Industrial Technology Development in Malaysia

Industry and firm studies

Edited by

Jomo K.S., Greg Felker
and Rajah Rasiah

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ROUTLEDGE

INDUSTRIAL TECHNOLOGY DEVELOPMENT IN MALAYSIA

Over the last decade Malaysia's remarkable economic performance has attracted attention around the world and been subject to much study and enthusiastic acclaim. However, in the wake of the present financial crisis, the debate has centred on whether this impressive growth rate can be sustained. As the economy moves beyond growth based on low labour costs and other factor-endowed advantages industrial technology development becomes increasingly critical to continued growth.

This volume, and its companion, *Technology, Competitiveness and the State*, evaluate Malaysian industrialization in terms of its experience of and prospects for industrial technology development. The focus is on the development of Malaysia's technological-industrial base from a sector and firm-specific perspective, including the role of foreign multinationals in this process. *Industrial Technology Development in Malaysia* provides a valuable analysis of the technological development of a Newly Industrializing Country and reflects on whether existing development strategies can be maintained in the wake of the financial crises sweeping the East Asian economies.

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1

INTRODUCTION

Rajah Rasiah and Jomo K.S.

The discourse on economic development policies has shifted during the 1990s. At the heart of current debates is the issue of productivity growth, and whether particular strategies can engender rapid increases in productivity by stimulating technical change. It has long been recognized that technical change is key to long-run growth. Until recently, the dominant approach to this question focused on changing factor endowments – with labour-intensive technologies giving way to capital- and technology-intensive activities through incremental adjustments as relative prices change – and supported neo-liberal policy prescriptions. This paradigm, which emphasizes a “natural rate of growth” and structural change, fails to adequately explain the unusually rapid growth of the East Asian newly industrializing economies. Thus, a heterodox approach has grown, one which views technology as a distinct set of capabilities partly embodied in physical capital (Kaldor 1957). In this view, rapid growth stems from deliberate efforts to broaden and deepen technological capabilities in conjunction with (and largely through) high rates of investment in new physical capital. Long-run differences in industrial development involve and reflect differences in the accumulation of technological capabilities – i.e. the national, industry and firm-specific skills; knowledge and organization that enable productive enterprises to efficiently utilize new knowledge; information and equipment.

Conceived in this way, industrial technology development involves not only the ability to innovate at the technological frontier, but more importantly for late industrializing countries, efforts to absorb and build upon knowledge related to existing production processes. The transfer of skills and information from one locale or firm to another is usually a protracted process. In a new environment with different physical, spatial and social characteristics – including new plant and equipment or processes, and new personnel at managerial, supervisory and other shop floor levels – the productivity impact of even well-known technologies is never entirely predictable. In order to effectively utilize new production technology, recipients must undertake an explicit learning process as well as make accompanying investments in new skills and managerial tools. Search, experimentation and experience, involving intra-enterprise as well as inter-enterprise relations, all have a bearing on whether firms and whole industries achieve "static efficiency". Becoming and staying efficient in the real world of dynamic change – with rapid product and process innovation as well as changing preferences and other market conditions – are even more challenging. In short, to maintain competitiveness successful technology transfer involves a process of capability-building on the part of the recipient, and this process may be viewed as a distinct category of investment.

Lall (1996: 31) suggests looking "at the development of firm-level competitiveness as investment in 'embodied' technology (plant, equipment, licences, blue-prints, other external inputs) accompanied by investments in skills, information, organisational improvements and linkages with other firms and institutions". If investments in embodied technology outpace investments in technological capabilities, the consequences are "likely to be inefficiency, stagnation and waste". Lall (1996: 31–3) highlights some key features of technological capability building-cum-investment:

- the investment has to be purposive as few capabilities can be developed costlessly;
- such investments are very sensitive to incentives, cost and resource availability;
- learning processes themselves often have to be learnt as there is no clear learning curve;
- technological capabilities can be developed at most points in production processes, and should not only be associated with formal research and development (R&D) except when approaching world technological frontiers for very advanced technologies;
- the costs, complexity and risks of such investments rise with the sophistication of the technology and level of technological development achieved;
- enterprises usually develop new capabilities through dense networks of formal and informal relations with suppliers, customers, competitors, consultants and technology, research and educational institutions which vary with the industry and enterprise and over time;
- technological capabilities evolve over unique trajectories. Such investments are best seen as cumulative, based on experience with utilization as well as modification and other modest innovations.

Different firms invest, to different extents and with different degrees of success, to achieve various technical objectives. These may include:

1 lowering process or labour costs, energy or materials requirements, as well as the wear and tear on plant and equipment;
2 adapting to host country market preferences, supply conditions and other conditions; raising labour or equipment productivity;
3 achieving full capacity;
4 improving product quality and reliability;
5 finding reliable subcontractors and supplies;

6 acquiring up-to-date information on relevant markets and technical change; and
7 innovating with new products as well as processes.

Influences on investments in capability-building

Lall (1996) identifies five major influences on technological capability acquisition:

- the incentive structure faced by firms, including macroeconomic policies, the international trade regime and domestic competition policies. He emphasizes the importance of efficient technology utilization and high rates of productivity growth;
- skills availability, in terms of quantity and quality, as well as in the formal educational system and work-related skill-upgrading efforts;
- technical information and support services availability, especially with the appropriate development of the national "science and technology infrastructure", particularly to address market failure problems due to the "public good" characteristics of certain crucial technological functions;
- availability of financing for such investments, requiring unconventional financing mechanisms for technological capability development, particularly since capital market failures are a major obstacle to technology development, especially in developing countries, partly due to some consequences of policy interventions (which should be eliminated), but also due to certain inherent features of financial markets;
- government technology development policies, especially the regulation of technology imports and foreign direct investment as well as focused R&D strategies, but also other direct policies such as fiscal and other incentives for technological development, procurement policies and other forms of support, as well as targeted technology development initiatives. Lall (1996: 47–9) warns against overly restrictive policies with adverse consequences, but also stresses the need for host country capability development efforts. He also cautions against complacent expectations of technology transfer through open door policies to foreign investment, and notes that transferring the results of innovation is quite different from transferring innovation capability.

Although all countries and firms nominally have equal access to the global stock of technology, there are significant differences in countries' and firms' abilities to use industrial technologies. Such differences are partly due to the different national environments, including policies and policy implementation, to which firms respond. In particular, developing countries' market and institutional conditions often make capability development difficult, slow, uncertain and expensive. The result is poor static operational efficiency and limited potential for further technological development.

Aware of the growing consensus that sustained industrial development requires distinct investments in productivity growth, governments of late industrializing nations have pursued strategies – utilizing both market and non-market co-ordination – to ensure continuous upgrading of their technological capabilities. The type and degree of manufacturing promotion has varied with industries, production stages and market niches. Industrial competitiveness has been achieved through domestic capability building rather than mere exposure to external competition. Government intervention has particularly been significant in averting potential market failures: e.g. where information asymmetry, scale economies, learning effects and public goods characteristics had been involved. Not all interventions by governments in latecomer economies have, however, been successful. Even in the elite North-east Asian economies, severe government failures afflicted certain industries. In general, however, effective state–business co-ordination helped minimize both government and market failures. The companion volume to this one evaluates the nature of the policy environment in Malaysia and its influence on technological change.

To assess the depth of industrial development, however, it is necessary to understand the dynamics of technical change itself. Technical change is a complex process that takes place under specific circumstances and with different implications. Some changes are simple and emerge in day-to-day operations, while others occur in radical spurts that demand wholesale shifts in production techniques. For a long time, mainstream economists have viewed technical change as exogenous to firms' ordinary operations and decision making. However, the walls of this unexplained "black box" crumbled when economists began to examine the technical change process in greater detail. Scholars of the field have developed frameworks for assessing the technological capabilities of economies as they move along the development trajectory, and for considering both direct and supporting agents of such change.[1] This book draws from this rich literature to examine technological change in Malaysia's manufacturing sector. Since technical changes in firms have several underpinnings (e.g. industry characteristics, competition, institutional support, etc.), the book builds on industry and firm-level case studies to assess Malaysia's movement towards technology frontiers.

The economics of technical change – innovation theory and economic development

Analysis of technical change can be traced to classical economists such as Smith, Ricardo and Marx, who generally confined their analysis to mechanization. Both Ricardo (1971: 378–9) and Marx (1961: 312–17) noted the additional gains that accrue to the creators of new productive methods. Innovation received further attention following Schumpeter's (1987) work on its role in driving economic growth.[2] Schumpeter pointed out the flaws in Alfred Marshall's assumption that the technology frontier is exogenously determined and that firms' marginal cost curves adjust to competition. He argued that entrepreneurial profits or monopoly rents, which orthodox theory views as wasteful anomalies, should accrue as an incentive to entrepreneurs investing in risky, lumpy and uncertain innovative activities. In the Schumpeterian framework, the innovator – motivated by the prospect of monopoly rents – actively shapes the technology frontier, in turn triggering emulative responses by other competing firms. There is, thus, no uniform or steady shift of the production frontier, but rather localized bulges, as noted by Atkinson and Stiglitz (1969). Although some innovations arise during actual production without specific efforts to generate them, a number of firms consciously seek to innovate. Such firms are driven to innovate by a combination of positive incentives in the form of *quasi-rents*, such as those that arise from patent legislation, and the pressures of competition. Nelson and Winter's (1977) seminal work elaborated on Schumpeter's insight and demonstrated that firms constantly seek to innovate.

