CHAPTER 3 – OVERVIEW OF MALAYSIAN INDUSTRIALIZATION AND THE DEVELOPMENT OF THE PETROCHEMICAL INDUSTRY

3.1 Introduction

This chapter presents a brief summary of Malaysia's industrialization process and the development of the country's petrochemical industry. It outlines the characteristics of Malaysian manufacturing industry, the various phases of the Malaysian government's industrialization drive, and the impact of the industrialization policy on the development of the manufacturing capability of local firms. The chapter discusses the role of MNC subsidiaries and local firms in the industrialization process and the role of the government in encouraging both MNC subsidiaries and local firms to embark on technological activities in manufacturing industry, especially in the capital-intensive petrochemical industry. It then gives a preview of the development of the petrochemical industry in Malaysia. The chapter closes with a discussion of previous research work on technological capability building in Malaysia.

3.2 Industrial Development in Malaysia

In the forty years following independence, Malaysia adopted two economic policies and two industrialization strategies that were instrumental in the country's journey towards industrialization (Okposin et al., 2005). The two economic policies were the New Economic Policy and the National Development Policy, and the two industrialization strategies were the Import Substitution Industrialization (ISI) strategy and the Export-Oriented Industrialization (EOI) strategy. According to Okposin et al. (2005:43), the key to the success of the ISI and EOI strategies was the 'Malaysia Incorporated' policy, introduced in 1983, which emphasized public-private sector relationships. The resulting partnership between the public and private sectors helped to reengineer the business environment in the 1980s and 1990s. With the partnership in

place, a strategy for upgrading and stirring the country's economy to new heights was developed. The strategy is based on Vision 2020 (promulgated in 1990), which promotes knowledge-based industries in order to add value to products with export potential. The Malaysian government has given high priority to export-oriented firms that are more knowledge-intensive than production-intensive, so as to transform the country's manufacturing in the direction of high-tech and knowledge-based industries.

3.3 Strategies for Industrialization in Malaysia

The industrial strategy adopted since independence can be classified into six phases (Noor, 1999; Ariffin, 2000; and MITI, 1996). These phases, which are not mutually exclusive and which indeed overlap one another, are summarized in Table 3.1 (see following page). They are discussed in detail in the following sections.

First Phase: The Pre-independence Period (prior to 1957)

The economy of colonial Malaya was based predominantly on the primary sector, which consisted of agriculture and mining. Primary industries generated 45.7 percent of GDP, as well as 61.3 percent of employment (Lim, 1994, Okposin et al., 2005). The MNC subsidiaries of the time belonged to the British Empire and were involved in the production of rubber and tin. Most of the rubber and tin produced was exported in the form of raw commodities, and between them rubber and tin made up more than three-quarters of all exports. The manufacturing sector contributed only marginally to the Malayan economy (Okposin et al., 2005). Only 10 percent of the workforce and 11 percent of the economy were involved in the manufacturing sector at that time (Von der Mehden and Troner, 2007).

Second Phase: The Import Substitution Industrial (ISI) Strategy

After independence in 1957, the Import Substitution Industrial (ISI) strategy was implemented under three five-year economic development plans: the First Malaya Plan (1956-60), the Second Malaya Plan (1961-65) and the First Malaysia Plan (1966-70). The ISI industries were mainly established to cater for the domestic market. A predominant feature of the policy was its emphasis on the promotion of industrial development via the private sector, and FDI was given a pivotal role in the process.

Table 3.1: Phases of Industrial Development in Malaysia

Phases	Industrial Strategy	Policy	Objective/Emphasis
Phase I	Pre-independence Before 1957	None	To increase the production of primary commodities.
Phase II	First-phase Import Substitution Industrial (ISI) strategy 1957-1967	Pioneer Industries Ordinance Act 1958	To diversify the economy, reduce imports and generate employment.
Phase III	First-phase Export Oriented Industrial (EOI) strategy 1968-1980	- Investment Incentives Act 1968 - Industrial Coordination Act 1975 - Free Trade Zone	To diversify the manufacturing sector, create linkages and employment. - emphasis on electronics and textiles for export.
Phase IV	Second-phase Import Substitution Industrial (ISI) strategy 1981 onwards	- Heavy Industrial Policy 1981 - Look East Policy 1981	To create linkages in the manufacturing industry. To reduce imports of intermediate and capital goods. - Domestic market oriented.
Phase V	Second-phase Export Oriented Industrial (EOI) strategy 1986 onwards	-IMP1 (1986-1995) -IMP2 (1996-2005) -IMP 3 (2006-2020)	To increase manufacturing linkages and competitiveness. -Resource-based industries and encouragement for exports.
Phase VI	Knowledge economy Late 1990s onwards	Multimedia Super Corridor (MSC)	To move higher skilled knowledge-intensive economy.

Source: Adopted and modified from Noor (1999), p 12; Arrifin (2000), p. 48, and MITI (1996)

During this phase, the import of technologies from industrialized countries was preferred. As a result, firms were required to possess the necessary technological capabilities. They needed highly skilled labor and the support of a strong R&D facility.

The major instruments to support this phase of industrialization were tax exemptions, establishment of industrial estates, provision of necessary services and infrastructure, and imposition of tariff protection. In the case of tariff protection, the Customs (dumping and subsidies) Ordinance was introduced in 1959 to protect domestic industries against unfair competition.

The ISI strategy broadened the country's emerging industrial base, expedited the diversification of the economy, reduced excessive dependence on imported products, utilized domestic natural resources and created employment opportunities (Okposin et al., 2005). However, it was realized that the strategy had its limitations (Jomo and Edward, 1993; and Fong, 1986). Studies show that when the ISI strategy was carried out through implementation of tariff and non-tariff protection of the domestic market, imports of manufactured goods during the period 1963-1968 rose more rapidly than exports of manufactured goods (Okposin et al., 2005). The ISI strategy also failed to absorb the economy's excess labor, leading to relatively high unemployment levels and subsequent political instability. Moreover, foreign companies operating during this phase were generally producing consumer products with technologies imported mainly from their parent companies. This was encouraged by the exemption from customs duties given to imported capital equipment and machinery.

Third Phase: The Export-Oriented Industrial (EOI) Strategy

The government realized that Malaysia had a relatively small domestic market. Consequently, with the relocation of the international semiconductor industry (electronic and electrical industry) from industrialized countries to developing countries in the 1970s, it embarked on the Export-Oriented Industrialization (EOI) strategy. This third phase of the industrial strategy ran from 1968 to 1980 and saw the enlargement of

the industrial base and the encouragement of exports. The import of capital equipment and machinery was continued on a more selective basis, but the EOI strategy was still heavily dependent on foreign inputs.

During this phase, FDI was further encouraged through the Investment Incentive Act 1968, the establishment of an Export Processing Zone (EPZ) and the restriction of labor unionization to attract MNCs looking for low-cost production sites. Incentives were given to foreign companies through the Act to encourage more FDI into export-oriented activities (Kanapathy, 1997). The incentives included investment credits, tax concessions for export, tax exemptions, tariff exemption on raw materials, and preferential treatment for import permits and other infrastructure facilities. Since cheap and docile labor was important to maintain competitiveness in labor-intensive industries, MNCs were allowed to set special strict regulations limiting workers' rights. All these incentives were given to investors to ensure efficiency and competitiveness for export-oriented activities.

The success of the EOI strategy is attributed to: 1) full use of the country's labor supply;

2) the use of simple technology in the processing industry; 3) making use of the country's natural resources; and 4) making use of light industry in the manufacturing sector (Chee, 1987). But despite its success, the EOI strategy did not create the necessary linkages between MNC subsidiaries and local industries (MIDA/UNIDO, 1986:15). The export-led growth came primarily from MNCs seeking low-cost locations, rather than from local firms seeking market opportunities for exports. Besides, the EOI strategy created a tight labor market. Export expansion was primarily based upon relatively labor-intensive industries such as the electronics and electrical industry and the textiles and apparel industry. These industries limited the country's capacity for further technological development of indigenous industries. As a

consequence, the industrial structure became dualistic in nature. It comprised of import-substitution industries and export-oriented industries, with few substantial inter-industry linkages being nurtured. This development led the Malaysian government to shift from labor-intensive and investment-driven industrialization to productivity-driven industrialization. This shift is described in the next section.

Fourth Phase: The Import Substitution Industrial (ISI) Strategy II

As a result of eroding competitive advantage in labor-intensive industries, the Malaysian government in the early 1980s embarked on a heavy industries program. Known as the second phase of the ISI strategy, it was expected to create better linkages with the local economy, especially through the utilization of natural resources. This phase started in 1981 with the launching of the Fourth Malaysia Plan (1981-1985). The important strategy in this phase was the promotion of heavy industries. Public sector investment in an ambitious heavy industrialization program led to the establishment of the Heavy Industries Corporation of Malaysia (HICOM) and a strategy of large-scale production for export.

The development of heavy industry was based on the need to: 1) reduce imports of capital and intermediate goods in order to sustain the growth process; 2) generate supporting industries to promote forward and backward linkages in the manufacturing sector; and 3) emulate the experience of Korea and Japan in developing strong heavy industries for industrial success (Lim, 1994, Lin, 1994). Furthermore, the heavy industries were promoted to encourage greater inter-industry linkages.

This second phase of ISI emphasized changing labor-intensive industries to be more capital- and technology-intensive. Such industries included machinery, steel, cement, automotive, petrochemicals and other resource-based industries in which Malaysia was

expected to develop comparative advantages (Okposin et al., 2005). These heavy industries provided a base for developing indigenous technology and the development and acquisition of skills that could be utilized in other industries.

To achieve its heavy-industry objectives, the Malaysian government added further tariff protection in the form of import duties on priority items, as well as protection through price control, import restrictions, duty exemptions and other investment incentives under 'pioneer' status. However, the development of heavy industries was not complemented by the expansion of indigenous technological capability. The scope for generating supporting industrial activities was not fully exploited (Anuar, 1992:20-30). In the case of the automobile industry, the automotive company still had to import a substantial number of its components from Japan. In addition, the level of protection for the motor vehicle assembly and cement industries was so high that, without it, these industries would not have survived (Edwards, 1990).

Fifth Phase: The Export-Oriented Industrialization (EOI) Strategy II

Under the second phase of the EOI strategy, the Industrial Master Plan I (1986-1995) was launched in 1986 (MITI, 1986). IMP1 provided the framework for the development of the manufacturing sector. It provided a long-term plan for the development of specific sector and policy measures for the period 1986-1995. It saw concentration on two major industries in Malaysia, namely electronics and electrical, and textiles. IMP1 focused on technology and stressed the importance of science, technology and human resource development in supporting the industrialization process. The government continued its effort to attract FDI by modifying the conditions of foreign ownership through the introduction of the Investment Promotion

Act 1986 to replace the 1968 Investment Incentives Act. The new Act provided a wider range of incentives for investments in manufacturing, agriculture and tourism.

