperation with R&D institutes and universities, while in Malaysia firms strongly rely on business and service providers including technical service providers. Hence, in a country like Malaysia that tends to depend on a FDI-led growth strategy with a high content of high technology manufacturing exports, MNCs play a critical role in technological progress and innovation.

In Malaysia, the manufacturing firms create innovative cooperation with customers (buyers), followed by parent or associate companies, suppliers and technical service providers (Berger and Diez, 2006). This suggests the forward linkages (with customers) and the backward linkages (with suppliers) are important sources of information for both process and product innovation (Table 5). The customers or clients (foreign and local MNCs) influence the innovative activities of local firms by providing technical assistance, knowledge and skills to undertake manufacturing. It also shows that to absorb and adapt the knowledge and technological know-how, local capability (resources) need to be present in local firms. Process related knowledge comes from

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[6] E.g. more practically-oriented than theory among graduates, and investment in equipments relevant to industry

[7] Courses provided by University Perlis Malaysia are practical based and requires their graduates to take up practical training for 6 months. Unlike many public universities, they (including other public university colleges established for this purpose -) offer limited number of courses which allows them to focus and develop the relevant course.

other sources of technology providers such as suppliers of machinery and equipments. Policy differences also contribute to the use of MNCs as technological upgrading channels. Whereas the policy in South Korea is to support technology programs, and in Taiwan the policy is directed towards creating dynamic local small and medium sized (SME) sectors, the Malaysian policy basically appears to be concentrated on providing incentives and better infrastructure to attract foreign investments. What's more, incentives and other forms of assistance are directed towards MNCs rather than SMEs. As a result, the possible channel of technological learning comes from interacting and creating linkages with MNCs. This appears to support the notion that the main source of technological catch-up in developing countries is through absorption and transfer of technology from foreign sources (Hobday, 2005).

Table 5: Sources of Technology

Innovation Information Sources	**Percentage of Firms Reporting High Importance**	
	1997-1999 (%)	2001-2002 (%)
Within the company	47.2	44.1
Other companies within company group	28.8	28.6
Suppliers of equipment ,materials, components, or software	31.8	38.9
Clients or customer	65.2	57
Competitors and other companies from the same industry	34.4	33.1
Universities or other higher education institutes	6.2	8.6
Government or private non -profit research institutes	11.7	16.9
Trade fairs and exhibitions	23.3	12.5
Scientific journals and trade /technical publications	16.2	10.6
Professional conference and meetings	16.2	10.6

Source : MOSTI, 2006

3.1.4 Government and Non-Governmental Agencies

To foster technological development, specific and general government and non-governmental agencies were established in Malaysia. The main role of these agencies is to act as coordinators or facilitators for technology/technological development. For this purpose, the Standards and Industrial Research Institute (SIRIM), Malaysian Venture Capital (MAVCAP) and Malaysia Industry-Government Group for High Technology (MIGHT) and ministries such as the Ministry of Science, Technology and Innovation were set up. For instance, SIRIM is involved in assisting industrial technological development as well as providing technical services for the industry, MAVCAP for commercialization and financing, while MIGHT (a non-profit organization) for promoting technology management and transfer.

SIRIM's primary objectives are to conduct R&D, contract research projects and to develop new innovations in product design and process development. Although some success is evident, the role of SIRIM is very much limited to the Klang Valley where SIRIM is located. Though few branches are available such as in Penang, industries generally do not consider them as the source of technology development due to the limited activities pursued by the branches. The distance discourages industries from establishing any kind of linkages with the headquarters. Except for the small and medium firms in the Klang Valley, which were the main beneficiaries, the others remain less connected with SIRIM. A survey on the electronics industry in Penang 2007 (Chandran et al., 2008) has revealed that the relevance of R&D institutions like SIRIM and the availability of venture capital for technological development was not viewed as important by most firms[8] (Table 6). This indicates that the potential impact of government and non-governmental agencies on technological development in firms is very limited. In other words, despite having a large number of government agencies to support them, the firms' access to programs that support innovative activities are still limited (Abdullah, 1996).

Table 6: Present Domestic Environment for Technology Development, 2006	**Mean Score**
Government incentives for innovation	2.46
Scientific/skilled manpower	2.55
Local universities for technical and R&D collaboration	2.17
R&D institutions for technical collaboration	1.77
Availability of venture capital	1.08

Source: Chandran et al., 2008 (Survey, 2007)
Note: Likert scale score (0-5 from none to highest rating)
N = 100

Other governmental agencies involved are the investment promoting agencies, which do not specifically engage in technological development directly, although their involvement is crucial as facilitators. In this aspect, although the Penang Development Corporation is seen as a vibrant agency in helping the facilitation of technological development, the evidence is still limited and only confined to Penang.