Unlike scientific advance, which usually involves increases in the stock of verified knowledge, technological learning is associated more closely with actual production experience. Since technical change is highly correlated with production experience, as Rosenberg (1969) and David (1975) have noted, firms' "ordinary" decisions on what and how to produce also affect their efforts to innovate. Rosenberg (1982) and David (1975) succinctly analysed the cumulative nature of innovations, with future innovations strongly shaped by previous innovations (path dependency) and their utilization in production.[3] Gains from innovations in firms generally depend on the extent of their utilization. As Nelson and Rosenberg (1993: 4) pointed out, the first firm to bring out a new product or process, i.e. the Schumpeterian innovator, often does not capture most of the rents from the innovation. Hence, innovations include changes to existing designs and processes that arise in the course of firms' efforts to absorb and utilize them. Firms often also considerably modify machinery developed and sold by other firms to maximize gains from their capital investments. Such adaptation of machinery by user firms is an important source of process innovation (see Rasiah 1995) even in the absence of systematic innovation strategies.

Recognizing these broad parameters of innovation is especially critical to industrial latecomers, who begin near the bottom of the technology ladder and have little capacity independently to invent new products and processes. The movement of firms towards technology frontiers can be viewed as involving four stages, namely: simple manufacturing; original equipment manufacturing (OEM); original design manufacturing (ODM); and original brand manufacturing (OBM). Such a sequence of catching up elevates the significance of technology "followership" through learning and imitation. Despite offering a sound explication of the innovation process, Schumpeter none the less underestimated the significance of incremental improvements that emerge from minor innovations (see Nelson and Winter 1977, Amsden 1989, Freeman 1994). Recent industrializes such as South Korea and Taiwan have relied considerably on incremental innovation to compete with firms in the technological vanguard. Reverse engineering, technical licensing and other opportunities for contractual and non-contractual technological absorption have quickened the pace of innovation, and thus narrowed the gap between successful latecomer firms and frontier firms. While technological supremacy, *inter alia*, requires investing in research and development (see Scherer 1992), the catching up experiences of firms like Samsung (see Edquist and Jacobsson 1987) and Hyundai (see Amsden 1989) of South Korea – in electronics and shipbuilding – have depended heavily on technological licensing and adaptive engineering. It is thus vital to study the prospects for and extent of absorption of technology by firms operating in Malaysia.

Institutional influences on innovation in industry

While firms are the critical agent for the creation and implementation of innovations, the long-term sustainability of innovative efforts depends very much on the institutional network in which they are embedded. The institutional framework necessary for successful innovation is not clearly defined, however. Such institutional frameworks are often loose, almost by definition, e.g. involving universities, government laboratories or firm-funded institutions. R&D activity is only one major component of such a framework. Even the successful examples of the United States, Germany and Japan have involved rather different institutional set-ups. For example, fundamental research in the United States is dominated by universities. Government laboratories concentrate on strategic policy areas such as nuclear energy, health, military and agriculture. An example of government-funded research that eventually inspired firms' utilization and development is the transistor invented in the Bell laboratories in 1948 (Marsh 1981). Publicly funded laboratories in Germany strongly emphasize both basic and applied research: Max Planck Institutes do basic research, while Fraunhofer Laboratories do applied research (Nelson and Rosenberg 1993: 13).

Innovations involve interactions among a far more diverse set of institutions than merely R&D institutes. The innovative capability of firms and the context they operate in depend on how related institutions influence technological advancement. As Nelson and Rosenberg contend, this depends, *inter alia*, on:

> the character and effectiveness of a nation's system of schooling, training and retraining not only determine the supply of skills from engineer to machine tender, but also influence the attitudes of workers towards technical advance. So too do the patterns of labour–management bargaining and negotiation, dispute resolution, and the degree of mutual commitment of firm and workers. Financial institutions, and the way firms are governed and controlled, profoundly influence the technical activities that are feasible and that managers choose to undertake.
>
> (1993: 13)

The importance of surrounding institutions is the touchstone of the literature on national systems of innovation, an approach developed in Lundvall (1985, 1992), Nelson (1985, 1993) and Freeman (1987), and addressed more extensively in our companion volume. The parameters of such a system go well beyond the institutions supporting R&D. Coombs *et al.* (1992) as well as Carlsson and Jacobsson (1993) note that such a system encompasses networks involving support from corporate and government bodies to establish technology alliances and access external scientific research information and innovations. This is a major channel of technology acquisition for generic technologies such as microelectronics (Nelson 1962, Dosi 1984, Freeman 1991, Lundgren 1991). The absorptive capacity of local firms is generally enhanced when national institutions effectively co-ordinate the absorption, adaptation, assimilation and further innovation of technology.

The institutions that shape innovation include not only specialized technology *policies* and *organizations*, however, but also the broader *rules* and *structures* that affect firms' investment incentives. Scholars have shown how different systems of management–labour relations, for example, powerfully influence technical advance, as demonstrated by the apparent success of the collaborative labour–management systems found in Germany and Japan (Best 1990, Lazonick 1992). Process innovations in particular depend on the nature of industrial relations. Ford Motors is a good example of a firm that has absorbed Japanese-style management practices (including just-in-time organization) to compete. Unions – whether enterprise-oriented, as in Japan, or nationally organized, as in Germany and Sweden – are often critical in determining the structure of management–labour relations and, through them, firms' innovation behaviour. Even where unions are weak or non-existent, some firms practise "progressive" labour relations because of their desire to accelerate technological learning. In Malaysia, for example, union activity is circumscribed by government policies, and labour exercises comparatively little political influence. In the foreign-dominated electronics sector, for example, government regulations permit only in-house unions, and even these are actively discouraged or controlled. Despite labour's weak bargaining position, firm- and industry-level studies have shown that some multinationals have adapted labour relations unilaterally as they have introduced flexible or lean production techniques to Malaysian conditions.

The institutions that influence innovation also include industry attributes like competitive structure, business networks and inherent technological properties. Some such attributes are generic to manufacturing as a whole, while others are industry-specific and still others are product-specific. The sophistication of the computers assembled by IBM, Compaq and Dell, for example, depends on the micro components manufactured by Intel, Motorola, Seagate and several other firms. Technical advancement in pharmaceuticals and palm oil is, however, different as it involves quite different and distinct products and uses. The likelihood of continuous improvements to existing products is relatively less, though process improvements are generally considerable, even in pharmaceuticals. Malaysia's industrial structure has become quite diverse so that its range of products varies from technologically simple garment and plywood making to sophisticated microprocessor redesign. This diverse spectrum of industries requires industry-specific assessments of the sources and patterns of successful innovation.

Although customers ultimately judge the usefulness of innovations, most choices between alternate paths of innovation occur inside firms and are opaque to customers. Developments in information technologies help intermediate customers to better access the production processes in supplier firms. Thus, information-sharing networks between upstream firms (e.g. components producers) and downstream firms (e.g. assemblers) may enhance innovation efforts and lead to greater overall dynamism. Networks for user–producer information sharing are evident in several Malaysian industries, particularly among multinationals and their key components suppliers. Final consumers typically do not share similar access to the innovation process. Successful firms have, nevertheless, increasingly attempted to integrate marketing with production and innovation so that their goods meet customer tastes. For example, just-in-time production seeks to meet both the qualitative as well as quantitative requirements of customers. Using producer–user feedback to stimulate innovation and gain competitiveness in international markets requires adopting some form of flexible production techniques. Some branches of Malaysia's manufacturing sector have adopted elements of flexible production systems along with explicit mechanisms to integrate marketing.

Modes of learning and innovation

Unlike product designs, many process and organizational technologies do not enjoy legal protection, and follower firms may imitate the innovator very quickly. This is particularly relevant to late industrializing economies, where national firms are generally still far from the technology frontier. Technology absorption takes place at a faster pace than new innovations generated by technological leaders, thus allowing latecomer firms to move closer to the global technology frontier. Given the cumulative nature of the innovation process, moreover, late-comer firms may begin from higher levels of productivity than the global leaders in an earlier era. Such an understanding of innovation also helps us assess the relative movement of particular – especially national – firms towards the technology frontiers.