The importance of technology was explicitly mentioned in the Fifth Malaysian Plan (1986-1990) and IMP1. IMP1 was implemented to target activities for strengthening comparative advantage, and the emphasis shifted towards a more selective strategy (Lall, 1996:157). The objectives of IMP1 were the promotion of the maximum utilization and efficiency of the nation's natural resources and an increase in indigenous technological capability and competitiveness (MITI, 1986:356). IMP1 recognized that the main technology transfer channel was through MNCs operating in the country (MIDA/UNIDO, 1986:15-24). However, technological competence in Malaysia was still largely constrained by local inability to understand fully the operational practices of MNC subsidiaries' technology (MIDA/UNIDO, 1986:15).

In 1990, the Malaysian government launched the Action Plan for Industrial Technology Development, based on IMP1, to ensure a more diversified and integrated manufacturing sector. With the Action Plan, the government continued its effort to attract foreign investment by modifying the conditions of foreign ownership. In terms of equity participation, foreign investors were allowed to hold up to 100 percent equity in a firm if it exported 80 percent or more of its production; for firms exporting between 51-79 percent of their production, foreign equity ownership of up to 51 percent was allowed; for firms exporting between 20-50 percent of their production, foreign equity ownership of between 30-50 percent was allowed; and for firms producing products that were highly technology-intensive and were regarded as priority products for the domestic market, foreign equity ownership of up to 51 percent was allowed.

These changes increased the flow of FDI into Malaysia. As a result of the various efforts by the government, rapid economic growth was experienced in the first half of

the 1990s. However, the failure to develop sufficient domestic linkages resulted in the growth of industries with a high import content both in capital formation and in industrial output. Thus Malaysia saw that it needed to avoid FDI that had low potential for linkages with the local economy. This presented a great challenge for the government, as MNCs' interests were not always in line with those of the host government (MITI, 1996).

Utilizing a broader perspective, IMP1 provided a long-term indicative plan for the development of specific sub-sectors, and it focused on policy measures and areas that required special emphasis. It tried to broaden Malaysia's industrial base and promote the development of local firms. However, by the end of IMP1 in 1995, Malaysia's manufacturing sector was still narrowly based and MNCs were still the main source of growth (MITI, 1996:9). Specifically, efforts were still needed to diversify the manufacturing sector and enhance manufacturing linkages and local technological capability.

In the mid-1990s industrial policy was adjusted to focus on total factor productivity growth, which requires strong synergy among all factors of production. The government introduced the Second Industrial Master Plan (1996-2005) (MITI, 1996). Through this plan, the government was able to put the focus on increasing technological capabilities by increasing manufacturing linkages and competitiveness.

IMP2 was thus basically a continuation strategy of IMP1, but with the focus on building an integrated industrial development that encompassed both manufacturing and business support services (MIDA/UNIDO, 1986: 101). IMP2 addressed the need to develop indigenous technology and capability, which are crucial in developing linkages between MNC subsidiaries and local firms. Also included in the IMP2 strategy was the aim to increase firms' competitiveness by being truly global, rather

than merely export-oriented. IMP2 envisaged a transition to "more automated operations involving high technology and knowledge-driven processes" (MITI, 1996:63). It aimed at a transition from labor-intensive to knowledge-intensive industries, as can be recognized in the requirement that the manufacturing sector should develop a global marketing capability. Recognizing the importance of MNC subsidiaries, IMP2 also identified strategies for increasing the role of local firms in the ongoing industrialization process. Networks were clearly perceived as key elements of transition. "The IMP2... focuses on the cluster-based industrial development approach [to] improve on the existing industrial foundation of the manufacturing sector. It will further strengthen industrial linkages both in terms of depth and breadth at all levels of the value chain" (MITI, 1996:30).

IMP2 expected that MNC subsidiaries would continue to be the main source of new technologies. The Malaysian government's strategy included: 1) Developing the value chain by encouraging MNCs to shift to more sophisticated operations in Malaysia; 2) Deepening the supply chain through the development of capabilities in domestic firms; 3) Moving to a higher technology plane through the acquisition and development of technological capabilities; 4) Developing the information technology (IT) and multimedia industries; and 5) Developing world-class Malaysian-owned companies in this context (Best and Rasiah, 2003; MITI, 1996).

The essence of the new growth strategy was a shift from assembly-intensive manufacturing to an integrated, industry-wide approach encompassing both manufacturing and related services (MITI, 1996:30). Dubbed 'Manufacturing ++' or 'manufacturing-plus-plus,' this strategy provided the framework for industrial development under IMP2. With IMP2, industrial development strategy shifted from the traditional industry-based approach to a cluster-based approach. It aimed to

develop dynamic industrial clusters and strengthen industry linkages, while promoting higher value-added activities.

As for the chemical industry, which was categorized into petroleum and petrochemical, pharmaceutical and fine chemical sectors, IMP2 specifically emphasized its integration with other manufacturing groups to strengthen industrial linkages and increase its productivity and competitiveness.

Under IMP2, Malaysia expected manufacturing's share of GDP to peak at 38.4 percent. Based on the experience of developed economies, a manufacturing share of about 30 percent is generally regarded as the optimum growth level. Thus Malaysia found that it needed to transform its economy to a service-led one. Hence, in 2005 the Industrial Master Plan III (2005-2020), a new policy initiative to diversify the economy into new growth sectors and also into high value-added services industries, was introduced (MITI, 2005).

Sixth Phase: Knowledge Economy Industrialization

To transform the country into a service-led economy, Malaysia promoted information technology (IT) and multimedia industries as the new sources of economic growth (Okposin et al., 2005). In 1996 the National Information Technology Agenda was formulated to provide the framework for the coordinated and integrated development of skills and infrastructure, as well as IT-based applications. Just as the Malaysian government had earlier promoted the Free Trade Zone, the Multimedia Super Corridor (MSC) was launched as a catalyst to expand the IT and multimedia industries. As part of this transformation, the government also wanted to attract Export-Oriented Industries firms that were more knowledge-intensive than production-intensive, in order to form a knowledge-based economy (K-economy).

3.4 The Development of the Hydrocarbon Industry in Malaysia

Oil was first found in what is now Malaysia by local people in Sarawak's Baram district in 1882 (Shell, 1985). The oil was initially used for medicinal purposes and later as fuel for lamps and also for waterproofing boats and roofs. The British Resident of Baram, Claude Champion de Crespigny, recorded in his diary the discovery of Minyak Tanah or 'Earth Oil' in some 18 wells that the local people had dug by hand. He made his report to the British Rajah of Borneo, but nothing was done until the arrival of his successor, Charles Hose, two years later. It was only in 1904 that Hose obtained the Rajah's permission to show his findings to the Anglo-Saxon Petroleum Company, a Shell company based in London.

In 1910 the rights to explore for oil were given to the Anglo-Saxon Petroleum Company, later known as Sarawak Shell. Commercial exploitation began in the same year when the company struck oil in the town of Miri. Miri became the first oil town in the then British Borneo, and this marks the start of today's Malaysian petroleum industry. In the 1960s, further major oil reserves were discovered off the Sarawak coast. The hydrocarbon industry in Malaysia flourished still more after the discovery of major oil reserves off the State of Terengganu in Peninsular Malaysia in 1978 (Von der Mehden and Troner, 2007).

As in many other developing countries, oil companies in Malaysia operated under a concession system up to the 1970s (Von der Mehden and Troner, 2007). Under this system, large geographical areas were made available to the companies under very generous terms while the Malaysian government retained very little control and was paid a small royalty and taxes. However, all this changed as a result of the 1973 Arab-Israeli war. As a result of the war, several Arab oil-producing countries decided to embargo oil shipments to certain countries, which resulted in a mad rush for oil. The price of oil shot up overnight and the world experienced its first energy crisis. The oil

embargo also made oil-producing countries realize the importance of controlling their own petroleum resources.

In order to better manage its exhaustible oil resource, Malaysia introduced the Petroleum Development Act 1974. This Act led to the formation of a national oil company, Petroliam Nasional Berhad or Petronas, to ensure that the country's petroleum resources could be developed in line with Malaysia's needs and aspirations. This principle is espoused in Article 2 of the Act, which states that the entire ownership in, and the exclusive rights, power, liberties and privileges of exploring, exploiting, winning and obtaining petroleum whether onshore or offshore of Malaysia, is vested in Petronas. Incorporated on 17 August 1974 under the Companies Act 1965, Petronas is wholly owned by the Malaysian government (Von der Mehden and Troner, 2007). Over the years, the national oil company has grown to become a fully integrated oil and gas corporation and is ranked among the *Fortune* Global 500 largest corporations in the world.[i] In this sense, Petronas acts as a regulator as well as a player in Malaysia's oil, gas and petrochemical industries. The company has ventured into more than 32 countries worldwide in its aspiration to be a leading oil and gas multinational.[ii]

3.5 Outlook of the Hydrocarbon Industry in Malaysia

Petronas was established to develop the nation's oil and gas reserves. With the Petroleum Development Act 1974, Petronas embarked on Production Sharing Contracts (PSC) with various multinational petroleum corporations (Sarmidi, 2001). Petronas has since been actively involved in the development of the petroleum and gas industry, starting from production and processing. It has now ventured into petrochemical industry operations (Sarmidi, 2001).

In Peninsular Malaysia, the development of the petroleum industry began when oil was first produced off the coast of Terengganu in 1978 (Von der Mehden and Troner, 2007). The first petroleum project was an oil refinery in Terengganu; it was fully owned and operated by Petronas and was completed in March 1983. The development strategy for the petroleum industry in the peninsula was to develop the basic infrastructure and facilities necessary to attract both local and foreign investors to participate in the growth of the petroleum and supporting industries. These efforts were further boosted by the discovery of significant natural gas reserves off the coast of Terengganu.[iii] In 1981, Petronas drew up a master plan for the development of the natural gas sector in order to support the government's national energy policy on fuel diversification.[iv]

The development of Malaysia's petrochemical industry has been driven by the availability of hydrocarbon feedstock from indigenous oil and gas, and by the Malaysian government's continued support of petrochemical developments via investment incentives and other measures (MITI, 1996). The availability and increased utilization of natural gas has acted as a catalyst for the development of a gas-based petrochemical industry (Petronas Prospectus, 2010). Malaysia's first petrochemical venture began in the south with the founding by Titan Chemicals of the first polypropylene plant in Pasir Gudang, Johor, in 1989.[v] The plant was commissioned in 1993. By the mid-1990s, based on government planning supported by an attractive environment and well-established infrastructure, the petrochemical industry was set to take off in the east coast of Peninsular Malaysia, with the growth of ethylene-based petrochemical production in Kertih, Terengganu, and propylene-based petrochemical production in Gebeng, Pahang ((*Petronas Prospectus*, 1 November 2010). Petronas and its partners have since developed various world-scale petrochemical plants through

the integrated petrochemical complex in Kertih and Gebeng, dubbed the 'Kertih-Gebeng Petrochemical Hub.'