3.1.5 Institutions and policies

Within the MSI, institutional arrangements[9] in the form of formal regulations, legislation and norms influence the interactions of firms and other organizations (North, 1990; Hollingsworth, 2000). Additionally, the national innovation policy (e.g. science and technology policy) functions as a diffuser of the NIS by facilitating and enhancing the rate of innovation. For instance, the Bayh–Dole Act of 1980 from the US is seen as one of the factors that drives patenting activities among universities and the transfer of technology to industries (Mowery, Nelson, Sampat and Ziedonis, 2001). The manufacturing sector's ability to adopt know-how also depends on the general government policies related to investment and the more specific policies on technology and innovation issues (Tidd and Brocklehurst, 1999).

Despite outlining policies that address the issues of innovation and creativity within the industrial, science and technology areas the government has provided a wide range of

[8] This is indicated by the lowest scores for R&D institutions and venture capital

[9] Institutions are defined in many different ways by different authors. For detail explanations see Nelson (2008). In this study, institution refers to the rules governing innovation systems while policies are understood as guidelines that are or may be institutionalized.

incentives and programs. The next section reviews policy matters and other institutional arrangements in Malaysia and assesses the effectiveness of these instruments in promoting technological changes. Although several successes of policy instruments and programs are evident, the overall impact of these policy instruments appears to be limited.

In general, policies concerning the promotion of foreign direct investment have worked well in the case of Malaysia especially in attracting the relocation of foreign MNC manufacturing activities. However, the translated results of this in terms of technological transfer and technological learning among local firms have recorded limited success. Various programs are already in place to promote technological upgrading. The efforts to develop linkages between foreign and local firms are encouraged via the Vendor Development Programs initiated in 1988. This scheme was designed to encourage the exchange of technical and managerial information and expertise, as well as to enable the technologically advanced firms (usually foreign MNCs) to provide contracts to local firms. This is complemented by the Global Suppliers Program to develop SMEs to become international suppliers via the promotion of education and training programs. The main focus is in the acquisition of technological knowledge and skills and the strengthening of linkages between TNC subsidiaries and SMEs. The acquisition of technical knowledge is promoted via training courses guided by instructors from TNCs.

Additionally, the Industrial Linkages Program was launched in 1996 especially to target the upgrading of SMEs' technological level. Incentives in the form of pioneer status (five years tax exemptions), a 60 per cent tax exemption on investments for equipments in SMEs, tax reduction on costs related to training, auditing and technical assistance for large firms were given. The establishment of the Small and Medium Development Corporation (SMIDEC) to promote the development of SMEs in 1996 also follows this. SME promotion policies with regard to financing, technology and human resources development were the main activities of SMIDEC. However, in general, most of the assistance created for SMEs is out of reach of most firms and its poor management has led to the failure of these programs (Abdullah, 1999). Between 1988 and 1996, 94 vendors had been selected by the TNC subsidiaries. In the case of Penang, instructors from Agilent Technology, Intel, Motorola and others participated in the program. Through the PSDC, skills upgrading and technological knowledge transfer was phenomenal in Penang. TNC subsidiaries in Penang established greater linkages with local firms due to the effective support and coordination by the PDC, the PSDC and the state government (Rasiah, 1994, 1999, 2002). Although the effectiveness of these programs is notable in Penang, the same success story is not apparent in the other states. This is due to the failure of institutional factors to cater for them (Rasiah, 2002).

Funding for innovation is implemented through various grants and incentives. The schemes include the Technology Acquisition Fund (TAF), the Commercialization of R&D funds (CRDF), the Demonstrator Application Grant Scheme (DAGS), the Multimedia Super Corridor R&D Grant Scheme (MGS), the Industry Grant Scheme (IGS), and the Industrial Technical Assistance Fund (ITAF), while the incentives include tax exemptions for use of R&D services, construction of industrial building for R&D, and approved R&D projects (see Li and Imm, (2007) for the summary of R&D

incentives). 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.

Tables 7 and 8 show the amount approved by sectors and sectors that obtained R&D double deduction relief. It is apparent that although there are efforts in disbursing funds to encourage R&D, the overall amount is still below expectations.