Such imitation and absorption, so crucial to late industrializing firms, remains distinct from the capacity to further develop acquired technology through autonomous innovation. This latter ability frequently requires more formal R&D activities. Because of the risks and uncertainties associated with R&D (see Schumpeter 1987), governments all over the world have offered varying degrees of support to promote R&D. Arrow (1962) justified government involvement – through subsidies and tax incentives – when there exists a gap between private and social rates of return. Given the scale and potential effects that can be generated by R&D, government intervention, whether direct or indirect, becomes critical. Government participation in R&D is extensive in Germany and France, while government-supported and -monitored R&D is central in Japan (Johnson 1982). South Korea strongly emphasizes long-term R&D projects involving experts from industry, universities and the government. R&D funding in Japan and South Korea shifted gradually towards industry domination only after firms had developed their own capabilities (Kim 1993). In Taiwan, where small and medium firms dominate the industrial structure, government funding is still dominant, while R&D tax credits, tariff exemptions and accelerated depreciation allowances are offered to stimulate firms' participation (Wang and Chen 1995). Even in Britain, where commercial institutionalization of R&D is weak, the government makes grants for priority R&D activities. Despite strong results in molecular biology, the main beneficiaries among firms of British R&D have been American firms (Nelson and Rosenberg 1993). In short, the mere existence of government R&D policies is insufficient to guarantee that national industry will benefit by way of improved innovative capabilities. The Malaysian government has adopted ambitious R&D promotional policies as described in a companion volume. This volume focuses on industry and firm-level assessments of R&D capabilities in Malaysia.

Though formal R&D is often important, firms also consciously invest in improving product design and processes without any separate R&D department or unit. In addition, firms also sometimes generate improvements in product design and production processes through experience. In the Malaysian context, for example, engineers involved in production have discovered more effective methods of palm oil processing, while several multinationals have programmes to gather suggestions for more effective organization from their line workers. Worker-based organizational improvements – often strongly stimulated by total quality management (TQM) systems that use collaborative industrial relations practices – may involve cognitive, statistical and innovative participation by all employees.

Systematic firm-level strategies to promote incremental innovations have long been in existence. Hollander (1965) and Townsend (1976) – who studied technical change in Du Pont's rayon plants and the British coal industry respectively – noted that the majority of innovations emerged as simple improvements by technical personnel to equipment and work organization. The Japanese have introduced new dimensions to incremental innovations, using external networking and internal co-operation through incentives, industrial relations, training and in-firm work systems such as quality control circles (QCCs) (see Dore 1973, 1987, Aoki 1990, Imai 1991); such practices are spreading across industries.

These organizational techniques have been a major source of efficiency gains among East Asian latecomer firms (Best 1990, Rasiah 1995). Schonberger (1982), Lubben (1988) and Sayer (1986) succinctly analyse the organizational synergies produced by these innovative techniques. TQM, cellular manufacturing, QCCs, total productive maintenance (TPM), integrated materials resource planning (MRPII) and statistical process control (SPC) are now proven mechanisms, not only for achieving a lean, efficient and competitive enterprise, but also for engendering continuous innovation involving virtually the entire workforce and all operations (see Rasiah 1993). Though early explorations pondered the contribution of Japan's unique culture to its firms' production flexibility, it is now widely acknowledged that such techniques can travel and generate competitive gains in other national settings (see Best 1990, Rasiah 1994, Kaplinsky 1994). Given the importance of state-of-the-art manufacturing techniques, some of the following chapters undertake firm-level studies of their impact on manufacturing performance in Malaysia.

Using innovations effectively generally requires firm-level production experience (see Pavitt 1984). During their early evolution, firms generally absorb few results from research laboratories. It is only as they get closer to the technology frontier that such discrete, formal innovations become relevant. In other words, the depth of innovations and proximity to the state of the art generally increase as firms expand their operations. As past studies show (see Freeman 1994), the significance of employees with scientific and technical backgrounds also rises and becomes critical as firms evolve. In a number of industries (e.g. textiles, iron and steel) latecomers require quality education and training for their labour force in the sciences and technical fields, well before starting formal R&D. It is thus important to examine whether the requisite human resource development (HRD) capabilities are developed to meet changing needs and requirements.

As noted earlier, in certain industries, such as chemicals and microelectronics, universities and complementary government laboratories have been critical in supporting the development of firms' technologies. Microelectronics has traditionally enjoyed government support in Germany, France, Japan and the United States. Similar trends also characterize South Korea and Taiwan. The eight-year plan in South Korea to promote electronics, and special incentives given to Taiwanese firms to invest in and utilize electronics-based research, exemplify the strong government participation in these economies. Given the multiple uses of microelectronics technology, it is understandable that close collaboration between government laboratories, universities and firms has been a critical component of the dynamic institutional arrangements associated with this field. Firms embedded in such institutional arrangements will have far greater potential to receive and utilize innovations. Electronics technology has a wide spectrum of potential for diffusion. The automation and infusion of digital systems in the production organization of several industries has raised the significance of microelectronics technology. Unlike industries such as textiles, apparel, steel and automobiles, electronics technology is increasingly becoming a major source of process efficiency in almost all industries. Hence, strong links among firms, universities and government laboratories are needed as firms get closer to their respective technology frontiers.

Foreign direct investment and technological learning

Foreign direct investment has long been viewed suspiciously as an agent of technology transmission. Critics of foreign firms often point out their reluctance to transfer technology (Amin 1973). It is important to note that technology transfer is a two-way process involving licensors and licensees or the producer and other users. Given the nature of capitalist institutions, it is unrealistic to expect any firm to transfer technology without sufficient gain or compensation. There are, however, several circumstances under which firms, driven by their own interests (e.g. to enjoy financial incentives), may contribute to such transfers. Even when such opportunities exist, though, transfers do not occur automatically or easily. Recipients' absorptive capabilities are critical for ensuring that transfers actually take place and lead to subsequent adaptation and further innovation. There are also several important aspects of know-how that diffuse without or despite patent controls (see Rasiah 1995). Such transfers become part of the technological infrastructure so important for "latecomer" development. The accumulation and development of technology may enjoy coherence and effective direction if governed by suitably dynamic institutions.

Licensing, know-how agreements, as well as technology sharing and spin-offs generated by foreign firms operating in Malaysia, are major sources of technical change critical for the development of firms. Fukasaku (1992) and Amsden (1989) have shown the strong influence of technological imports to Japan and South Korea. The import, absorption, assimilation, adaptation and further innovation of foreign technology have been important stages of the technological learning undertaken by domestic firms in these economies. Mitsubishi Nagasaki Shipyard in pre-war Japan (Fukasaku 1992) and Hyundai Heavy Industries Corporation in South Korea in the 1970s (Amsden 1989) are classic examples of successful technology acquisition and development that enabled beginners to catch up with and eventually overtake the leaders in shipbuilding. Freeman (1987) also noted evidence of management of technological development by improving imported technologies in Japan in the 1950s and 1960s.

Some transfers take place from transnationals to local firms, while others occur within transnationals from headquarters to local employees in offshore sites. Innovations in such sites sometimes bring about a reverse flow of technology from the overseas subsidiary to the home-country headquarters. Recent research into Malaysia's foreign-dominated manufacturing branches depicts several instances of such patterns (Rasiah 1995: chapter 2). Given the prominence of multinational corporations in Malaysia's industrialization, it is important to examine several issues: the extent of technology imports into the country; the relative significance of local firms in the utilization of imported technology; the development of inter-firm technology flows from foreign subsidiaries in Malaysia to local firms (e.g. through subcontracting links); the impact of institutions governing technology appropriation on the extent and form of transfer activities; and the extent of success achieved by local firms in acquiring technology. Each of the chapters which follow take up some or all of these issues.

The chapters

Taking cognizance of these aspects and dynamics of technical change, this book examines technology development in the Malaysian economy, sectors and firms. Given the varied nature of technical change, the book does not claim to offer a comprehensive account of technology development in industrial firms in the country, but instead assesses the extent and depth of such development in selected industries and firms. The chapter by Mohd Nazari Ismail focuses explicitly on the question of the TNCs' (transnational corporations') role in fostering technological development. Mohd Nazari's analysis finds that TNCs have undertaken substantial technological development in Malaysia in several vital areas, including forming linkages to local firms, training and promoting local workers and managers, integrating R&D and design with production, producing increasingly complex and sophisticated electronics products. Some of these trends are more advanced than others; for example, most TNCs continue to rely on parent companies for product R&D. However, Mohd Nazari finds that "the trend in TNCs' Malaysian product R&D and design activities is quite promising, as the downstream segments of the electronics industry continue to expand".

Ong Fon Sim and Mohd Nor Othman examine the adoption of best-practice innovation management and organization in Malaysian industry through a firm-level comparative analysis of local companies and Japanese MNCs (multinational companies). Their study compares the strategies, organizations and processes which four companies use to manage technological innovation of various types (products, processes, and social/human capital). The study finds differences between Malaysian-owned and Japanese firms in the scale and type of innovation which stem in large part from length of production experience as well as production and marketing strategies. Differences are most stark, however, in the realm of "social innovation" and in the process of innovation management. The Japanese firms invest heavily in worker training and encourage open horizontal and vertical information flows for continuous improvement, whereas Malaysian companies rely on limited on-the-job training and manage technical change hierarchically. Ong and Mohd Nor also argue that Malaysian industries must adopt a new paradigm of best-practice management principles if the goal of stimulating private sector technological capabilities is to be achieved.