The extent of the oil, gas and petrochemical industry in Malaysia is shown in Figure 3.1. Thus far, its main activities include oil and gas exploration; development of oil and gas reserves; crude oil refining; petroleum and natural gas processing; and manufacturing of petrochemical products. The oil, gas and petrochemical cluster in Kertih-Gebeng has established supporting infrastructure and logistics facilities that include three ports (Kertih Port, Kemaman Port and Kuantan Port), a crude oil terminal, an onshore gas terminal and an onshore slug catcher in Kertih.[vi] The extensive products resulting from the oil and petroleum refining processes offer opportunities to develop manufacturing industries which use these by-products as feedstock, particularly the development of a wide range of polymer resins and materials.

Figure 3.1: National Positioning of Petrochemical Zones in Malaysia

Source: Various Sources from Petronas-related websites and the ECER website.

With the development of the oil, gas and petrochemical industry on the east coast, the Malaysian government in 2007 promulgated the idea of transforming the region into a developed one by 2020.[vii] It was dubbed the 'East Coast Economic Region' (ECER) and an East Coast Economic Region Development Council (ECERDC) was established under an Act of Parliament, the East Coast Economic Region Development Council Act 2008 (Act 688), to drive the implementation projects and key programs identified in the ECER Master Plan.

Among the activities to further develop the petrochemical industries in the ECER was the establishment of the Kertih Plastics Park (KPP), located near Kertih Integrated Petrochemical Complex (KIPC), which is itself close to the main source of petrochemical feedstock such as polyethylene (PE), polypropylene (PP) and polyvinyl chloride (PVC).[viii] The KPP project was proposed to promote investment further downstream into the plastics and plastics-related industries. For the petrochemical industry, the project was expected to add value to national hydrocarbon resources by moving up the product value chain and expanding downstream activities into plastics and plastics-related industries.[ix]

3.6 Structure of the Oil, Gas and Petrochemical Cluster

Since its establishment, Petronas has spearheaded the development of the oil, gas and petrochemical industries in Malaysia. As a national oil company, Petronas' direction is guided largely by national policies and by its own corporate vision and mission. The relevant Acts and regulations, and the national policies related to the development of the oil, gas and petrochemical industries, are the Petroleum Development Act 1974; the National Petroleum Policy; the National Energy Policy; the National Depletion Policy; the

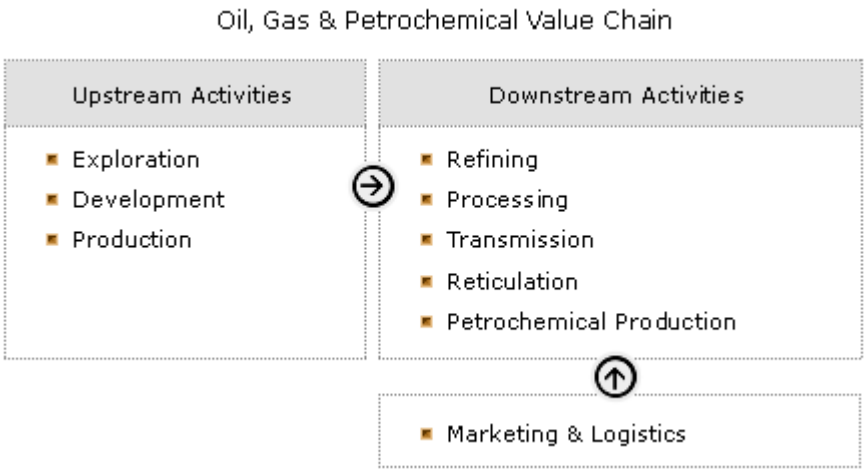
Gas Supply Act 1993; the Ninth Malaysia Plan (2006-2010); IMP1 (1986-1995), IMP2 (1996-2005) and IMP3 (2006-2020).

During the Second Industrial Master Plan (1996-2005), the Malaysian government classified the chemical industry under the manufacturing categorization. The chemical industry group then comprised of two sectors, namely petrochemical and pharmaceutical (MITI, 1996). Both of these sectors were basically import substituting industries and foreign investment driven. In this industrial plan, Malaysia adopted the manufacturing strategy based on the cluster-based industrial development approach, as described in Section 3.3. This approach emphasizes industrial linkages and the role of support industries and services.

The main idea of IMP2 was to develop the chemical industry in the form of an industrial cluster where industrial symbiosis could flourish (MITI, 1996:21). Within this chemical industry cluster, firms formed partnerships with suppliers and even competitors to gain mutual benefits through collaborative value-added activities. They drew upon a common labor pool, which served to diffuse new knowledge and related skills rapidly throughout the cluster. The firms established strong links with domestic R&D institutions, including universities, to strengthen product development design as well as marketing and distribution capabilities (MITI, 1996:23). This approach to industrial development required industries and related institutions to adopt a new management and operating strategy that would foster collaboration, inter-firm cooperation, strategic alliances, and 'smart' partnership[x]. In short, the clustering approach "provide[d] the basis for the achievement of a broad-based, resilient and internationally competitive industrial sector" (MITI, 1996:21).

The oil, gas and petrochemical industry cluster is essentially divided into upstream and downstream activities. 'Upstream activities' refers to exploration, development and production of oil and gas reserves. Downstream activities are economic activities that relate to crude oil refining and the retailing of petroleum products; natural gas processing; transmission and reticulation, as well as liquefaction; logistic operations of crude oil, petroleum products and LNG; and manufacturing of petrochemicals, as shown in Figure 3.2.[xi]

Figure 3.2: Oil, Gas and Petrochemical Value Chain

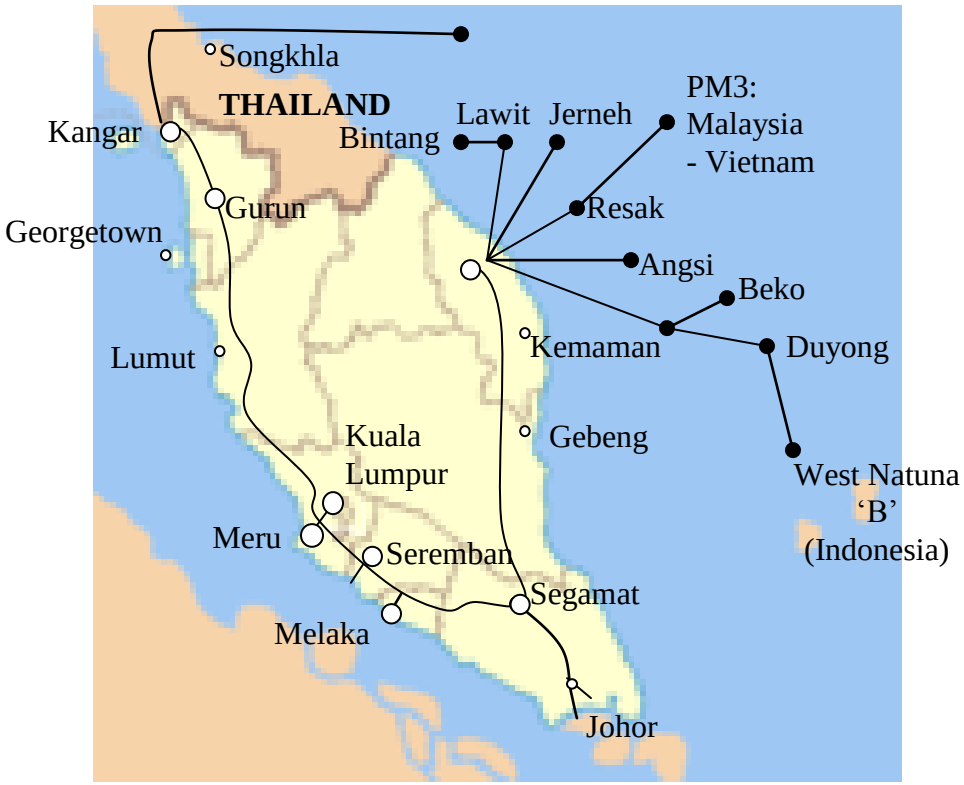


Source: ECER website

Presently, Petronas has over 25 wholly owned subsidiary companies, over 13 joint-venture companies and more than ten associate companies.[xii] It is involved in all upstream and downstream activities, including the production and marketing of petroleum products and petrochemicals, both locally and abroad. The oil, gas and petrochemical cluster located in the Kertih-Gebeng Petrochemical Hub has evolved into a mature and fully integrated one with high intra-linkage between facilities and plants.[xiii] Figure 3.3 shows the linkages between upstream and downstream activities in the East Coast region. As a result of the

oil and gas cluster development, there has been an increase in oil and gas reserves and production, as well as an increase in the number of PSC companies operating offshore in the Kertih-Gebeng Petrochemical Hub. Many local services companies, formed within the last twenty years, have developed local expertise and competencies to serve Petronas and other international oil companies operating in Malaysia.[xiv]

Figure 3.3: Linkages between Upstream Activities in the ECER and Downstream Activities



Source: Various sources and the ECER website

3.6.1 Upstream Activities: Petroleum and Natural Gas Production

Upstream activities are essentially driven by the resource prospects of the area where they occur. At present, Malaysia has about 45 oil fields in production, with several others under development. Malaysia is also involved in natural gas production and exploration (Von der Mehden and Troner, 2007). Around 15 of the 218 gas fields discovered in Malaysia are already in production, with several more under development. Under the Production Sharing Contract, Petronas Carigali (a Petronas subsidiary) has been partnering with several oil major players such as ExxonMobil and Shell over the last 20 years, both in Malaysia and abroad. A total of fourteen multinational oil companies have operations in upstream activities in Malaysia.[xv]

In January 2003, Malaysia's petroleum reserves were estimated to be about 3.2 billion barrels and 87.5 trillion cubic feet (tcf) of natural gas, equivalent to 16.4 billion barrels of petroleum. Malaysia's petroleum industry has grown from production of less than 100 barrels per day (bpd) over a century ago to 600,000 bpd of oil and 4.7 billion cubic feet of gas per day in 2009.[xvi] In 1997 Malaysia produced 767,000 bpd of crude oil, 4.336 billion cubic feet of gas per day, and 19,000,000 metric per annum of liquefied natural gas (LNG). In oil production, for example, Malaysia's total oil production reached 767,000 bpd in 1997, up from 716,000 bpd in 1996, 703,000 bpd in 1995 and 663,000 bpd in 1994.[xvii]

Under the National Depletion Policy, however, Malaysia needs to sustain its natural reserves. For the period 2001-2005, Malaysia maintained its oil production level of 600,000 bpd. At current rates of oil production, the country's oil reserves are expected to last about 15 years, and gas reserves about 35 years. But, as a result of increasing overseas activities, Petronas has accumulated additional international reserves equivalent to about 3.71 billion barrels of oil.[xviii]

3.6.2 Downstream Activities: Refining and Downstream Processing

In downstream activities, Petronas is involved in both refining and petrochemical plants in Malaysia and abroad (Von der Mehden and Troner, 2007). Since downstream oil and gas activities are basically demand driven, the refineries together with the marketing facilities and retailing outlets are mostly located on the west coast of Peninsular Malaysia. A total of 11 companies have been given approval to operate petroleum refineries (Sarmidi, 2001:8); however, only six refineries with a combined capacity of about 716,000 bpd are in operation.[xix] Besides oil refining, downstream activities also include petrochemical production (this will be discussed in greater detail later).