Table 7: Cumulative approval and amount approved under ITAF 2 and ITAF 3 by sector, 2003 - 2005

Sector	Number of Projects		Amount Approved (RM million)	
	ITAF2	ITAF3	ITAF2	ITAF3
Services	1	3	0.1	0.04
Manufacturing related services	1	10	0.1	0.23
Paper and printing	2	23	0.06	0.52
Miscellaneous	1	35	0.07	0.91
Machinery and engineering	12	112	0.68	3.23
Transport equipment	14	62	1.36	1.6
Electrical and electronics	23	79	1.42	3.12
Mineral products	6	24	0.59	0.65
Non-metallic mineral products	4	9	0.52	0.22
Plastic products	17	68	1.04	1.68
Rubber products	2	19	0.1	0.5
Chemical products	15	42	0.86	1.05
Textile and apparels	1	16	0.05	0.46
Leather and leather products	0	9	0	0.22
Wood and wood products	4	10	0.1	0.2
Palm oil based products	2	5	0.2	0.14
Food manufacturing	7	157	0.37	3.46

Source: MOSTI, 2006b

Table 8: Leading Recipients of Double Deduction relief for R&D by industry sector 2002-2004

Sector	2002 (%)	2003 (%)	2004 (%)
Automotive & parts	72	54	65
Agricultural	6	6	7
Agrochemical	5	4	1
Electrical products	5	4	18
Tiles	2	-	-
Petroleum	1	-	1
Semiconductor	-	-	2
IT/telecommunication	-	8	-
Electrical components	-	8	-
Others	9	16	6
Total (RM million)	122.9	356.8	499.4

Source : MOSTI, 2006b

Lim and Imm (2007) reported the discouraging results of the incentive scheme where uptake from the relevant firms was limited. The reasons for the poor response include: rigid and vague compliance conditions of incentive awards; lack of firm's confidence in undertaking R&D; reluctance to reveal confidential information to the government, and limited facilities conductive for R&D including lack of expertise. Lim and Imm (2007) further suggest that the lack of direct policy and incentive schemes directed to firms as the major cause of the lackluster results of R&D activities among firms.

Scholars also attribute the limited success of the manufacturing sector in terms of technological upgrading to the general policies related to development and migration. Henderson and Phillips (2007) contend that the poor performance of the Malaysian industrialization process was due to the unintended consequences of the redistribution policy and an unfavorable migration policy. Additionally, the underdeveloped capability of the SMEs has contributed to the lack of an ability to link with the TNCs, especially in the knowledge intensive and higher value added activities. The limitation includes politically motivated issues related to entrepreneur development by race, lack of government efforts in encouraging productive activities and an unfavorable migration policy. Similarly, Ritchie (2005) argues that although Malaysian policies contributed to rapid economic growth, policies that encourage unproductive agents through the redistributive policy had retarded technological development in manufacturing. He further attributed the lack of technological development to the lack of attention to the quality of education (unequal opportunities among races and among the Malays as well, lack of opportunity to use skills acquired from abroad), ignored SME development, discontinuity of the institutional engagements and ignorance on issues of information exchange, investment appropriation, monitoring and enforcement. In sum, institutional and policy failures appear as major contributors to the lackluster results of technological development in Malaysia.

The discussion above suggests that government intervention in terms of policies do contribute to the progress of foreign investment, exports and to the overall performance of manufacturing firms. However, the spillovers with regard to technological progress are still very limited. While certain policies, incentives and programs have shown limited results others have not and have limited technological progress. Coordination, coherency and proper implementation of these policies are vital to promote technological change. Additionally, compared to Singapore (Mathews, 1999) limited success of leveraging from FDI in Malaysia and even differences in success between states in Malaysia have been the results of improper implementation and coordination of these policies (Rasiah, 2002). And more clearly, institutional failure translates into poor formulation of policies, coordination and implementation. Adding to this is the local socio-political structure differences.

3.1.6 Global Integration

A well-established global integration program can promote innovation. Scholars adopting the value chain (Gereffi, 1994, 1999; Kaplinsky, 2000; Humphrey and Schmitz, 2002) as well as fragmentation framework (Dedrick and Kraemer, 1998; Lowe and Kenny, 1999; Borrus, Ernst and Haggard, 2000) have highlighted the importance of insertion of local firms into the global value chain for technological upgrading. Additionally, the framework is seen as a viable alternative to study technological upgrading in developing countries. However, as a whole, the evidence shows limited participation of local firms in the global value chain due to the insufficient absorptive capacity of the local firms. Only limited success is noticeable in the case of electronics firms in Penang where many of the firms are well integrated globally. Evidence suggests that they have also established sales centers, and other supporting services in other countries. Indeed, with the presence of world class multinational firms, opportunities in terms of learning to access and reach the global market were made possible (e.g. Globetronics). Additionally, firms supplying to the OEM were well integrated with the global market especially with the US, Japan, Singapore and Europe although the integration is very limited in low value added services like packaging, and the like. The sectors (e.g. electronics) which is more export oriented is more successful in establishing global integration. And, the presence of significant foreign MNCs act as the catalyst for the global integration efforts. Learning from foreign MNCs is vital in forming global integration. Only firms that have learned substantially from MNCs were able to integrate globally when they started to expand their business activities. This provides room to search for new strategic partners, technology transfer, and other technological development activities.