Several chapters examine technological change in Malaysia's leading industry, electronics, in which foreign affiliates predominate. Michael Hobday's study of twenty electronics firms reveals that "while the amount of R&D carried out in Malaysia is still very low, there is abundant evidence of significant innovations, including improvements to capital equipment, innovations in production processes and incremental product design". Global changes in automation technology triggered technological upgrading in the late 1980s, but Hobday shows that it was a prolonged process of local technological learning which enabled Malaysian subsidiaries of MNCs to assume higher and more vertically integrated niches within the MNCs' global networks. Though limited in scope thus far, MNCs' backward linkages are quite vibrant, as intensified competition has led most foreign producers to seek reliable local sub-contractors. Hobday concludes that the industry's technological dynamism suggests that it is likely to overcome oft-noted structural weaknesses and continue to deepen and advance, and that host government policies should aim to support technological upgrading in this foreign-dominated sector.

Lai Yew Wah and Suresh Narayanan present a survey of technology acquisition in Penang's electronics and electrical industry which indicates widespread use of medium- and high-level technology, both among foreign MNCs and their local supporting industries. Their analysis shows that product quality and production volume, rather than labour costs or other factor prices, are the key determinants of the level of technology used by firms in Penang. Serving quality-sensitive and technologically dynamic export markets induces MNC producers and their local suppliers, most notably electronic components firms, to achieve higher levels of technology utilization, while other Malaysian firms make fewer investments in upgrading their capabilities. Lai and Suresh note that Penang has several characteristics not easily duplicated elsewhere in Malaysia, including long-established MNC–local firm linkages, greater specialization in high-technology components production, and ethnic ties between MNC managers and local suppliers. Yet, the analysis does suggest that any effort to raise local firms' technological capabilities should emphasize the incentives for technical change created by involvement in quality-competitive export markets, either directly or through joint ventures.

Goh Pek Chen's study comes to a very different conclusion based on a comparison of Malaysia's semiconductor industry to the industry's earlier development in Korea and Taiwan. According to Goh, the Malaysian industry suffers from crucial structural limitations related to overwhelming domination by foreign companies, including concentration in relatively low-technology assembly, the absence of the higher value-added and more technologically sophisticated stage of wafer fabrication, and weak linkages to domestically owned suppliers and customers. These characteristics contrast sharply with the developmental pattern in the first-generation East Asian NICs, especially Korea and Taiwan where domestically owned firms expanded their stake in the industry and achieved integrated design, production and assembly with crucial government assistance. Goh notes the incipient positive trends in linkages to Malaysian firms, but draws attention to the constraints due to Malaysia's ethnic relations (dividing the ethnic Malay-dominated government authorities from the mainly ethnic Chinese domestic manufacturing interests) and weak human resource base for capitalizing on these trends.

Norlela Ariffin and Martin Bell study the relationship between capability-building in MNC subsidiaries and the forms of interaction between subsidiaries and their parent companies. Norlela and Bell also find substantial evidence of intra-MNC technological deepening. In contrast with mechanistic analyses which see subsidiaries as confined to simple production roles or as upgrading automatically over time, patterns of subsidiary development vary widely according to the role which subsidiaries play in their parents' global networks. Subsidiaries' linkages to their parents may involve ongoing participation either in production *or* innovation, or may focus on learning higher-level production or innovation capabilities through new training and information flows. The types of subsidiary/parent relationships observed in Malaysian-based electronics MNCs have evolved dynamically over time to the point where some have reversed the flow of technological information and provided assistance to their parent and affiliate companies elsewhere.

Giovanni Capannelli's study concentrates specifically on technology acquisition or transfer in Malaysian electronics. He isolates the question of technology transfer through sub-contracting linkages in his survey of Japanese consumer electronics producers. Capannelli argues that MNCs' local purchases of parts and components offer a powerful mode of technology transfer. However, domestic supplier investments in developing absorptive capabilities are a crucial prerequisite. Malaysian supplier firms have, in fact, benefited from direct forms of technology transfer from Japanese assemblers, such as advice on production problems, as well as indirect forms such as exposure to the buyers' high-quality standards and management culture. Yet, Capannelli finds that the assemblers source most technologically sophisticated components from other Japanese companies, while mainly procuring low-technology parts from Malaysian and joint-venture companies. His quantitative and contextual analysis of MNC procurement strategies suggests that the limited linkages to Malaysian suppliers reflect, among other factors, the dearth of such technologically competent, high-quality suppliers. Limited local investments in absorptive capacity thus appear to be a key constraint on technology transfer.

Rajah Rasiah's study of Eng Hardware highlights the potential as well as the limitations of ancillary supplier industrial and technology development in the foreign-dominated (mainly US) electronic components sub-sector. While the presence of US transnationals in Penang did not give rise to much local supplier activity in the 1970s, appropriate initiatives by the Penang state government and the rise of Malaysian managers in the foreign subsidiaries opened up opportunities for local suppliers with relatively limited relevant experience and capabilities. However, new firm requirements for more proximate local supplies as well as rapid learning by doing on the part of the emerging suppliers soon resulted in significant ancillary supply industrial activity. Contrary to some expectations, at least some of these suppliers have independently developed considerable capabilities and do not merely depend on their main customers indefinitely.

While Malaysia's electronics sector industry has developed under the unchallenged control of foreign investors, the automotive sector has been transformed by the state's direct role in production through Proton and subsequent national car ventures. Hans-Georg Leutert and Ralf Südhoff analyse technology development in Malaysia's automotive industry from the perspective of the literature on industrial clusters which highlights the need for flexible organizational forms and intensive interaction at the intra-firm, inter-firm and public/private levels. Drawing on surveys and interviews, they find that a competitive and technologically dynamic industrial cluster has failed to emerge thus far, despite the immense resources invested in the effort to develop an integrated industry. Ethnic entrepreneurship promotion goals and excessive protection were important policy flaws, while at the level of individual firms, Proton, its suppliers and non-Proton companies have made little progress in adopting key elements of the flexible production paradigm – technology such as computer-controlled machinery and management practices such as concurrent marketing, production and design. Domestic parts firms remain confined to low-technology products and are still highly dependent on foreign technology suppliers. Inter-firm sub-contracting networks remain undeveloped despite Proton's high-profile efforts at vendor development. Similarly, firms do not draw significant support from public technology or human resource and training institutions, few of which specialize in automotive technology. The analysis points to the need for more concentrated efforts to forge co-operative networks for innovation and technology diffusion. The authors note that several recent reforms move in this direction, though trade liberalization commitments leave little time for their maturation.

Kamaruding Abdulsomad's comparison of the evolution of the automobile industries in Malaysia and Thailand suggests parallel development in the 1960s and 1970s, with divergence beginning in the 1980s with the Mahathir government's decision to develop a national car project. Kamaruding considers some of the major implications of these different industrial policy choices for the development, nature and likely competitiveness of car manufacture in the two neighbouring South-east Asian countries, and particularly for the technological capabilities of ancillary automotive components manufacturers. While the lumpy nature of the investments involved and the changing nature of the international automobile industry and market does not allow any quick and easy conclusions, his comparative analysis offers useful insights, especially for those considering industrial policy alternatives.

Butler and Gill's study of Japanese-owned industrial joint ventures (JVs) in Malaysia considers the significance of trust, particularly in affecting their organizational dynamics. Their careful comparison of the experiences of two JVs offers useful insights into the actual role of the Malaysian government in terms of encouraging and affecting the emergence and development of such JVs. In one case, the policy environment has led to a JV with nominal ethnic Malay participation, but effective Japanese control, to qualify for vendor status to supply Proton, the national car project. In the other case, the ethnic Chinese Malaysian partner is far more involved in the firm, which has become internationally competitive, but does not qualify on ethnic grounds to supply the Proton.

Rokiah Alavi's study of Sapura considers the consequences of ethnic promotion more generally for industrial policy and technology development. As *Bumiputera* preference has not been conditional on rigorous performance criteria, most beneficiaries have understandably sought out lucrative opportunities offered or created by state intervention without devoting much effort to developing internationally competitive technological capabilities. While Sapura's growth and performance have been much more exemplary, e.g. as reflected by its significant investments in research, design and development, it has continued to rely on government-provided opportunities for much of its business expansion. Not surprisingly then, as the telecommunications industry has been increasingly opened to international competition, Sapura has sought to retain profitability by shifting to the still highly protected automotive industry.