Petronas has several important projects in oil refining, gas processing and the production of petrochemicals. In 2005, Petronas petrochemical subsidiaries produced 7.8 million metric tons of petrochemicals in its worldwide operations (Von der Mehden and Troner, 2007). In downstream activities, Petronas has partnered with Dow Chemical (formerly Union Carbide), Kaneka, ConocoPhillips, Toray, Polyplastics, Mitsubishi, Mitsui, Dairen, BP, BASF, Titan, Idemitsu, DSM, Eastman Chemicals and Thirumalai (Von der Mehden and Troner, 2007).

Presently, Petronas own three crude oil refineries, which process 240,000 barrels of oil per day.[xx] It owns and operates the Petronas Kertih Refinery through its wholly owned subsidiary Petronas Penapisan (Terengganu) Sdn Bhd. This refinery, the company's first in the State of Terengganu, processes 40,000 barrels of Malaysian light, sweet crude oil per day. The refinery has been expanded to include a condensate splitting facility known as KR-2 with a rated capacity of 63,500 barrels per day of condensates. The naphtha produced is used as feedstock for the Aromatics plant adjacent to the refinery. In the State of Melaka, the Petronas Melaka Refinery Complex houses two refining trains. The first

train, known as PSR-1, is owned and operated by Petronas Penapisan (Melaka) Sdn Bhd, a wholly owned subsidiary of Petronas. It was completed in 1994 and has the capacity to process 100,000 barrels per day of Malaysian light, sweet crude and condensates. The second train, PSR-2, is owned by Malaysia Refining Company Sdn Bhd, a joint venture between Petronas and Conoco. Operated by Petronas Penapisan (Melaka) Sdn Bhd, it commenced operations in phases from December 1998 and has a rated capacity of 100,000 barrels per day of sweet and sour crude. Other refineries in the country are the Esso Refinery (86,000 bpd) and the Shell Refinery (155,000) – both of which are in Port Dickson, Negeri Sembilan – and the Shell Refinery in Lutong, Sarawak (45,000 bpd).

In its efforts to increase the use of natural gas, Petronas has developed (through its subsidiary Petronas Gas Sdn Bhd, PGSB) a network of natural gas pipelines from Terengganu to Johor and Singapore to the south of Peninsular Malaysia and to Klang and Port Dickson along the west coast of the peninsula. These developments marked Phase I and II. Phase III is the extension from Klang along the west coast of the peninsula to the border with Thailand. Phase IV is the extension of the pipeline from Kelantan on the east coast to Kedah on the west coast.[xxi] The gas pipeline system in the peninsula illustrates the link between upstream activities and downstream activities (refer to Figure 3.3).[xxii]

3.7 The Petrochemical Industry in Malaysia

The petrochemical industry, founded as early as 1973 to add value to the country's oil and gas resources, is an important sector of the Malaysian economy (Gale, 1981). Up to 1995, it had attracted more than RM15 billion in investment (MITI, 1996:107). By 2005, the cumulative investment in the industry had reached more than RM55 billion, with Malaysian investment contributing RM34.8 billion, or 63.3 percent, and foreign

investment, RM20.2 billion (36.7 percent) (MITI, 2006:387). For 2008, investments in the petroleum and petrochemical industries were in the region of RM57.2 billion (MIDA, 2007). Petrochemicals contributed RM864.8 million, RM204 million and RM981.1 million in gross output, value-added and fixed assets respectively in 1993. The industry is highly technological and capital-intensive, with fixed assets per employee of RM 264,510 in 1993, significantly surpassing the manufacturing sector's average figure of RM58,602. It is also highly productive in its use of labor, as indicated by the value-added-per-employee figure of RM55,010 (MITI, 1996:107-108).

Even though the petrochemical industry does not employ many people (it has an estimated workforce of 10,000 persons, largely at the packaging level), it has extensive intra-linkages with downstream activities, as well as other industries (MITI, 2006:390). The downstream activities mainly involve polymer compounders, converters (plastic packaging producers) and fabricators (plastic injection moulding producers), producing products for application in industries such as E&E, medical devices, automotive, construction and agriculture. The involvement of Malaysian-owned companies, including SMEs, is mainly in downstream activities, mostly in producing plastics parts and components and packaging materials. Besides these downstream activities, the petrochemical industry has significant linkages with many other industries. For example, in the agriculture industry, fertilizers such as urea and ammonia are made from petrochemicals. And in the fabric industry, resins made from petrochemicals are used as the raw materials.

Although the Malaysian petrochemical industry is dominated by a few large foreign MNCs, there are two major local producers: Petronas Chemicals Group Berhad (PCG) and Titan Chemicals Group (Titan) (*Petronas Prospectus*, 1 November 2010). Titan focuses on olefin and polyolefin production, with an integrated operation based on naphtha

feedstock. PCG also focuses on olefin and polyfin production but moves further downstream in its activities by producing other petrochemical products such as methanol, ammonia, urea, aromatics and other derivatives.

Table 3.2: Petrochemical Plants in Peninsular Malaysia

Petrochemical Plants	Location
Ethylene Malaysia	KIPC
Optimal Butanol	KIPC
Optimal Butyl Acetate	KIPC
Optimal Ethamolamine	KIPC
Optimal Ethoxylates	KIPC
Optimal Ethylene Glycols	KIPC
Optimal Glycol Ethers	KIPC
Optimal Glcols Ethylene Oxide	KIPC
Optimal Olefins Ethylene	KIPC
Optimal Olefins Propylene	KIPC
Petlin (M) Sdn. Bhd.	KIPC
Ammonia Syngas Plant	KIPC
Aromatics Malaysia (Benzena Plant)	KIPC
Aromatics Malaysia (Paraexylene Plant)	KIPC
Petronas-BP Acetyl Acid	KIPC
Polyethylene Malaysia	KIPC
Vinyl Chloride Malaysia (VCM Plant)	KIPC
Vinyl Chloride Malaysia (PVC Plant)	KIPC
BASF-Petronas Acrylic/Acrylics Esters Plant	GIPC
BASF-Petronas Butanedols Plant	GIPC
BASF-Petronas Oxo-Alcohols Complex (1)	GIPC
BASF-Petronas Oxo-Alcohols Complex (2)	GIPC
BASF-Toray	GIPC
BP Chemicals	GIPC
Eastman Chemicals	GIPC
Flexyss (1)	GIPC
Flexyss (2)	GIPC
Kaneka Malaysia	GIPC
Kaneka Electic	GIPC

Kaneka Eperan	GIPC
Kaneka Paste Polymers	GIPC
MTBE	GIPC
Polyplastics	GIPC
Polypropylene	GIPC
Propane Dehydrogenation Plant	GIPC
WR Grace	GIPC
Titan Petrochemical (Ethylene)	Pasir Gudang
Titan Petrochemical (Propylene)	Pasir Gudang
Titan PP Polymers	Pasir Gudang
BASF Sdn. Bhd.	Pasir Gudang
Petrochemical Sdn. Bhd.	Pasir Gudang
Idemitsu Styrene Monomer	Pasir Gudang
Idemitsu Ethyl Benzene	Pasir Gudang
Dic Epoxy	Pasir Gudang
Polymer Latex	Pasir Gudang
Toray Plastics	Prai, Penang
Malaysian Electrochemical Industries	Prai, Penang
Cabot	Port Dickson
MPI Polyester	Shah Alam, Selangor
Petronas Fertilizer – Ammonia	Gurun, Kedah
Petronas Fertilizer – Urea	Gurun, Kedah
Petronas Fertilizer – Methanol	Gurun, Kedah

Source: Own compilation from Petronas websites, and Sarmidi (2001)

Malaysia has attracted a number of major international petrochemical producers. As at the end of 2005, investment by these companies totaled RM31.5 billion, with RM15.6 billion, or 53.2%, being from FDI. Petronas is the major domestic investor in the industry. As of 2007, there were forty petrochemical companies in operation, with a combined capacity of 12.8 million metric tons per annum (MIDA, 2007). Of these forty companies, nineteen were joint ventures, fourteen were wholly foreign-owned, and seven were wholly owned

by Malaysians. Domestic investment is mostly through joint ventures with these MNCs, which are also normally the technology providers. The involvement of MNCs is also important for gaining access to the world market. The largest source of foreign investment is the United States (40.3%), followed by Germany (22.8%) and Japan (14%) (MIDA, 2007). The major investors are Dow Chemical, BP Amoco, Shell Gas B.V., BASF, Eastman Chemicals, Toray, Mitsubishi, Idemitsu, Polyplastics, Kaneka, Dairen and Titan Petchem. Table 3.2 shows the list of petrochemical plants in Peninsular Malaysia.