4. Review of R&D and Innovative Activities in the Malaysian Manufacturing Sectors: An Analysis of Innovation Data and Literature

Tables 9 and 10 show that R&D investment and R&D investment as percentage to intermediate input purchases by sub-sectors. The R&D activity by sub-sectors varies. As depicted in Table 9, the R&D activities among manufacturing firms are still low where out of the 28257 firms only 9.1per cent (around 2563) engage in R&D investment. The examination of Table 9 shows that when sectors are ranked by their R&D investment, the four sub-sectors that have higher R&D spending are chemical and chemical products, radio, television and communication equipments, office, accounting and computing machinery and motor vehicles (Table 9). The high R&D investments in sectors like radio, television and communication equipments are due to the high foreign participation in these sub-sectors.

Table 9: Research and Development in Manufacturing, Malaysia, 2005

Sector	Total Establishment	Establishments with R&D	%	R&D (RM million)
Chemical and Chemical Products	893	205	22.96	810.2
Radio, television and communication equipments	426	121	28.40	564.7

Office, accounting and computing machinery	67	24	35.82	436.1
Motor vehicles, trailers and semi trailers	304	47	15.46	253.7
Machinery and equipment n.e.c	1164	136	11.68	78.7
Rubber and plastic products	1815	317	17.47	56.8
Food products and beverages	4372	401	9.17	29.9
Electrical machinery and apparatus n.e.c	474	73	15.40	22.9
Other non-metallic mineral products	1260	126	10.00	20.2
Other transport equipment	271	21	7.75	12.0
Others	17211	1092	6.34	78.1
Total	28257	2563	9.1	

Source: DOS, 2006

R&D investment as total intermediate input purchase shows that the range of R&D investment in Malaysian manufacturing is below 2 per cent. This means that in average R&D investment in Malaysia did not exceed 2 per cent with the lowest being 0.04 per cent, in industries where Malaysia has lost its competitive advantage due to the new emerging markets that serve as the low cost production sites. Differentiating R&D investment by sectors also indicates that the more capital intensive industries to have a higher investment rate in R&D while the resource-based and labor intensive sectors such as textile, furniture, food to have a lower R&D investment rate (Table 10).

Table 10: R&D Expenditure as a percentage of total intermediate input, 2005

	R&D %
Food and Beverages	0.04
Tobacco products	0.06
Textiles	0.03
Wearing apparel; dressing and dyeing of fur	0.10
Footwear and Tanning/dressing of leather	0.04
Wood products	0.05
Paper and paper products	0.19
Printing, publishing and recorded media	0.16
Coke and refined petroleum products	0.01
Chemicals and chemical products	1.92
Rubber and plastic products	0.19
Non-metallic mineral products	0.19
Basic metal industries	0.03
Fabricated metal products except machinery and equipments	0.05
Machinery and equipments n.e.c	0.56
Office, accounting and computing machinery	0.78
Electrical machinery and Electronics	0.19
Radio, television and communication equipments	0.46
Medical, precision and optical instruments, watches and clocks	0.22
Motor vehicles, trailers and semi trailers	1.30
Other transport equipment	0.20
Furniture and fixtures	0.05
Manufacturing n.e.c and recycling	0.30

Source: DOS, 2006

Since many manufacturing industries in developing countries are involved in incremental innovation, the proxies of R&D spending is inappropriate to reflect the level of innovative activities among the manufacturing firms (Hobday, 2005). For this purpose, to illustrate the actual level of innovation among Malaysian manufacturing firms, the survey data of the National Survey of Innovation 2002-2004 conducted by MOSTI is utilized. Table 11 depicts both process and product innovation. Based on the survey data, incidences of innovation were higher in sectors like radio, television and telecommunication equipments and textiles sub-sectors while wearing apparel, coke, refined petroleum and non-metallic minerals sectors record lower incidence of innovation (less than 40 per cent). Distinguishing innovation by types, the results show that in sectors like rubber and plastic, chemical, food and beverages and electrical machinery, a large number of firms reported carrying out both, product and process innovation.