Jaya Gopal's study of the emergence and competitiveness of the palm oil refining industry in Malaysia from the mid-1970s is probably the biggest success story for industrial policy in the country. Export duty exemptions rising with the degree of refining encouraged investment in refining capacity from the mid-1970s. Rapid learning and innovation for specialized palm oil refining – as opposed to generic vegetable oil – enabled the Malaysian industry to become very efficient and profitable within a decade. While the growing international market for oils and fats provided the basic environment, small but strategic interventions encouraged and facilitated investments in refining capacity which soon became internationally competitive.

This collection of studies reveals the complexity and dynamism of the industrial technology development process associated with Malaysia's rapid industrialization. In analysing technology development as endogenous capability-building, the studies capture the broad array of economic, strategic and institutional forces which shape firms' decisions to invest in innovation. Weighing both structural patterns and emerging trends at the micro- or firm-level, the authors differ in their assessments of the growth of technological capabilities and its contribution to Malaysia's manufacturing success. It should be noted that, whereas technical progress is central to economic growth, the relationship between the two is complex and difficult to measure with certainty. The recent debate about the contribution of productivity growth to East Asian economic success underscores this point (Krugman 1994).

One area of relative consensus reflected in this volume concerns the foreign sector. Several studies point to considerable technological development in the foreign-dominated industrial branches, though they differ in their assessment of whether these trends will overcome the constraints and challenges confronting Malaysia's high-tech ambitions. If current trends represent a successful transition to self-sustaining, technologically progressive industrialization, it will not be the result of state leadership, or the "natural" evolution of local firms, or even benign MNC-led globalization. Rather, these studies indicate that it would be an expression of the creation of new types of industrial governance appropriate to an era of globally integrated production – a particular intersection of strategies and governance roles played by the state, domestic businesses, MNC subsidiaries and MNC parent companies. Singapore's successful MNC-led industrialization involved a high degree of strategic intervention through a range of non-trade policy instruments, combined with specific changes in MNC strategies and networks.

Notes

1 See Rasiah (1997) for an account of the direct and indirect agents of technical change.

2 Although it has been established by other economists that growth precedes innovations (e.g. Svenilson 1954, Passinetti 1981), the central role of innovations in sustaining long-term growth is now indisputable.

3 Despite the uncertainty involving innovations, the general concentration of production and research energies around related innovations obviously makes history a major shaper of future innovations, i.e. path dependence. In contrast, Arrow (1994) seems to assume that history is not too relevant here.

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2

FOREIGN FIRMS AND NATIONAL TECHNOLOGICAL UPGRADING

The electronics industry in Malaysia

Mohd Nazari Ismail

Over the last three decades, developing countries have often viewed transnational corporations (TNCs) in largely negative terms. While many observers viewed TNCs as undesirable but often necessary, others saw them as the instruments of core-country capitalist exploitation of peripheral economies. According to such analyses, TNCs have few positive roles in the development of Third World nations and, in fact, create dependency effects which constitute one of the main obstacles to growth. However, developing countries' views on foreign TNCs seem to have changed over the last two decades and, consequently, they are no longer described in such negative terms. In fact, developing countries are now scrambling to attract foreign capital. Underlying this change is the belief that TNCs can indeed play a significant role in their host countries' technological development. But is this optimism justified?

This chapter discusses the role of foreign TNCs in Malaysia's technological development process by examining the impacts of electronics TNCs' local operations. There are two main reasons why the focus is specifically on the electronics industry. First, the industry is the leading sub-sector in Malaysian manufacturing in terms of export earnings and employment.[1] At the same time, it is also the sub-sector most dominated by foreign firms.[2] The chapter is partly based on data obtained from semi-structured interviews involving senior managers of twenty-nine foreign electronics TNCs and five local supplier firms conducted by the author in 1992. In addition, published data, including the findings of other studies, are also relied upon.

The chapter is organized in the following way. The next section reviews the development of the electronics sector in Malaysia, highlighting the role of TNCs in its growth and technological development. The following section considers the TNCs' contribution to three aspects of technological upgrading: linkage formation, skills formation and development of Malaysian managers, and technological deepening from manufacturing to R&D and other technology development. The chapter's central argument is that TNCs in Malaysia have spearheaded technological development in each of these areas, and that technological upgrading within TNCs can make major contributions to industrialization in developing countries.

The electronic's industry in Malaysia

The Malaysian government first wooed foreign investment as part of its effort to establish an import-substituting manufacturing sector. Early foreign investment was motivated by the desire to overcome tariff barriers and expand market shares. However, Malaysia's domestic market was not significantly attractive to most major electronics TNCs due to its relatively small population and low per capita income. Towards the end of the 1960s, dissatisfaction with the importsubstitution programme began to grow. The government decided that the import-substitution policy was not generating enough employment, and that the manufacturing sector was not absorbing enough labour due to inappropriately capital-intensive techniques.

In 1968, the Investment Incentives Act was passed to offer a number of incentives to encourage the growth of export-oriented industries. It also designated the electronics sector as a "priority industry" for investment incentives to attract export-oriented foreign investment (Aziz 1989: 120). The government's search for a new, employment-generating development strategy was accelerated by the race riots of 1969, which have been attributed to the unequal distribution of wealth and employment among Malaysia's ethnic groups. The Bayan Lepas Free Trade Zone (FTZ), the first in Malaysia, was established by the Penang State Government as part of its strategy to attract foreign TNCs oriented to the export market. Subsequently, other states followed Penang's example, and by the 1990s there were ten FTZs in Malaysia (MIDA 1992: 51). Foreign firms have therefore played an important role in the Malaysian electronics sector from its beginnings in the early 1970s.

Concurrent with policy changes in Malaysia, the global electronics industry was experiencing fundamental changes. Competitive pressures from new entrepreneurial start-ups and from Japanese companies encouraged American semiconductor TNCs to shift their assembly activities to low cost locations in Asia (Dicken 1992: 331). In due course, Japanese semiconductor manufacturers were also affected by similar competitive pressures. In addition to rapid increases in labour costs, Japanese firms' competitiveness was also eroded by steady appreciation of the value of the yen. Japanese firms also faced increasing trade friction resulting from the trade imbalances between the US and Japan. Therefore, from the late 1970s onwards and especially after 1985, Japanese electronics firms also shifted labour-intensive assembly operations out of Japan to a number of low-wage developing countries, including Malaysia. Unlike the semiconductor industry, where the activities transferred to Third World countries were largely labour-intensive assembly activities, firms producing consumer electronics (such as televisions) transferred other parts of the production processes overseas, including the production of crucial component parts such as picture tubes, flyback transformers and housings. As in the case of the semiconductor industry, an important factor that influenced the relocation of production facilities in consumer electronics to the South-east Asian region was the increase in the level of competition. However, while the main reason for American semiconductor manufacturers to locate their investment in the East and South-east Asia was competition from within the US, consumer electronics manufacturers were responding to competition from manufacturers from Japan and other emerging NICs in East Asia (Dicken 1992: 338).

Beside labour costs, Malaysia succeeded in attracting a large share of electronics investment for a range of reasons: its "healthy" industrial relations climate, relative political and economic stability, good infrastructure, generous incentives and other support for industry, the perception that the Malaysian government is development-oriented and favours the expansion of high-technology electronics, a relatively modern and efficient banking system free from foreign exchange restrictions, good air and sea connections to other Asian cities, the US and Europe, a relatively advanced telecommunications system, and readily available and competitively priced energy (USECM 1986, Hill 1989: 137). In recent years, another factor influencing the location decisions of TNCs has been the fact that the East Asian region is currently the fastest growing market for semiconductors in the world. The rise of the regional electronics market is due to the tremendous growth in consumer electronics manufacturing in the region who represent the end users for component electronics such as semiconductors. The creation of AFTA (the ASEAN Free Trade Area) on 1 January 1993 signified the first step towards creating an integrated regional market,[3] and the impressive economic performances of many countries in the region are additional factors influencing TNCs to consolidate their presence in Malaysia.

By 1992, there were seventeen US electronics manufacturers in Malaysia, thirteen of whom were manufacturing semiconductors and semiconductor components (MAEI 1992). The American electronics manufacturers employed nearly 41,000 people, and exported RM7.3 billion worth of products in 1992, representing 56 per cent of total Malaysian exports of electronic components (MAEI 1992). Their total investment by 1990 was nearly RM6 billion (US$2.2 billion) (*Far Eastern Economic Review*, 1 Nov. 1990, p. 64). Japanese semiconductor manufacturers also have a significant presence in Malaysia. By 1990, Japan had emerged as the biggest foreign investor in the Malaysian electronics industry with ten chip makers employing around 9,000 employees (*Far Eastern Economic Review*, 1 Nov. 1990, p. 64). In conclusion, the growth of the Malaysian electronics industry since 1970 has been due to a number of factors including the active efforts of the Malaysian government to attract foreign investment, the fortuitous circumstances in the industry during this period, in particular the increase in the level of competition, and the growth of markets for electronic products in the region.