At present, Malaysia is a net importer of petrochemicals (MITI, 2006:392). Imported petrochemicals are used as materials in the manufacture of various products, including other petrochemicals, which are subsequently exported as intermediates or consumer goods. Total exports of petrochemicals increased by an average annual rate of 21.8% from RM2 billion in 1996 to RM14.6 billion in 2005. On the other hand, total imports of petrochemicals increased by an average annual rate of 10.1% from RM5.8 billion in 1996 to RM17.2 billion in 2005. Major exports of petrochemicals in primary forms were commodity grade polymers, such as polyethylene (PE) and polypropylene (PP), and petrochemical derivatives such as acrylic acid, methanol, methyl tertiary butyl ether (MTBE) and specialty chemicals. Polymers were mainly exported to the People's Republic of China (PRC), India and ASEAN countries. However, exports of specialty chemicals were mainly to PRC, the European Union and the US. Major imports comprised specialized and engineering grade polymers and co-polymers from the US, Japan and the Republic of Korea (MITI, 2006:392).

The petrochemical industry is poised to become an important industry within the chemical industry. But although Malaysia has substantial oil and gas resources, the uncertainty hanging over the availability of feedstock poses a problem for the industry's development.

Further development of this sector, among others, will depend on the availability of feedstock, technology and skilled manpower (MITI, 1996). Future development of the petrochemical industry will, however, take place in both the domestic market and in regional export markets.

IMP3 focuses only on the petrochemical industry, categorized as one of six resource-based industries in the Malaysian manufacturing sector, rather than on the whole oil, gas and petrochemical cluster. This emphasis on petrochemical development is also a natural progression of the mature Kertih-Gebeng oil and gas cluster, in line with the objective of the Ministry of International Trade and Industry to develop and transform Malaysia's manufacturing sector by strengthening industrial links, increasing value-added activities and enhancing productivity. Other resource-based industries include pharmaceuticals, woods, rubber products, oil palm products and food processing (MITI, 2006).

According to IMP3, the objective of the petrochemical industry in the period 2006-2020 is to expand its current manufacturing activities, to develop new products and to diversify into manufacturing-related services and facilities. IMP3 believes these areas of focus will assist in achieving the full integration of the industry (MITI, 2006:387). As espoused in IMP2, the government believes that once a cluster becomes mature, the firms in the cluster will be connected to a global network of subcontractors, affiliates and vendors (MITI, 1996:23)

To realize Malaysia's goal of transforming its manufacturing sector, ten strategic thrusts have been set for the petrochemical industry (MITI, 2006:398):

i) Expand and enhance the value of existing capacities and broaden the range of petrochemicals produced;

ii) Diversify into manufacturing-related services and support services;

iii) Enhance links with downstream industries, in particular plastics and oleochemicals;

iv) Intensify the development of technologies in materials and product applications;

v) Improve chemical process technologies and the application of catalysts to increase yields;

vi) Undertake the full integration of existing petrochemical zones;

vii) Establish new petrochemical zones in Bintulu, Sarawak; Gurun, Kedah; Tanjung Pelepas, Johor; and Labuan;

viii) Ensure the availability of feedstock at competitive prices;

ix) Improve market access through free trade agreements (FTA); and

x) Enhance the technological and management skills and expertise of the workforce.

3.8 Petrochemical Plants in Malaysia and the Development of the Malaysian Petrochemical Industry Zone (Complex)

The first petrochemical plants in Malaysia started as early as 1973 with the production of polyvinyl chloride (PVC) and subsequently of polystyrene (PS) resins based on imported monomers in Tampoi, Johor and at a PVC plant in Prai, Penang (Sarmidi, 2001:11). The most notable shift in the industry took place in 1985 with the production of methanol from domestic natural gas in Labuan, as well as the production of ammonia and urea in Bintulu, Sarawak. The Asean Bintulu Fertilizer plant in Bintulu marked the first entry of Petronas into petrochemical manufacturing.[xxiii] After that, the pace of development of petrochemical plants gained momentum in the late 1980s with the domestic production of

gas-based and naphtha-based petrochemicals in Pasir Gudang, Johor and the Kertih-Gebeng Petrochemical Hub (MITI, 1996:107-108).

While petrochemical plants exist in numerous locations in Malaysia (for example Gurun, Kedah; Bintulu, Sarawak; and Labuan), in this study only the three petrochemical industry zones (complexes) established in Peninsular Malaysia are described in detail – namely, Kerteh, Terengganu; Gebeng, Pahang; and Pasir Gudang-Tanjung Langsat, Johor. Each of these zones is an integrated complex equipped with crackers, syngas and aromatics facilities to produce basic feedstock for the production of downstream petrochemical products. Petronas has contributed significantly to the development of support infrastructure, dedicated utilities and services in the Kertih and Gebeng zones, so creating an investment environment conducive to the expansion of the petrochemical industry within them.

The Kertih Integrated Petrochemical Complex (KIPC) focuses on ethylene-based products, the Gebeng Integrated Petrochemical Complex (GIPC) focuses on propylene-based products (Bowie, 2001), and the plants in the Pasir Gudang-Tanjung Langsat Petrochemical Zone are naphtha-based. See Figure 3.1 for the locations of these zones.

The industrial clusters that form the demand centers for the products of the three petrochemical zones are located some distance away on the west coast of the peninsula. For example, the automotive industry, the electrical and electronic industry and the packaging industry are all located on the west coast.

3.8.1 The Pasir Gudang-Tanjung Langsat Petrochemical Zone

Malaysia's first integrated petrochemical industry complex started with the founding of the first polypropylene plant by the Titan Group in 1989. This was followed in 1993 by Titan's commissioning of its first polyethylene plant at Pasir Gudang, Johor.[xxiv] Titan's first cracker for olefins and derivatives complex started up in 1994 using naphtha as feedstock. It then started up its second cracker and polyolefin complex in 1999. The petrochemical plants under the Titan Group are: a polypropylene plant through Titan PP Polymers (M) Sdn Bhd; a polyethylene plant through Titan Polyethylene (M) Sdn Bhd; and a naphtha cracker through Titan Petrochemicals (M) Sdn Bhd. Besides these plants, the Titan Group has expanded its capacities on site, as well as adding new products. As a result of limited space at its current site, the group has also relocated its new projects to Tanjung Langsat, ten kilometres from Pasir Gudang. The Johor State Government is promoting the new site for use by heavy industries.[xxv]

To date, the Titan petrochemical complex has earned the reputation of being the largest integrated olefins and polyolefins producer in Malaysia and the second-largest polyolefins producer in Southeast Asia in terms of capacity (Anon HA, 2004).

Other multinational firms have plants in the Pasir Gudang-Tanjung Langsat Petrochemical Zone. In partnership with Idemitsu, Petronas built two plants to produce ethylbenzene and styrene monomers, and these commenced operations in 1997. The well-known German multinational BASF also has a manufacturing facility producing polystyrene in this zone.[xxvi]

3.8.2 The Kertih Integrated Petrochemical Complex

The Kertih Integrated Petrochemical Complex (KIPC) focuses on ethylene-based products (Bowie, 2001). The construction of the Gas Processing Plant (GPP) in Kertih has led to the opening of the Petrochemical Processing Complex in Kertih and Gebeng. The first petrochemical plant at Kertih, Ethylene Malaysia Sdn Bhd (EMSB), a joint venture company between Petronas, BP and Idemitsu, was built in 1995 to produce ethylene and polyethylene resins using ethane gas as feedstock. This was the second olefins plant in Malaysia. The cracker started up in late 1995 with a capacity to produce 320 thousand metric tons of ethylene per year, expanded to 400 thousand metric tons per year in 1997 (Petronas Prospectus, 2010).

The coming on-stream of the second cracker in Kertih attracted attention to the Malaysian petrochemical industry. In 1995, an agreement was signed between Petronas and Mitsui VCM Holdings of Japan for a vinyl chloride monomer plant and a PVC plant in Kertih using ethylene as feedstock. These plants have the capacity to produce 400 thousand metric tons per annum of VCM and 150 thousand metric tons per annum of PVC.[xxvii] In 1999, an agreement was made between Petronas and Polifin Ltd, South Africa and DSM Polyethylene BV, the Netherlands, for the construction of a Low Density Polyethylene (LDPE) plant in Kertih to start operation in 2002.[xxviii]

By early 2000, other major developments had made progress in Malaysia's petrochemical industry. For example, Dow Chemical and Petronas launched the Optimal Group as a joint venture consisting of Optimal Olefins (Petronas 70%, Dow 30%) and Optimal Glycols and Optimal Chemicals (each a 50/50 joint venture).[xxix] In January 2002, Optimal Olefins set up Malaysia's third ethane cracker. The cracker has an ethylene capacity of 600 thousand metric tons per year and uses ethane/propane feedstock.[xxx] The Optimal Glycols plant was

commissioned in February 2002 and produces ethylene oxide/ethylene glycols.[xxxi] Optimal Chemicals, commissioned in April 2002, produces ethoxylates, butanols, butyl acetate and other derivatives.[xxxii]

Aromatics Malaysia Sdn Bhd, a joint venture between Petronas and JMPX (a holding company for Mitstubishi Corporation and Japan Energy Company), completed Malaysia's first aromatics complex (designated KR-2) at Kertih, adjacent to the Petronas KR-1 refinery in July 2000. The complex has a capacity for 420 thousand metric tons per year of para-xylene and 150 thousand metric tons per year of benzene.

3.8.3 The Gebeng Integrated Petrochemical Complex

The third key petrochemical location in Malaysia, the Gebeng Integrated Petrochemical Complex (GIPC), is located in the Gebeng Industrial Estate in Kuantan, Pahang, which is near the Kuantan Port. The site had been earmarked as a heavy industrial site by the Pahang State government. The GIPC focuses on propylene-based products (Bowie, 2001). BP (formerly Amoco Chemicals) started up its purified terepthalic acid (PTA) plant in Kuantan, producing 500 kta of the acid, in 1997. It has expanded PTA capacity by 100 thousand metric tons per year, to 600 thousand metric tons per year. BP also started up a 450-thousand-metric-tons-per-year acetic acid plant in a joint venture with Petronas (the joint venture being known as BP Petronas Acetyls) in December 2000.[xxxiii]

Petronas set up MTBE Malaysia Sdn Bhd to produce MTBE and propylene for its polypropylene plant. MTBE Malaysia Sdn Bhd commissioned its propane dehydrogenation plant in 1989 to supply propylene feedstock to its other joint venture company. The MTBE plant was originally a joint venture between Petronas, Idemitsu

Petrochemical and the Nestle's subsidiary Borealis. The plant produces 300 kta of MTBE and 80 kta of propylene. It is a gas phase reactor using Unipol's technology.[xxxiv] In 2000, in a joint venture with BASF, Petronas started its highly integrated propylene derivatives complex in Kuantan. The joint venture firm, BASF Petronas Chemicals Sdn Bhd (BASF, 60 percent and Petronas, 40 percent), produces acrylics, oxo alcohols, butanediol and their derivatives. The first phase of the acrylics complex came on stream in July 2000 and included crude acrylic acid, glacial acrylic acid (for super absorbent polymers), butyl acrylate and 2-ethylhexyl acrylate. The second phase, the oxo alcohol facility, including butanol, 2-ethyl exanol and plasticizers (DOP), started up in the first quarter of 2001. The third phase consisted of the butanediol complex, which began commercial operation in 2003 (Petronas Prospectus, 2010).