Table 11: Incidence of innovation by sector

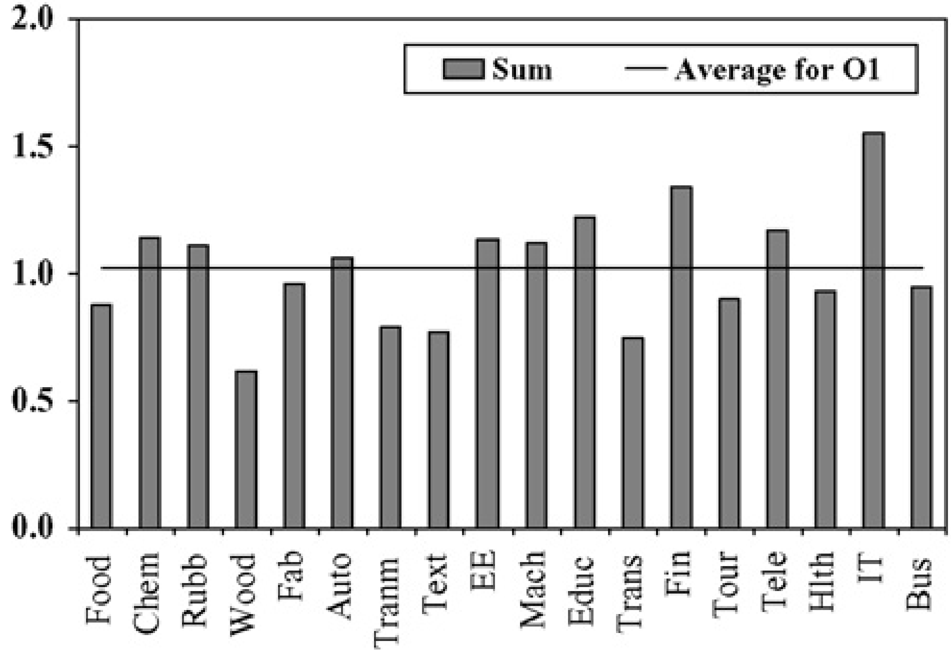
Industry	Innovating Firms (%)	Process Innovation	Product Innovation	Product & Process Innovation
		Number of firms		
Food and beverages	46	3	8	27
Textiles	73	-	10	16
Wearing apparel	29	-	-	11
Tanning and dressing of leather	62	4	3	14
Wood	55	2	2	17
Paper	56	2	2	10
Publishing and printing	41	4	1	12
Coke, refined petroleum and nuclear fuel	25	-	-	-
Chemical	57	2	4	20
Rubber and plastics	62	4	3	24
Non-metallic mineral	32	-	10	20
Basic metals	58	2	-	14
Fabricated metals	56	4	3	15
Other machinery and equipment	47	1	2	17
Office, accounting and computing machinery	63	1	-	2
Electrical machinery	57	10	-	19
Radio ,television and communication eq.	76	2	11	13
Scientific equipment, watches and clocks	67	1	-	8
Motor vehicles ,trailers and semi trailers	71	1	-	5
Other transport equipment	50	1	2	18
Furniture	43	2	3	15
Recycling	67	10	-	-

Source : MOSTI, 2006a

A small number of firms reported that they carry out only product or process innovation except for radio, television and communication equipments, food and beverages, and other non-metallic and textile where product innovation is dominant. The main sources of innovation for these companies are clients or customers and suppliers. Although most of the research grants are provided to public research organizations it is surprising to find that research organizations contributed very little. Indeed, this shows the failure of research organizations in establishing networks with the industrial sector. Many of the innovative companies also indicated that they did not receive sufficient government support, assistance and incentives. This may further indicate the need to investigate the effectiveness of the government's support mechanisms in enhancing the innovative capabilities of the firms. It is also claimed that factors such as high cost of innovation, lack of skilled personnel, lack of information on technology and appropriate markets to be the major factors hindering innovation.

Shapira, Youtie ,Yogeesvaran and Jaafar (2006) undertook a survey on knowledge-based innovation and suggested that generally in the manufacturing sectors in Malaysia, the knowledge content is modest. Their findings revealed that foreign owned firms have a higher median score of knowledge measure of 10.8 compared to 8.1 for domestic firms. Additionally, most foreign owned firms conducted R&D and provided training for employees. In the manufacturing sectors (except for E&E, machinery, chemical, rubber and automotive sectors which have values above the industry average, however only marginally) it was found that knowledge generation is typically low. This signifies a lack of innovation (Figure 2) which can be explained by the fact that most firms in this sector acquire knowledge solely by adapting and adopting foreign technology (Shapiro et al, 2006). The result of logistic regression indicates the existence of a significant association of the knowledge content measures (at least one measure) and technology innovation. More importantly, external linkages were found to be positively significant in explaining the variations in technology innovation.

Figure 2: Innovation in Manufacturing and Services sector, 2003.