Technological upgrading

The electronics industry in Malaysia of the 1990s bears little resemblance to that of the early 1970s. After two and a half decades, lowly skilled labour-intensive assembly operations are increasingly scarce. The industry has gradually evolved, with foreign firms significant in the process of technological upgrading. Technological upgrading has occurred in a number of ways, the most important of which are: the linkages forged between foreign TNCs and local suppliers and ancillary firms; skills formation and the promotion of local personnel working within TNCs; and technological deepening from simple manufacturing to more technology-intensive functions, including design and R&D.

Linkages

The most basic type of linkage between electronics TNCs and local firms are production linkages involving TNCs sourcing of component inputs from local manufacturers. My 1992 study, involving twenty-nine foreign electronics TNCs and five Malaysian firms in the ancillary and supporting industries, revealed that TNCs were increasing their local sourcing very rapidly, notwithstanding their continued heavy reliance on imported inputs (Ismail 1995: ch. 4). This was especially true of consumer electronics manufacturers, where a large number of components, including sophisticated electronics devices, were increasingly manufactured locally. However, the trend towards local sourcing among electronics component manufacturers was significantly slower.

Besides material production inputs, linkages between foreign firms and local firms also involved the sourcing of indirect inputs, such as equipment and tools (e.g. jigs and fixtures). Local sourcing of indirect inputs developed, both through subcontracting arrangements and through arm's-length market purchases. Although the bulk of TNCs' capital equipment was imported, a number of firms did obtain some of their capital equipment from Malaysian-owned manufacturers. Local procurements included fairly sophisticated automated machines, for example, chip unloaders. Rasiah (1994) also found that as a result of on-going linkages with foreign electronics TNCs, local machine tools manufacturers have expanded from simple parts fabrication to high-precision tooling and the production of fully automated systems, some of which were exported.

From the standpoint of technological development, the most important aspect of linkage formation is not the volume of local sourcing, but the nature of TNC/local firm relationships, in particular the extent to which foreign TNCs provide technical assistance along with purchasing contracts. Several studies have shown that TNCs have provided extensive technical assistance to their Malaysian suppliers (Ismail 1995, UNDP 1993). My own study found that many foreign TNCs assisted local firms in beginning to manufacture parts that were previously imported, e.g. by providing local manufacturers with drawings and written specifications. In other words, TNCs have actively encouraged and supported local firms' efforts to acquire the technical capabilities needed to produce component parts. Other forms of assistance have included daily and weekly visits by the TNCs' production and quality-control engineers. In some cases, TNC engineers have been seconded to local suppliers' factories for up to two weeks in order to carry out tasks such as factory layout, production planning, machinery installations, trouble-shooting production problems, etc. In other cases, managers and employees of local supplier firms have been invited to attend courses on quality control conducted by the TNCs. Some TNCs have even sent employees of their Malaysian suppliers abroad (usually to their home countries) to learn new production techniques from their home-country suppliers. TNCs were motivated by growing competition in the global electronics industry to adopt such practices in pursuit of the cost savings and efficiency benefits which they create.

Skills formation and local management promotion

TNCs have upgraded the capabilities and skills of their local employees in several ways, most importantly through various formal in-house training programmes. My study found that TNC training programmes were both widespread and extensive in nature (Ismail 1995: ch. 5). Typically, all employees from all categories have to undergo on-the-job training (see Table 2.1). TNCs also make use of local off-the-job training, sending nearly a third of both production and professional employees to short courses in local institutions. Finally and more interestingly, a significant number of employees from all categories are sent abroad for training. Overseas training stints can last from as little as two weeks to as much as two years. Short training programmes of a few weeks may be repeated a few times annually, with some employees sent abroad several times in a single year. Long periods of training are usually conducted prior to the introduction of a new model or product, or the transfer of new functions (e.g. design, procurement, marketing) to the Malaysian factory. Long training may also involve seconding

Table 2.1 Percentages of total employees in training programmes instituted by TNCs by category of employee and country/region of origin of TNCs

	Location of training								
	On-the-job			*Local off-the-job*			*Overseas*		
Employee category	*US*	*Jap*	*Eur*	*US*	*Jap*	*Eur*	*US*	*Jap*	*Eur*
Production	100	100	100	35	40	30	0	2	0
Maintenance	100	100	100	20	25	20	10	15	10
Professional and technical	100	100	100	25	35	30	30	30	40
Managerial	100	100	100	15	10	10	25	30	30

Source: Ismail (1995: Table 5.1).

key local personnel to the TNC's other branches world-wide or to the headquarters on job assignments. In this way, the TNC maximizes the local manager's exposure to different tasks in the company's global operations prior to his assuming a senior management position in the Malaysian factory. For example, the US firm Motorola sent local employees to train in production control methods in its Texas plant prior to transferring the function to Malaysia. Similarly, Japan's Sharp company sent Malaysians to Japan to train in production methods for the manufacture of CD player mechanisms prior to transferring production from its Japanese factory to Malaysia. ASE Semiconductors, a Taiwanese company, sent newly recruited engineers to Taiwan for training in statistical process control. Such training represents very important methods for the transfer of technology by the TNCs to the host country.

TNCs' investments in upgrading local employees' technical skills appear to have become a standard component of higher-technology operations in Malaysia. Moreover, local skills formation looks likely to receive even more emphasis in the future for several reasons. First, the increases in the wage level in the country means that TNCs will have to raise labour productivity to maintain their competitiveness. Wages in the Malaysian manufacturing sector increased by 15.1 per cent in 1993 against 9.6 per cent in the first half of 1992 and 6.0 per cent in 1991 (*Financial Times*, 30 Oct. 1992, p. 12, Ministry of Finance, *Economic Report, 1995/1996*, p. 251). The reactions by TNCs in Malaysia are quite similar to their responses to similar conditions in Singapore in the 1980s. Instead of moving their facilities wholesale to lower-wage countries, TNCs in Singapore reacted by retaining high value-added operations in Singapore and transferring low value-added activities utilizing cheap manual labour to Malaysia and Indonesia. Similarly, TNCs in Malaysia decided to overcome labour cost increases by boosting the value of the activities performed by the Malaysian workforce. As such, it is necessary to upgrade local workforce skills and capabilities.

Second, firms need to increase productivity and quality due to increased competition in the electronics industry. New methods and techniques of production are constantly being introduced across the world, usually involving the installation of new production equipment which often includes automated equipment. In 1991, the members of the Malaysian-American Electronics Industry (MAEI) invested more than RM750 million in new capital equipment, representing an increase of 24.3 per cent over the investment made in 1990. In 1992, the companies expected to invest a further RM835 million (MAEI 1992: 8). As a result of such developments, the worker–machine ratio (the average number of machines used by a single worker) has been fast declining. For example, whereas manual operations largely characterized the electronics industry in Malaysia in the 1970s, in recent years, workers have been handling more machines, some of which are highly automated.

Installation and maintenance of automated machines, in conjunction with new production methods, require workers to develop or upgrade skills in statistical process control methods, basic programming and overall understanding of the production process. It is therefore not surprising that among the MAEI members, training expenditures increased by more than 70 per cent to RM19 million in 1991, were forecast to grow a further 6 per cent in 1992, and were expected to be in excess of RM24 million per annum by 1994 (MAEI 1992: 14).

The introduction of new, more capital-intensive production methods is also partly a result of recruitment problems faced by the TNCs since the late 1980s. Many firms are developing long-term plans to increase capital-to-labour ratios, and few have plans to increase their labour force in the future regardless of the growth of output. To illustrate, Intel's Penang factory's production volume in 1994 was three times the volume in 1984. However, the number of workers employed has largely remained the same – around 2,000 – while the ratio of skilled to non-skilled workers has increased (*AWSJ*, 3 October 1994). Those TNCs that do plan to increase their labour force, however, are looking for skilled technicians and engineers rather than for cheap unskilled labour. Though the MAEI members registered a marginal decrease in the total number of production workers from 31,205 in 1990 to 31,129 in 1991, a result of the continuing shift from labour-intensive to more capital-intensive modes of production, they reported an increase in the number of engineers hired from 1,222 to 1,378 (MAEI 1992: 11 and 13). At Intel Penang, one in every six workers were engineers in 1994 compared with the 1980 ratio of one in forty (*AWSJ*, 3 October 1994).

The TNCs' general strategy thus seems to be to increase their existing workforce's productivity levels by increasing the level of automation and the use of other more sophisticated equipment. A few firms also mentioned the possibility of producing more sophisticated products in Malaysia. These strategies demand that firms increase their employees' technical capabilities in order to handle the more sophisticated machines as well as the production of more complex products. Such tendencies imply a drive for higher productivity via technology-intensive investment.