3.8.4 Other Petrochemical Sites

Malaysia has other sites where petrochemical plants are located (Sarmidi et al., 2001). The downstream activities of the plants at these sites are smaller in size and are not integrated with upstream activities or other petrochemical plants that produce basic raw materials as feedstock for the plants. The plants owe their locations to market conditions and incentives given by the government. Among them are plants producing PVC resins in Prai, Penang and in Tampoi, Johor (these were among the earliest petrochemical plants in the country) and petrochemical plants in Gurun, Kedah, and Bintulu, Sarawak, where Petronas owns ammonia/urea fertilizer complexes. The Gurun complex also produces methanol and formaldehyde.

3.9 Development of Supporting Industries in the Oil, Gas and Petrochemical Industry Cluster

The oil, gas and petrochemical industry is highly capital-intensive. This imposes a natural barrier to entry for new companies, especially those with limited financial resilience, as undertakings such as oil and gas exploration and production activities have long gestation periods. Companies have to take a long-term perspective in the oil, gas and petrochemical industry to develop a track record, capacities and capabilities, and to accumulate the relevant experience. Due to the high capital intensity, most companies in the core activities of the oil and gas industry (exploration, production, refining and processing) are foreign-owned, with the exception of Petronas. Hence, there is limited participation of local companies in these core activities.

Nonetheless, besides the economic activities related to the development of the oil, gas and petrochemical industry, the cluster also produces supporting industries as service providers and SMEs. The development of the oil, gas and petrochemical industry on the east coast of the peninsula, for example, has generated substantial spin-offs, especially in the development of supporting industries such as services, maintenance and supplies and other related areas. MITI (1996) listed the structure of the petrochemical industry cluster at the time it was published as shown in the tables below. The supporting activities for the oil, gas and petrochemical industry cluster are shown in Table 3.3, Table 3.4 and Table 3.5. Table 3.3 shows the current and future core petrochemical products that the Malaysian government was considering during IMP2. Table 3.4 shows the key current and future suppliers to the petrochemical producers. Table 3.5 shows the current and future institutions and organizations in the Malaysian petrochemical industry.

Backward Linkages in the Malaysian Petrochemical Industry

The traditional vertically integrated, self-sufficient organizations are being replaced by interdependent organizations focused on core competencies (Kotler, 1994; Porter, 1985; Corbett, 1997). Backward linkages or outsourcing have become a popular substitute for full self-sufficiency. The rationale for these backward linkages is that they add value to the organization and stakeholders by transferring non-core activities to a more competent outside service provider (Corbett, 1997). As explained in Chapter 2, backward linkages or the outsourcing process involves two firms, namely the petrochemical companies and the suppliers or outsourcer.

Many organizations have now looked for new approaches to develop competitive advantages (Porter, 1985; Campbell, 1995). Having backward linkages is a strategy that can lead to greater competitiveness (Embleton and Wright, 1998). It is reported that petrochemical companies from developing countries faced competition from global competitors who enjoyed the advantage of cheaper resources due to their global reach. Meanwhile, increasing expenditure on maintenance was eroding profit margins.[xxxv] In order to offer a competitive price, companies had to respond by decreasing their maintenance costs.

A survey conducted in US petrochemical plants showed that firms had outsourced either all of their equipment and facility maintenance or the specialized aspects of maintenance (Campbell, 1995). Today, as shown in Table 3.6, there are at least four methods of plant maintenance in the petrochemical industry. The first is to use in-house maintenance crews with minimal use of contractors (Type I). The second is to hire contractors to help the existing maintenance workforce (Type II). Type III is to outsource maintenance activities to contractors but keep the maintenance workforce to supervise and manage the plant

maintenance program. And Type IV is to outsource the whole plant maintenance to contractors with no minimum intervention from the petrochemical company (Campbell, 1995).

Table 3.3: Core Industries in the Malaysian Petrochemical Industry

	Ethylene	Propylene	Methane	Butylenes	Aromatics
Current	PE PVC	PP	Ammonia Nitrates Urea Formaldehyde Methanol Methyl chloride Methyl ester	MTBE ABS PS PTA	Benzene Toluene Xylene
Future	EO/EG EDC VCM EB SM VA PVC PS PET SAN PVA	PG IPA Polyols AN PP PES Copolyester SAN Copolymers OPP Polyurethanes Epoxy resins Plasticizers	Halomethanes Methylamine Acetic acid Acetylene	Butadiene MMA Aromatics BisphenolA PET ABS MBS PC Synthetic rubber Nylons	Aromatics PTA Phenol PS PC Maleic anhydride Caprolactam Nylons Rubber/plastic additives Intermediates for paints

Source: MITI (1996)

Table 3.4: Key Suppliers to the Petrochemical Producers

Current	Raw Materials	Equipment & Machinery	Support Services	Other Chemicals
	Petroleum & gas Syn-gas Methane Ethane Propane Butane Refined petroleum fractions Naphtha	Machinery/tools Storage tanks Waste storage/ treatment facilities	Industrial gases, Oxygen, Nitrogen, Carbon dioixide	Basic chemicals e.g. inorganic acids, oleochemicals, solvents
Future	Aromatics Chemical oxidants	Storage tanks Pipes Recycling facilities	Increase industrial gases	Catalyst

Source: MITI (1996)

Table 3.5: Institutions and Organizations in the Petrochemical Industry

Current	Human Resources	Technology	Finance	Physical Infrastructure	Tax & Regulatory Agencies
	. Specific technical training centers at UTM . Industrial . Petroleum Training, Trengganu (Petronas) . Kuching Polytechnic, Sarawak . PMA/PDC . . Plastic Technology Training Center . Petroleum Training Center, Bangi (Petronas)	Up-to-date imported technology through MNCs	Bank/ financial institutions Parent companies	Ports Roads/rails Electricity Water Telecom-munication	IRD MITI DOE
Future	.University level training .Petroleum University	Storage tanks Pipes Recycling facilities	. Banks/ financial institutions . Parent companies	. Specialized pipelines Waste treatment facilities Ports	IRD MITI DOE

Source: MITI (1996)

Table 3.6: Petrochemical Industry Maintenance Types
(based on the number of MNC subsidiaries who responded to the researcher's survey)

Maintenance Type	Number of Companies using this Maintenance Type in the Survey
Type I	0
Type II	1
Type III	2
Type IV	5

Maintenance Type

Type I: to use in-house maintenance crew.

Type II: to hire contractors to help the existing maintenance workforce.

Type III: to outsource maintenance activities to contractors but keep the maintenance workforce to supervise and manage the plant maintenance program.

Type IV: to outsource the whole plant maintenance to contractors with no minimum intervention from the petrochemical company.

3.10 Roles of Government in Technological Development

This section focuses on government policies relevant to encouraging technological activities in both MNC subsidiaries and local suppliers in Malaysia. It also introduces some of the programs offered by government institutions and government statutory bodies that deal with the promotion of linkages in the manufacturing sector, especially in the petrochemical industry. Its scope is limited to programs and institutions that have the goal of furthering industrialization through linkages between MNC subsidiaries and local suppliers.

Since the early stages of the development of the oil, gas and petrochemical industry in the 1970s, Petronas has maximized local participation in the industry through the National Petroleum Policy. The policy takes into consideration the country's development of the Bumiputra Commercial and Industrial Community (BCIC), one of the initiatives of the New Economic Policy (NEP) (Malaysia, 1996: 93). Under the NEP, the Malaysian government promoted Bumiputra or indigenous Malay firms' participation, particularly in the SME and supplier/subcontracting sectors. The strategy was to develop the BCIC in the oil, gas and petrochemical clusters. It was directed at developing the capabilities and capacities of indigenous Malays via apprenticeship, training and education programs. The programs include training for developing skilled manpower and entrepreneurs.

With globalization, Malaysia has basically liberalized both upstream and downstream activities in the oil, gas and petrochemical cluster. For example, there is significant foreign ownership participation in the manufacturing industry. In developing local suppliers, the thrust is that these SMEs should be able to operate at the level of technology that meets the requirements of MNCs and be part of the overall cluster with strong links to the regional and global value chain. Although the sample of local suppliers in this study is preferably

equally distributed between Bumiputra suppliers and non-Bumiputra suppliers, too little data was available to differentiate between the two groups. Therefore, this research does not deal with government policy on the development of Bumiputra firms, but with the petrochemical industry as a whole.

At the national level, there are two main programs offered by government organizations involved with industrial development. Both programs are available for local suppliers in Malaysia. They are:

1) The Vendor Development Program (VDP), offered by the Ministry of Domestic Trade and Consumer Affairs.
2) The Industrial Linkages Program (ILP), offered by the Small and Medium Enterprise Corporation (SME Corp) under the Ministry of International Trade and Industry (MITI).

In addition to the programs mentioned above, there are organizations which offer other short programs, training courses, seminars and funding for local suppliers. They are: 1) the Human Resource Development Fund (HRDF); 2) the Industrial Technical Assistance Fund (ITAF); and 3) Double Deduction Incentives for Training (DDIT). Some of these organizations offer programs targeting the technological development of local suppliers, while others provide funding, advice and consultation to local firms and MNC subsidiaries. Some of the organizations' roles and characteristics, as well as how programs are implemented, are briefly explained below.

3.11 Linkages Programs offered by the Malaysian Government

As explained earlier, IMP2 was introduced due to various negative results from IMP1, including excessive emphasis on labor-intensive industry and the lack of industrial linkages due to the slow development of industries producing intermediate and capital goods. IMP2 represented an attempt to transform the investment-led economy into a production-led economy. Many government programs were introduced to back up the IMP1 and IMP2 strategies. The two main programs available for linkages at the national level were the Vendor Development Program and the Industrial Linkages Program. In 1995 the Malaysian government launched the Small and Medium-Scale Industries Development Corporation (SMIDEC) to function as a point agency to coordinate all incentives and assistance for the technological development of local firms (Felker and Jomo, 2003). In addition to linkages between foreign and local firms, the government also creates linkages between itself and industry.