Source: Shapira, Youtie ,Yogeesvaran and Jaafar (2006).
Note: Innovation indicators include the introduction of new and improved product, process and managerial innovations.

Narayanan and Wah (2000) argued that FDI via MNCs has largely played a role in the rapid development of manufacturing sectors, and in particular for the increased share of high-technology exports in Malaysia. They identified that MNCs have transferred the know-how in production practices. They further argue that in the Malaysian manufacturing sector local firms were able to perform operational related functions such as production process, maintenance work, repairing and modifying machineries (incremental innovation)[10]. Despite the progress in incremental innovation, limited evidence is available on the transfer of R&D activities. It is argued that R&D levels (especially product innovation) in the Malaysian manufacturing sector are far below the maturity of the manufacturing industrial structure. The factors attributing to the lack of internationalization of R&D activities in the Malaysian manufacturing sector are skill formation within the MNCs, lack of public sector participation in industry-linked research, reliance of R&D activities on the interest of MNCs headquarters abroad, limited local R&D capabilities, less demanding technological content activities (assembly and testing in the case of electronics), and poor organizational support[11].

Focusing on three manufacturing sub-sectors of Malaysia, the automotive, telecommunications and home electronics sectors, Noori (1999) assessed the implementation of the advanced manufacturing systems (AMS). Results show the use of a wide range of flexible automation like CAD, CNC, and robotics in manufacturing. However, the implementation of AMS by these firms were at their maturity stage suggesting that majority of the firms are still employing older technologies. External sources were found to be important in the adoption of AMS. Additionally, despite having firms that agreed that they invested in new technologies (most of the firms appear to move forward in their technological trajectories), there is no minimum engagement in higher value-added activities such as designing and engineering. Foreign owned firms were only involved in matured products that required stable processes (Noori, 1998).

Within the electronics sector, Ariffin and Figueiredo (2004) found that leading electronic firms had moved substantially into the higher level of technological capabilities involving capabilities to generate and manage technical changes (Level 4 and 5 using Lall's technological taxonomy). All the 53 firms mastered the basic process and production functions, product engineering and capital equipment, tooling and moulding. The upgrading of technological activities and transfer of more R&D related activities to TNC subsidiaries in Malaysia were found to be strongly associated with greater autonomy for local decision-making, automation level and exports. Limitation of the TNC's innovative activities is still prevalent in areas of advanced level of product development and R&D. These activities still remain in corporate R&D centers in advanced countries.

Hobday (1996) found a substantial amount of incremental innovation activities among TNC subsidiaries in Malaysia particularly during 1980s (Table 12). Table 12 depicts that within the electronics industry Singapore has far exceeded Malaysia in terms of technological progress where significant R&D is required. Consequently, more TNCs view Singapore as a potential technological support hub of the region. Hobday (2003) noted that the progress in technological transfer in manufacturing is primarily to enable

[10] Based on the survey of 64 firms in Malaysia, 78.1% able to undertake operational activities, 71.8% maintenance, 60.9% repair and modification independently. However, only 4.7% were able to undertake R&D activities. In the paper, similar results is also reported in the transfer of technology in Japanese firms in Malaysia. Lack of design, production and equipment development were reported based on the study of Yamashita (1991) –cited in Narayanan and Wah, 2000)

[11] E.g. education, liberalized policies in attracting foreign expertise and Malaysians from abroad, lack of supervision and coordination of the technological upgrading process

exports (in support of the export-led growth). The start-up of plants, expansion of existing investment and upgrading efficiency and products were primarily caused by the need to be export oriented. This has motivated TNCs to acquire higher manufacturing process skills, product design capabilities (however limited), and to be involved in process improvements and adaptation. The study shows that radical and R&D based innovation is still lacking in the manufacturing sector. The motive for technological transfers among TNCs is driven by the need for rapid and efficient expansion of capacity. Among others, the local firm's capabilities are seen to be an important ingredient for the successful transfer of TNCs' technology stressing that without local capability building, technology transfer would never occur.

Table 12: Stages of Technology Development in ASEAN-5

	Malaysia	Singapore	Thailand	Indonesia	Vietnam
1960s		Assembly			
1970s	Assembly	Process Engineering	Assembly		
1980s	Process Engineering	Product Development	Assembly	Assembly	Assembly
1990s	Product Development	R&D	Process Engineering	Process Engineering	Assembly

Source: Hobday, 2003

Giroud (2000, 2003) analyzed knowledge transfer between Japanese subsidiaries and their local suppliers in the electrical and electronics sectors in Malaysia. The most significant transfer of knowledge occurred in product and process technology. The product technology transfer involved product specification and physical/technical specification transfers. The process technology knowledge transfer involved the supply of tools and the provision of information on technical information and input procurement. This provides evidence for technological learning by local firms via the interaction of foreign subsidiaries in Malaysia.