The "amount" or "level" of skills transferred to local employees is difficult to measure. However, one way of gauging the sophistication of skills formation is by looking at local employees' level of involvement in running the operations of the subsidiaries, especially at the managerial level. Very high involvement of locals can be argued to evidence skill transfers at a high level. US manufacturers are particularly notable in this respect, as can be seen from Table 2.2. Out of the sixteen member firms of the Malaysian-American Electronics Industry, nine are managed by Malaysian teams, including local managing directors. Although the other seven have expatriate American managing directors, their total number of expatriate employees is very low. For example, National Semiconductor's only expatriate in Penang is the managing director himself. Texas Instruments and Motorola have 2,800 and 4,000 employees respectively, but both have only three expatriate managers in Malaysia.

Among European firms, the picture is quite different. Only two of the firms are completely run by Malaysians, and it is interesting to note that they were

Table 2.2 Localization of top and middle management

Country of origin of firms	*Number of Malaysian MDs* [1]	*Percentage of Malaysians in middle and upper management* [2]
US	9 out of 16	90
Japan	0	40
Europe	2 out of 7	60

Notes
1 Data for the US firms were obtained from the interview survey and the annual report of the Malaysian-American Electronics Association while data for the Japanese and European firms were solely derived from the interview survey.
2 Middle and upper management are defined as employees above supervisory level; figures are estimates based on discussions with managers.

formerly American firms which were subsequently acquired by European parent corporations. In other words, the "Malaysianization" of their management teams occurred when they were under American ownership. The other five firms are managed by expatriate European managers. However, with the exception of one, they also have a remarkably small number of expatriate managers. Lucas, a British firm, has no other expatriate manager aside from its managing director; Grundig (of Germany) has only two expatriate managers, as does Electrolux (of Sweden), while Audio Electronics (a subsidiary of Philips of The Netherlands) has five.

Japanese companies are the least "Malaysianized" in terms of the composition of top management. In contrast to the American electronics TNCs, none of the managing directors of Japanese electronics firms is Malaysian except for one joint venture. This picture is broadly similar to cases of Japanese firms in other countries. However, even though the number of local managers in the management of the Japanese firms in this study is low, Malaysian involvement in the running of the firms is increasing. This is quite contrary to the picture often painted of Japanese-owned TNCs (e.g. see *Far Eastern Economic Review*, 28 March 1991). For example, Matsushita Precision in Johor has only five Japanese managers from among its fifteen managers. The rest are all Malaysians occupying posts such as Factory Director, Production Manager, Material Control Manager and Plant and Engineering Manager. The Malaysian Factory Director is in charge of important matters, including the complete design and commissioning of its large modern new factory in Johor. He is also in charge of the overall running of the firm and has a number of Japanese managers under him. In the case of Sharp-Roxy in Kedah, even though the Managing Director is Japanese, all the other managers are Malaysian. The Japanese engineers who work in the plant only act as "consultants" without any managerial powers. It is envisaged that the Japanese consultants will leave once Malaysians are capable of running the operations themselves. Clearly, even though less than in the case of American firms, the level of involvement of Malaysians in Japanese firms is rapidly becoming more substantial.

Another indicator of the extent of transfer of skills by TNCs to local employees is the ability of employees to run their own production organization subsequent to leaving the TNCs. There have not been significant cases in Malaysia of employees leaving and setting up firms which produce the same products as their former TNC employers because of the size of capital and access to technology needed for these types of industries. Most migrating employees set up firms in the ancillary and supporting industries to supply material inputs, such as plastic and metal component parts, or to provide other services to the TNCs. In some cases, they supply tools and equipment to their former employers.

One exception is that of Carsem Malaysia, a locally owned semiconductor assembly firm. The company, formerly a Malaysian–Australian joint venture managed by British expatriate managers, was originally known as Carter Semiconductor (M) Sdn Bhd. Carter produced transistor packages, discrete semiconductors and integrated circuits (ICs). In 1984, Hong Leong Corporation, a large Malaysian Chinese-owned conglomerate, acquired the company. Malaysian managers from subsidiaries of American TNCs such as Motorola, Harris and National Semiconductor were hired to run the firm, and Carsem became the first locally owned semiconductor sub-contracting house to provide assembly, test and packaging services to semiconductor manufacturers world-wide. The general manager of the firm is an ex-manufacturing manager of Motorola Malaysia who had been working there for ten years.

The company set up another plant in September 1991 equipped with modern assembly equipment including automated machines such as wafer saws, die and wire bonders, moulders, pad markers, wave solderers, etc. The plant also houses a Reliability and Failure Analysis laboratory as well as an R&D centre which conducts research on new materials, packages and processes using fairly sophisticated equipment such as scanning acoustic microscopes, scanning electron microscopes, energy dispersive X-ray machines, etc. The plant assembles a wide range of semiconductors, from simple discrete packages to 100L microprocessors. Its customers include the major semiconductor manufacturers such as Motorola, AMD, Toshiba, Ericsson, GEC, Siemens, Hewlett-Packard and Harris. The company currently employs 3,400 workers. According to the general manager, the main source of the company's expertise continues to be former employees of American semiconductor manufacturers. Though unusual, Carsem is not entirely unique. Another locally owned company run by a Malaysian general manager formerly with Motorola – O.Y.L. Electronics – produces electronic control units for air conditioners for both local and export markets.

Another method of assessing the skills transferred to Malaysian employees is by looking at their involvement in the world-wide activities of foreign TNCs. A significant number of Malaysians are now involved in TNCs' global manufacturing activities. One Malaysian engineer working for Hewlett-Packard was responsible for building a new production line in Idaho, USA. A Malaysian is also the head of Motorola's operations in China.

Technological deepening

The electronics industry in Malaysia, as in other Third World countries, began with low-skill, labour-intensive assembly activities. In recent years, however, many firms have transferred activities, such as product research, design and development or customer support services, to Malaysia. Table 2.3 presents the findings of my study of non-assembly-type activities taking place among some TNCs in Malaysia.

In general, TNCs do not have product R&D facilities in Malaysia. This is because product R&D teams have to work very closely with marketing personnel to ensure that R&D efforts are in line with the company's marketing strategies. Since the TNCs' marketing offices are located in their major markets, they therefore concentrate their product R&D facilities in either Japan, Europe or the US. Moreover, R&D skills cannot be developed overnight; it may take from five to ten years to develop a capable R&D engineer.[4] Therefore, R&D engineers are relatively scarce in Malaysia. Many consumer electronics firms, such as Santronics, Audio Electronics and Toyo Audio, maintain regional product R&D facilities in Singapore. Audio Electronics established its R&D centre in Singapore nearly twenty years ago which now has a staff of seventy-five to a hundred engineers; products designed there are manufactured in Hong Kong, Penang and Singapore.

Another reason why firms are hesitant to set up R&D facilities in Malaysia and to develop the necessary talents is because of the need to pay engineers very high salaries in order to retain them. Thompson Audio started an R&D centre in a Kedah plant in 1990, but had to abandon the project because of the high turnover of engineers, many of whom left for more attractive remuneration offered by R&D centres in Singapore. In the end, Thompson decided to concentrate all R&D work in its Singapore centre.

However, several TNCs do carry out significant product research, design and development locally, with greater emphasis on design and development. The completely Malaysian-managed Motorola Communications in Penang does design work on communications equipment, including walkie-talkies, mobile radios and state-of-the-art second-generation digital cordless phones. According to its R&D

Table 2.3 Non-assembly activities by firms surveyed

Activities	*Firms*
Product design and development	Motorola, Sharp-Roxy, Texas Instruments, Matsushita, Intel
Research on production methods and processes	Texas Instruments, Motorola, Harris, Quality Technologies, Matsushita Precision, Fujitsu, Robert Bosch and Thompson Audio
Customer support services	Thompson, Motorola, Intel and Harris
Production control	Motorola

director, design and engineering tasks for the above products, for both hardware and software, have been carried out in Penang. The only input it receives from the US is in the form of marketing specification sheets. Motorola's R&D department was set up in 1976 and is currently staffed by eighty engineers. It manages to attract and retain engineers simply by paying them very well. In 1992, the typical monthly starting pay for its production engineers was RM2,200, while for its R&D engineers, the starting pay was considerably more. By contrast, the monthly starting pay for an engineer in the Malaysian public sector was only RM1,400.

Sharp-Roxy, which produces audio electronics products, is another firm which carries out product design in Malaysia. The design work carried out in its Kedah plant is limited to products manufactured there, but is quite comprehensive and includes raw materials specification and production process design. All the local design projects are performed by Malaysian engineers using Sharp's state-of-the-art computer-aided-design (CAD) tools. Some of the design work is also carried out in Sharp's Design Laboratory in Japan by Malaysian design engineers who are sent over for periods of up to six months per year to work independently of Japanese engineers on specific projects. The reason for this arrangement is the limited capability of the Malaysian subsidiaries' design equipment. The design centre in Kedah is connected on an on-line basis with the Research and Design Centre in Japan using very sophisticated communications equipment, such as DISF (digitized image sender facilities), allowing the engineers from both sides to communicate with each other efficiently. Moreover, the Kedah design centre is also hooked up to Sharp's database in Osaka using the company's global communication network. Sharp-Roxy is currently in the process of expanding and upgrading its Kedah design centre, which will eliminate the need to send engineers to Japan in the future.