In 1993 the government created the Malaysian Business Council (MBC), the Malaysian Industry-Government Group for High Technology (MIGHT) and the Malaysian Technology Development Corporation (MTDC) to promote public-private cooperation in upgrading. In addition, public research institutes such as the Standard and Industrial Research Institute of Malaysia (SIRIM) were created to promote basic and early-stage R&D in infant and new technology sectors and to supply development assistance to local firms. Since this research focuses solely on linkages between firms, government-firm linkages are not covered in detail here.

3.11.1 The Vendor Development Program (VDP)

The Vendor Development Program (VDP), which started in 1988, was one result of the Proton Component Scheme, a supplier development program run for the auto industry by the government (Malaysia, 1996:282). The VDP was extended to other industrial subsectors, such as electrical and electronics, timber and engineering, during the Sixth Malaysia Plan (1991-1995). It involves tripartite arrangements between MITI, anchor companies and financial institutions. Under this arrangement the anchor company will guarantee market access to the vendors, which in this case are the local SMEs, while financial institutions provide them with loans. The program is coordinated by the various relevant ministries. For the petrochemical industry the coordinating ministry is the Ministry of Domestic Trade and Consumer Affairs. Petronas is the only participating anchor company.[xxxvi] The VDP is aimed at upgrading the technological level of SMEs in collaboration with MNCs, vendors and banks, so that the vendors can grow into global suppliers for MNCs. The responding anchor MNCs select vendors and provide technical as well as managerial guidance, while financial institutions provide long-term, low-interest loans for vendors.

3.11.2 The Industrial Linkages Program (ILP)

The Industrial Linkages Program (ILP) was launched in 1996 under the coordination of MITI (MITI, 1996, Malaysia, 1996). It targets the upgrading of SMEs' technological level through linkages with MNC subsidiaries. All local firms are eligible to apply under the program. Among the incentives for the participation in the program are 1) SMEs producing intermediate products are awarded 'pioneer' status, which gives them the right to apply for a tax exemption for five years or the full application of a 60 percent tax

reduction for equipment investment, and 2) large companies are given the right to apply for a tax reduction on auxiliary costs relating to training, auditing and technical assistance.

3.12 Available Funding by the Malaysian Government

Given the limited role of Malaysian public training institutions in regard to private sector retraining and skill upgrading of their employees, the government has implemented three programs, namely the Double Deduction Incentives for Training (DDIT) scheme, the Human Resource Development Fund (HRDF) scheme, and the Industrial Technical Assistance Fund (ITAF). These programs offer funding to encourage firms to play a greater role in meeting their own training demands.

3.12.1 Double Deduction Incentive for Training (DDIT)

The DDIT scheme allows firms to subtract twice their training expenditures from gross income as a tax deduction. The scheme can be used to send employees to approved training institutions or to apply to MIDA for approval of in-plant training programs. The take-up rate for the DDIT incentive has been uneven across sub-sectors and firm size and ownership. The electrical and electronics sector accounted for almost 60 percent of incentives approved by MIDA under this scheme in 1995.[xxxvii] Usage of DDIT was initially dominated by MNC subsidiaries: in 1995, about 50 percent of the companies taking part were wholly foreign owned and another 45 percent had some foreign ownership. The take-up rate of DDIT by small firms was low. Therefore, since 1993, only companies with less than 50 employees have been eligible for DDIT. To make this incentive work for small companies, the government decided to use a levy-rebate scheme to promote training in larger firms.

3.12.2 The Human Resource Development Fund (HRDF)

The HRDF was established in 1992 with a grant from the government (Malaysia, 1996:119). It is administered by a council with both private sector and government representatives. Unlike the DDIT program, the HRDF is not a subsidy scheme. Employers who have contributed 1% of total payroll for at least six months can reclaim a portion of allowable training expenditures. The rates of reimbursement vary by type of training and firm size. The scheme has three components: a scheme for approved training in registered institutions, a scheme for ad hoc in-plant or external training from non-approved institutions, and a scheme for firms that train regularly and do not want to submit applications every year. Initial use of the HRDF scheme was low.[xxxviii] As with the DDIT scheme, there are wide variations in take-up and non-compliance across sectors. The highest rates are in scientific instruments and machinery, while sub-sectors with low rates are food, textiles and apparel. In contrast, of the eligible firms not registered with the HRDF, 27% said that their training had increased, and about 50% said that their training had remained unchanged.

3.12.3 The Industrial Technical Assistance Fund (ITAF)

This ITAF is a matching grant-type (50% of the total cost paid by a beneficiary) assistance scheme that was introduced in 1990 (Malaysia, 1996). The grant, which is coordinated by MITI, is meant to achieve productivity improvements, strengthening of cost competitiveness and quality improvement among SMEs. It is considered to be an excellent SME support measure. However, judging from the SMEs' low level of response to it, not many firms are even aware of its existence (JICA and PDC, 2001 quoted in Iguchi (2007).

3.13 Developing the Manufacturing Capability of Local Firms

The experience of Newly Industrializing Economies (NIEs) shows that these countries stress the development of local SMEs. For example, SMEs are given assistance to develop and enhance their technological capability (Anuar, 1992; Mukerjee, 1986; Hobday, 1995). In Malaysia, SMEs play an important role in the country's economy. They provide employment and have a crucial impact on regional or locational development. The target for SMEs was to raise their contribution to GDP from 32 percent in 2005 to 37 percent in 2010. At the same time, their contribution to exports was to rise from 19 percent to 22 percent, and their contribution to employment was to increase to 57 percent (MITI, 2009:1). The SME 2008 Annual Report stated that the majority of SMEs are still in the traditional sectors of the economy. The main problems besetting SMEs are their low technological capability, difficulties in obtaining financial assistance, inadequate linkages with industries and lack of export penetration.

Trend performance from SMEs in the manufacturing sector is shown in Table 3.7 (SMIDEC, 2006). In 1996, SMEs accounted for 22.1% of manufacturing sector output, 19.5% of value-added and 29.6% of employment. By 2005, these shares had increased to 29.6%, 25.9% and 31.3% respectively. This implies an annual average growth of 5.3% in output, 5.7% in value-added and 2% in employment from 1996-2005.

Table 3.7: SME Performance

Indicators	1996	2005
Total output Value (RM billion)	51.5	81.9
% Share of manufacturing sector	22.1	29.6
Average growth rate (1996-2005)		5.3
Added value Value (RM billion)	10.1	16.6
% Share of manufacturing sector	19.5	25.9
Average growth rate 1996-2005		5.7
Employment manufacturing sector	329,848	394,670
% Share of manufacturing sector	29.6	31.1
Average growth rate		2.0

Source: SMIDEC, 2006 and various sources from the Department of Statistics, Malaysia

Table 3.8 reveals a total of 523,132 establishments in the manufacturing, agriculture and services sectors in Malaysia in 2005, comprising 39,219 enterprises in the manufacturing sector (7.3%), 451,516 in the services sector (86.9%), and 32,397 in the agriculture sector (5.8%). Overall, there were 516,855 SME establishments, accounting for 98.8% of all enterprises in the country. In the manufacturing sector, SME establishments accounted for 96.6% of the 37,866 overall manufacturing enterprises. The largest number of SMEs was found in the textiles and apparel sector with a share of 23.2% (8,779 establishments), while chemical and chemical products accounted for only 2.8% (1,047 establishments)

(SMIDEC, 2006). For the chemical and chemical products SMEs, these establishments contributed 5.7 % towards employment. The food and beverages industry was the largest contributor with 17.1%, followed by timber products and furniture with 16.4%, and metal and metal products and rubber and plastics products with 12.8% each. These five sectors of SME establishments together contributed 64.8% of employment in the manufacturing sector.

Table 3.8: Status of SMEs for 2005

	Total number of establishments	**Total number of SMEs**	**% of SMEs**	**% of structure**
Total number in Manufacturing	39,219	37,866	96.6	7.3
Total number in Services	451,516	449,004	99.4	86.9
Total number in Agriculture	32,397	29,985	92.6	5.8
Overall total	523,132	516,855	98.8	100

Source: SMIDEC, 2006

The importance of developing local firms, especially SMEs, has been recognized in every major Malaysian economic plan. IMP2 (1996-2005) aimed to increase the participation of local firms in a broad range of activities, especially in areas identified as being strategically important in the future development of the manufacturing sector (MITI, 1996:11). Petrochemicals are one such strategic industry. The allocation for SME development increased 21 percent (RM546.9 million) in the Seventh Malaysia Plan (1996-2000), compared to 7% (RM105.2 million) in the Sixth Malaysia Plan (1991-1995) (Malaysia, 1996:299).

As discussed previously, the Malaysian government's commitment to the development of SMEs started in the early 1970s. The New Economic Policy, introduced in 1971, was aimed at improving people's welfare and restructuring the ethnic economic imbalance. The government was committed to the development of SMEs. The commitment was reflected in IMP2, which ended in 2005, and is reflected again in IMP3 (2006-2020), as part of the country's vision of becoming a developed nation come 2020 (MITI, 2005). As shown in Table 3.9, Malaysian SMEs can be defined according to size, turnover and activity and fall into two broad categories (SMIDEC, 2002):

1. Manufacturing, manufacturing-related services and agro-based industries, which have either fewer than 150 full-time employees or an annual sales turnover of less than RM25 million.
2. Services, primary agriculture, and information and communication technology (ICT), which have either fewer than 50 full-time employees or an annual sales turnover of less than RM5 million.

Table 3.9: Definition of SMEs in Malaysia

	Category	Micro-enterprise	Small enterprise	Medium enterprise
1.	Manufacturing, manufacturing-related services and agro-based industries.	Sales turnover of less than RM250,000 or fewer than five full-time employees.	Sales turnover between RM250,000 and RM10 million or between five and 50 full-time employees.	Sales turnover between RM10 million and RM25 million or between 51 and 150 full-time employees.
2.	Services, primary agriculture and information and communication technology (ICT).	Sales turnover of less than RM200,000 or fewer than five full-time employees.	Sales turnover between RM200,000 and RM1 million or between five and 19 full-time employees.	Sales turnover between RM1 million and RM5 million or between 20 and 50 full-time employees.