5. R&D Activities and Capabilities in Foreign and Local Manufacturing Firms

Based on the National Innovation Survey dataset, it is found that local firms recorded a higher percentage of non-innovating firms (67.4 per cent) while for majority local owned firms the differences are marginal (Table 13). On the contrary, the results indicate that foreign firms were largely involved in innovation where the proportions of foreign innovating firms (21.1 per cent) are twice the proportion of non-innovating foreign firms. This indicates that out of the total number of firms by ownership, foreign firms are more likely to be involved in innovation. In terms of R&D expenditure, foreign firms were found to have contributed 43.7 per cent out of the total R&D spending of 2032.6 of the manufacturing sector (Table 13).

Table 13: Innovation and R&D Spending by Ownership

Ownership	Non-Innovating	Innovating	R&D Expenditure (Percentages)
Local Owned (100%)	67.4	58.2	541.1 (26.6)

Majority Local Owned (less than 100%)	10.3	14.9	394.2(19.4)
Foreign Owned (100%)	11.6	21.1	888.4(43.7)
Majority Foreign Owned (less than 100%)	6.3	5.4	208.9 (10.3)
Missing Value	4.5	0.4	-
Total	100	100	2032.6

Source: MOSTI, 2006

By examining the patent application trend of Japanese, European and US MNCs operating in Asia, Belderbos (2006) found that R&D activities in Asia by these MNCs are still limited, although there has been a continuous increase over the years. The findings show that in Asia the leading performers are electronic firms where multinationals are still responsible for a sizeable share (between 20 per cent to 50 per cent) of host country patenting activities, especially in Singapore, Thailand, India and Malaysia. However, in South Korea and Taiwan the influence of MNCs is negligible. This indicates that in Malaysia and other ASEAN countries, although limited, the MNCs dominate R&D activities. Recognizing the lack of R&D inside local firms, leveraging from MNCs is a viable option for local firms to pursue and improve research capabilities. However, efforts to create linkages and integration with MNCs are vital to benefit from the spillovers of MNCs. Noor, Clarke and Driffield (2002) found that linkages with MNCs influence a local firm's decision to get involved in technological efforts.

Rasiah (2003) found that in general, foreign firms have better product and process technology and human resources capabilities in Malaysia. However, sectorial analysis (semiconductor, consumer electronics, computer and peripherals and PCB and low assemblies) on different proxies of innovative activities indicates mixed results. With the exception of semiconductors local firms were found to conduct more product development activities, while foreign firms engage in more in-house process R&D. In terms of R&D personnel, local firms dominate in consumer electronics while foreign firms dominate in semiconductors, PCB, and other low added activities. R&D activities[12], although limited, were more dominant in foreign firms. It is also found that overall, the R&D capability is still low among Malaysian manufacturing firms. Comparing four countries, Taiwan, Malaysia, Thailand and Korea, Rasiah (2004) found the technological intensities and R&D intensities of foreign owned firms to be higher than local firms in the Malaysian sample. Additionally, the process technological capabilities of foreign firms were also found to be higher among the foreign firms. Rasiah (2004) further highlighted the failure of the sectorial targeting Industrial Master Plan launched in 1986 and the Action Plan for Industrial Technology Development in uplifting the technological capabilities of local firms. The plans did not emphasize human capital development, inter-firm and institutional coordination.

Cassey and Ging (2007) used the National Innovation Survey datasets to analyze innovation activities among SMEs in the manufacturing sector. They found that foreign ownership was not a significant determinant of innovation. This means that within the SMEs, there are no apparent differences in innovative activities among foreign-owned SMEs and locally-owned ones. They found that within the small-sized firms, younger

[12] R&D expenditure over sales

firms were more innovative. Likewise, within the medium and large-sized firms, older firms with higher market concentration were likely to have a higher probability to innovate.

Although Malaysia's efforts to develop products and design R&D is better than Thailand's (Lall, 1999), it is still limited. Owing to the long historical development of the primary sectors (e.g. palm oil and rubber), R&D in Malaysia in these sectors are at the frontier. An increasing number of innovative activities are observed in these sectors where it is primarily conducted by PORIM, RRI and MARDI. However, except for process innovation (Bell, et al., 1995; Hobday, 1996; Rasiah, 1994) there is limited evidence of moving the innovation frontier, especially in product R&D in other sectors. Evidence shows that in other sectors, process innovation is rampant while product innovation is low. Moreover, many of these innovations come from foreign-owned firms who are export-oriented and large, and not among the local firms or SMEs that support the MNCs.

Although studies report that foreign firms undertake a significant amount of research compared to local firms, the results of who undertakes R&D are mixed depending on sectors, types of innovation, and location. In electronics, foreign firms were found to undertake a significant amount of research compared to local firms, but equally important, when different types of innovation are considered, local firms were also found to be significantly conducting process innovation (Rasiah, 1994; Hobday,1996; Ariffin and Figueiredo, 2004). While spillovers in Penang are greater, other industrial areas such as in Johor do not record a significant amount of technological upgrading. The differences in technological upgrading greatly depend on the institutional support, the presence of MNCs (e.g. Penang has a significant number of committed MNCs with long history of establishment), pool of skilled workforce, and presence of infrastructure as well as the active role of entrepreneurship. However, the manufacturing industries in Malaysia still suffer from R&D deficiencies that slow the movement into higher value-added activities. Indeed, compared to the scale of operations of MNCs, commitment to R&D by foreign as well as local MNCs[13] is still below par. However, among the important drivers of innovation the manufacturing firms still depend on the role played by the TNCs in uplifting the innovation content of the sectors, especially within TNCs but also among local firms.

6. Discussion and Conclusion

In developing countries technological upgrading is a major challenge. The observation made via the manufacturing systems of innovation framework suggests that the internationalization of MNC activities provide the needed catalyst for developing countries to upgrade its technological capabilities. Examining the Malaysian manufacturing innovation systems clearly show that technological learning among firms

[13] Few MNCs especially US MNCs relatively performs R&D in Malaysia e.g. Intel located its design center for microprocessor, while Motorola established its R&D center for cordless telephone. Others include Komag - for advanced process development activities and Matsushita - for R&D center for air-conditioners (see Hobday, 1996 for other forms of innovative activities by local and foreign firms)

occur through inter-firm linkages with MNCs and other global players e.g. via global integration, while other sources and agents play a very limited role. Similarly, the drive to be more competitive in export markets has encouraged TNCs to outsource part of their activities while specializing only in core activities. Likewise, past research strongly suggests that among the more significant mechanisms of technological progress in Malaysian manufacturing innovation remain in the context of sub-contracting or linkages (especially with the TNCs and other MNCs), technological transfer, strategic alliances, OEM manufacturing, outsourcing and FDI. Hence, local firms' interaction with these multiple sources (especially within the manufacturing actors – TNCs and MNCs) can lead to accumulation of knowledge and provide opportunities for production and technological upgrading as well as innovation. Benefiting from the technological and knowledge spillovers of TNCs requires linkages (Cantwell, 1989; Halbach, 1989; Giroud, 2001; 2003, Rasiah, 1996; Hansen and Schaumburg-Müller, 2006). The backward linkages have benefited the manufacturing sectors in Malaysia (Narayanan and Wah, 2000). In this aspect, Iguchi (2008) identified that in the case of electronics and electrical sub-sectors considerable linkages are created, especially in Penang. Hence, analyzing outsourcing activities at product level and the benefits such linkages offer is of vital importance in unpacking the technological black box of the developing nations' technological upgrading and innovation activities. Leveraging through FDI (Mytelka and Braclay, 2004; Narula, 2004; Hobday 1995, Mathews, 2006), insertion into global production networks (Ernst and Guerrieri, 1998; Henderson, 2002; Ernst and Kim, 2002; Sturgeon, 2002) or global value chains (Gereffi, 1994; Kaplinsky, 2000; Humphrey and Schmitz, 2002; Giuliani et al. 2005; Gibbon, 2001; Altenburg, 2006; Morrison et al. 2008) has offered the current path to analyze and explore how firms in developing countries learn, upgrade technological and innovative capabilities. Hence, this study offers an analysis and empirical evidence on the role of outsourcing and internationalization of R&D activities of foreign MNCs in upgrading the technological and innovative capabilities of local firms in the Malaysian manufacturing sector.

However, as a whole, Malaysia has not been chosen as a site for off-shoring or outsourcing of R&D activities to a significant degree. Product and process development are conducted in certain industries by foreign subsidiaries and may be on the rise in the key electronics industry. However, R&D strong-holds in Malaysia have so far mainly evolved in the natural resource-based industries with local and foreign ownership, and not in the manufacturing sector. The Malaysian manufacturing systems of innovation have been weak and failed to provide the necessary preconditions for MNCs to tap into the local R&D infrastructure. And, with a few exceptions, local firms have not (yet) built absorption capacities to learn and upgrade from foreign linkages in a systematic and collective way.

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