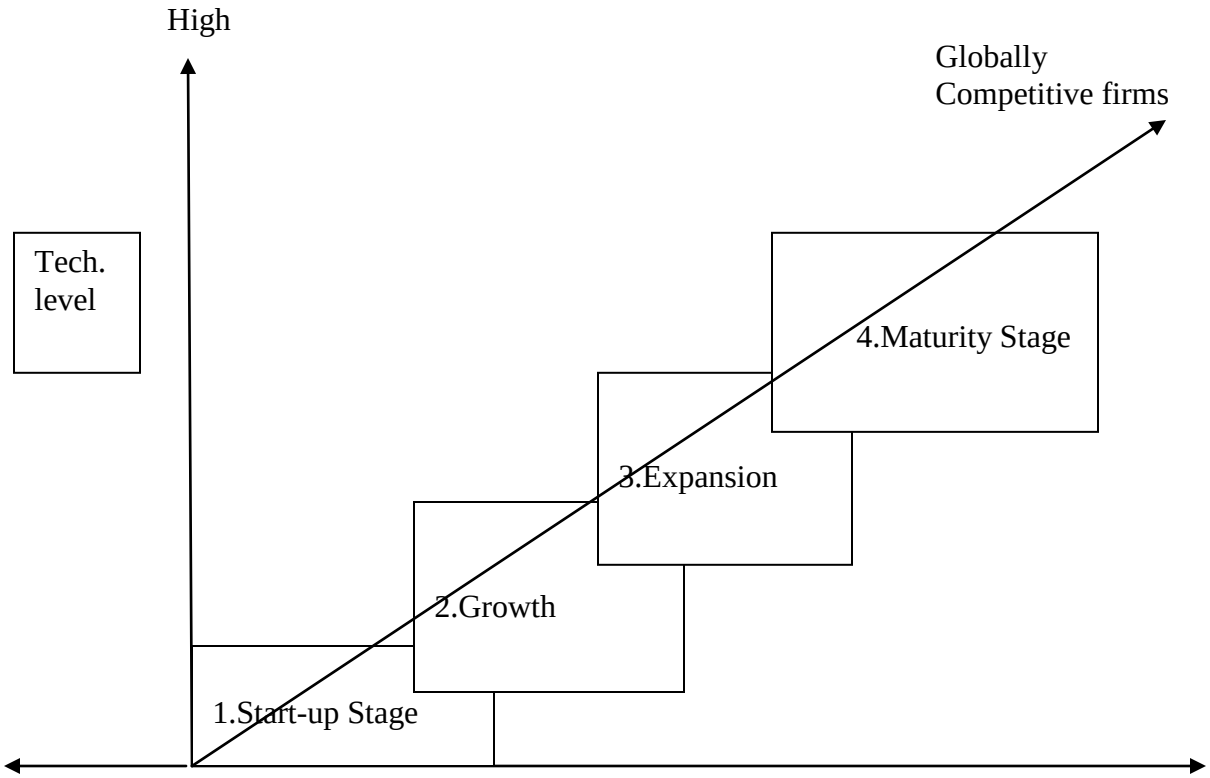
Source: SMIDEC, 2002

There were various policies and strategies under these IMPs to enhance the growth of the manufacturing sector across the entire value chain and cluster-based industrial development. Figure 3.4 shows the phases of development of enterprises in Malaysia's SMEs. As in many other countries, SMEs in Malaysia face barriers to their growth, which studies have identified (Saleh and Ndubisi, (2006); Moha, 1999; and SMIDEC, 2002).

Incentives are available for local firms to undertake technological activities. The types of assistance extended to local firms comprise financial assistance, fiscal incentives, advisory services, training and infrastructure support, and R&D. Among fiscal incentives for local suppliers are 'pioneer' status, an investment tax allowance (ITA), abatement for adjusted income (AAI), and a reinvestment allowance (RA). Besides this assistance, special industrial zones for local suppliers have also been set up. However, despite the government's commitment to develop local suppliers, a significant number of incentives

and assistance measures have not been taken up. Studies have shown that bureaucratic red tape, collateral requirements and the inappropriateness of services offered are the main factors contributing to the ineffectiveness of such assistance (Salleh, 1992:21).

Figure 3.4: Phases of Enterprise Development (Source: SMIDEC, 2002)



1. Start-up
R&D incubator
Adequate workforce
Market knowledge
Adequate raw material supply
Adequate infrastructure

2. Growth
Certification/standard
Technical assistance
Automated process
Tax benefit
Market development

3. Expansion
Technological capability
Management capability
ICT capability
Brand development
Venture capital
Outsourcing
Distribution channels

4. Maturity
Design capability
Brand name promotion
Industrial upgrading
Investment abroad

3.14 Previous Studies on Local Suppliers' Technological Capability Building in Malaysia

This section explores existing studies on technological learning through backward linkages in Malaysia. In regard to the petrochemical industry, there is as yet no study on backward linkages in Malaysia. Most of the studies that have been done on backward linkages in Malaysia concern the E&E industry. For the E&E industry sector, studies have found that MNC subsidiaries have provided significant technical support to their local suppliers (Ismail, 1999). Among the forms of support given are the solving of specific technical problems (Capannelli, 1999) and assisting in factory layout, production planning and machinery installation (Ismail, 1999). In a report to the Malaysian government for the E&E industry, Lall (1994) questioned whether economic growth could be sustained in the long run due to a heavy reliance on FDI and a lack of participation by local firms in the manufacturing sector. Wong (1991) and Capannelli (1999) found that there was a lack of local supporting firms to begin with, and this lack contributed to the lack of subcontracting linkages between Japanese MNC subsidiaries and local suppliers. Other authors have also reported on the lack of "local linkages" in Malaysia (Lim and Pang, 1991:107; Anuar, 1992; O'Brien, 1993). As a result of these studies, the Malaysian government has put down incentive (local content) policies through the five development plans, and also the three Industrial Master Plans and programs such as the VDP and ILP, to encourage inter-organizational linkages between MNC subsidiaries and local SMEs.

In the middle 1990s, many MNC subsidiaries encouraged local firms to undertake technological activities. However, it was found that linkages were inadequately formed due to the nature of the industry, which depends heavily on imported components (Noor, 1999). Yet, other studies provide evidence that local suppliers have formed linkages with

MNC subsidiaries to enhance their innovative capabilities (Ariffin, 2000). This tends to counter the belief that there is a lack of subcontracting linkages between subsidiaries and local suppliers. Rasiah (2002) found that MNC subsidiaries in Penang tend to enjoy greater linkages with local firms due to greater synergy with local support institutions and the local industrial cluster. Giroud (2003) found that MNC subsidiaries had an impact on Malaysia through backward linkages, even if the overall impact was small.

Even though studies have shown that there is evidence of backward linkages and spillover effects from the presence of MNC subsidiaries, the impact on local suppliers has not been measured except in regard to innovative capacity, which was measured by Ariffin (2000). In a study based on interviews in 1999, Best and Rasiah (2003) measured the innovation activities of firms in the Malaysian E&E industry. They found that the most innovative firms in Malaysia, in regard to product innovation, were MNC subsidiaries. These studies show that such firms are innovative because they have access to R&D capacities at their home headquarters. By contrast, local firms are limited to less sophisticated products. Innovative product design is similarly dominated by MNC subsidiaries, although there is some evidence of diffusion and the development of design capacity in local firms (Best and Rasiah, 2003). For process innovation, there are more signs that Malaysian firms are near the cutting edge, at least in the area of assembly and test operations (Best and Rasiah, 2003). Best and Rasiah (2003) also mentioned that component firms had introduced process improvements to help them to meet market fluctuations.

The development of local suppliers' capabilities has resulted in a gradual sharing of development tasks between MNC subsidiaries and Malaysian firms. Malaysian firms are not yet ready to undertake major innovations, but incremental innovation, especially in the form of minor improvements, is quite common (Best and Rasiah, 2003). Giroud (2003)

shows that local sourcing can be high in Malaysia, even if it does often result from purchases by foreign suppliers operating in the local market. Iguchi (2008) found that for the E&E industry, firm-level factors such as a subsidiary's level of autonomy and local sourcing rate as well as environmental factors are positively related to the intensity of backward linkages. In the case of local suppliers linkages with the subsidiary, Iguchi (2008) found that the technological capability level of local suppliers is affected by the breadth of backward linkages and that local suppliers' technological capability is affected by the internal factors of suppliers.

3.15 Conclusion

An overview of industrialization and technological development in Malaysia shows how the economy has expanded. Petronas, a government-linked company, was established to develop the nation's oil and gas resources. The company has since been actively involved in the petroleum and gas industry, and has now taken a leading role in petrochemical industry operations. The Malaysian petrochemical industry has become a major engine of economic growth in the country. The chapter gives an overview of the petrochemical industry with a view to answering two questions: whether Petronas has done enough to upgrade the technological capabilities of local suppliers in the petrochemical industry and, if it has done so, how it was done.

[i] See www.malaysiaenergy.com
[ii] Ibid.
[iii] From interview with LOP.
[iv] From interview with LOP.
[v] *Technology Business Review*, Vol.21 p.86.
[vi] http://www.ecerdc.com/ecerdc/oil.htm accessed 27 Oct 09.
[vii] Malaysian Prime Minister's Office website, www.pmo.gov.my
[viii] Ibid.
[ix] Ibid.
[xx] Sarmidi, 2001, p. 8.
[xi] ECER website: www.ecer.gov.my
[xii] See www.associatedcontent.com
[xiii] From interview with LOP.
[xiv] From interview with LOP.
[xv] See www.malaysianmission.com accessed 20 Oct. 09.
[xvi] Ibid.
[xvii] See www.jaring.my/petronas/economic/genstat.html#crudeoil accessed 20 Oct. 09.
[xviii] www.malaysianmission.com accessed 20 Oct. 09.
[xix]ww.wikepedia.com accessed 20 Oct. 2009.
[xx] See www.petronas.com.my
[xxi] www.petronas.com.my accessed 20 Oct. 2009.
[xxii] Malaysia, 1996 7th Malaysia Plan.
[xxiii] M.I. Abdul Mutalib, Platform, Jul-Dec 2004, p. 3.
[xxiv] *Technology Business Review*, Vol. 21, p. 86.
[xxv] Sarmidi, 2001, p. 12.
[xxvi]Sarmidi, 2001, p. 12.
[xxvii] Sarmidi, 2001, p. 13
[xxviii]M. I Abdul Mutalib, Platform, Jul-Dec 2004, pp. 3-4.
[xxix] Petronas Prospectus 2010.
[xxx] http://www.optimal.com.my/about_us/optimal_olefins.asp accessed 5 Nov 2009.
[xxxi] http://www.optimal.com.my/about_us/optimal_glycols.asp accessed 5 Nov 2009.
[xxxii] http://www.optimal.com.my/about_us/optimal_chemicals.asp accessed 5 Nov 2009.
[xxxiii] Petronas Prospectus 2010.
[xxxiv] Sarmidi, 2001, p. 13.
[xxxv] From interview with LOM.
[xxxvi] From interview with LOP.
[xxxvii] http://www.mohr.gov.my
[xxxviii] http://www.mohr.gov.my