Texas Instruments carries out research on process definition in Malaysia. This entails investigating and subsequently explaining to customers what a semiconductor does under different conditions. The information is a crucial input in the design of end products as well as for software development. In 1992, twelve of Texas Instruments' four hundred technical staff were involved in the task. Texas Instruments envisaged expanding this function in the future due to the growing number of end users of microchips setting up plants in Malaysia.

Intel Penang is possibly the most technically self-reliant of all the American semiconductor firms in Malaysia. Beginning in the mid-1980s, Intel Penang started acquiring key responsibilities in product engineering as well as quality reliability engineering and planning for mature products (i.e. those products whose demand has stabilized at sizeable manufacturing volumes), leaving only the management of design and customer marketing interface to Intel USA. Eventually, it assumed full responsibilities for mature products which included the 80386 microprocessor as of 1990 (Lim 1991: 142). This implies that any new design changes to those products (known as product design optimization) have been completely undertaken in Penang. Intel Penang acquired this expertise by stationing its design engineers in the US for periods from one to two years to work with the design team there prior to the transfer of full responsibilities to Penang. By 1991, there were twelve Malaysian design engineers working in Intel US design teams (Lim 1991: 150). Currently, Intel Penang's design activities have extended beyond the initial sole focus on mature products. Its engineers are also currently engaged in designing state-of-the-art microcontrollers and chip packages (*Business Week*, 30 Nov. 1993). With regard to chip packaging, Intel has concentrated all its ceramic package research and development in Penang. Since ceramic packaging is used by Intel for all its top-of-the-line microprocessors, the Penang factory is responsible for the development of packages for Intel's latest microprocessor in the early 1990s, the Pentium. Moreover, the Penang ceramic package research group has also been involved in developing packages for the Pentium's successor, code-named P6 (*Far Eastern Economic Review*, 3 June 1993, p. 64).

Matsushita R&D, a subsidiary of Matsushita Corp. set up in Malaysia in 1991, also carries out research and development of products manufactured by Matsushita subsidiaries in Malaysia. The firm's R&D centre in Shah Alam designed 90 per cent of TV sets' chassis, which would rise to 100 per cent in 1993 (*Business Week*, 30 Nov. 1992, p. 74).

The trend in TNCs' product R&D and design activities in Malaysia has been quite promising since the downstream segments of the electronics industry have continued to expand. Many firms which use electronic components are not only relocating their production facilities in Malaysia but are also planning to develop design capabilities in the country. Since design engineers in components firms must work very closely with design engineers of the final products, it will be necessary for the semiconductor manufacturers to enhance the capability of their research and design departments in Malaysia.

The main factor which might hinder this trend has been the established and often preferred position of Singapore as a regional technological and design centre for many TNCs. TNCs may therefore tend to further consolidate their design centres in Singapore instead of expanding their Malaysian design and staff development and capacities.

The foregoing discussion concentrated on product research, design and development. The picture was notably more positive with regard to research on production methods and processes. The majority of the firms interviewed had some form of local research, design and improvement of production methods, including the designing of equipment used in the manufacturing processes. The American semiconductor manufacturers were again quite advanced in this regard. Texas Instruments had sixty employees engaged in the design of manufacturing equipment. Motorola, Harris and Quality Technologies also had similar, though somewhat smaller, groups. According to the managers of these firms, Malaysian subsidiaries' know-how in the area of assembly and testing was such that they were no longer dependent on input from headquarters. In other words, improvements in manufacturing methods were being generated from within the plants themselves, rather than as a result of inputs from abroad. By 1992, production process decisions (e.g. the choice of equipment to be used, factory layout, etc.) were totally made by local managers. "It has now come to a stage where Malaysian engineers no longer need any more advice from headquarters as far as assembly and tests are concerned", said one manufacturing manager at Motorola. In fact, some of them said that, after twenty-odd years of accumulated experience, TNCs' expertise in these areas was now based in Malaysia. At Texas Instruments Malaysia, staff from other facilities, including those in the United States, came to be trained in certain aspects of the production of bi-polar digital semiconductors. One study reported that Malaysian managers from a number of subsidiaries frequently visit the parent plants of American semiconductor firms to improve the organization of production lines in the US (Rasiah 1993: 8). The study also reported that in one case Malaysian managers developed a production system incorporating just-in-time (JIT) technique and product planning, which was then used by the corporation in other subsidiaries world-wide. In another case, Malaysian engineers developed automated equipment, such as die-attach machines, which the firm subsequently sold to local ancillary firms which then mass-produced them for export markets (Rasiah 1993: 9). One Malaysian engineer at Intel Penang was responsible for designing a chip packaging technique which prevents the epoxy from discolouring, thus enhancing their long-term efficiency (*AWSJ*, 3 Oct. 1994: 8).

A number of Japanese firms also have production or engineering research or design activities in their Malaysian subsidiaries. Matsushita Precision, for example, had a production engineering department set up to improve plant efficiency by modifying lay-out and other such activities. Similarly, Fujitsu has established an industrial engineering department in its Malaysian factory. Large numbers of Malaysian engineers have been sent to Japan for training in industrial engineering and technology. Fujitsu (and a number of other Japanese firms) has long-term plans to transfer as much production know-how as possible to the Malaysian plant, thereby freeing personnel in Japan to concentrate on product research and design. In the following years, Fujitsu and a number of other Japanese firms planned to produce manufacturing equipment, including automated machines, at their Malaysian plants.

This trend among the electronics TNCs to develop their production or industrial engineering departments in Malaysia is not confined to American and Japanese firms. European manufacturers, such as Robert Bosch and Thompson Audio, have also established industrial engineering departments in their Malaysian plants to research ways to improve and modify production methods.

The general picture which emerged from my study was that, over time, more and more production know-how was being transferred to TNCs' subsidiaries in Malaysia. In the first few years of operations, expatriate engineers helped to consolidate the plant and carried out trouble-shooting tasks. At the same time, Malaysian engineers were trained, with the goal of eventually replacing the expatriates, principally for cost reasons. Malaysian engineers have not only subsequently mastered the production techniques but have also subsequently been able to improve these techniques themselves. Due to a combination of factors, including the rapid nature of technological change in the field, the pressures of competition, as well as the capability of Malaysian engineers to acquire technical capabilities, a number of TNCs have found that Malaysian engineers have even moved ahead of parent-company engineers in certain areas of process technology.

Other functions besides research, design and development have also been gradually transferred to Malaysia, albeit on a modest scale thus far. SGS Thompson, Motorola, Harris and Dell Computers Corp. provide marketing and customer support services to customers in the fast-growing Asia Pacific region. Countries like Singapore, Malaysia and Thailand are experiencing the fastest growth in demand for chips compared to any other region in the world. Moreover, the firms have also been experiencing stiff competition in these markets. In order to retain or improve their market shares, firms realized that they must outshine their competitors not only in terms of the quality of their products but also the quality of marketing and other services provided including customer support.

To what extent other semiconductor manufacturers will develop marketing and other related activities in Malaysia will certainly depend on the future growth of the electronics end-product industries in the region. Such growth could, of course, enhance Singapore's position as a regional marketing centre at the expense of Malaysia. However, this would be most likely for firms with already established regional headquarters in Singapore, or firms situated in neighbouring Johor state. Those firms with assembly facilities elsewhere in Malaysia, which have yet to establish regional headquarters in the region, might just as easily locate their marketing operations together with their Malaysian production operations.

The nature of electronics products manufactured in Malaysia

Another issue that needs to be considered is the question of whether products manufactured in Malaysia are complex or simple in nature. Complex products usually imply higher value-added manufacturing activities and more complex production processes, and vice versa. Product sophistication also reflects an important additional dimension of technological upgrading in the country. Even though lower-range products can be produced by highly automated and capital-intensive techniques, higher-range products need to be produced by techniques involving a higher level of automation and capital intensity. As an example, testing and assembly facilities for complex chips (e.g. those required for military applications) are more complex than for simple memory chips.

In the case of electronic components manufacturers, the evidence strongly indicates that the products manufactured in Malaysia are quite advanced. Precision parts manufacturers, such as Matsushita Precision and Hitachi, manufacture very precise parts for products, including some state-of-the-art consumer electronics products such as microcassette players and digital telephone answering machines. Likewise, semiconductor manufacturers have transferred higher-end products to Malaysia. Motorola has designated its Malaysian factory the focus facility for microprocessors and memory devices, and assembles and tests the whole range of semiconductors, from the simplest of memory devices to the most complex of their microprocessors, including, as of 1992, the 64-bit 68060 microprocessors as well as military devices which have sophisticated testing requirements. Harris Semiconductor's products also include very advanced chips with military applications. Intel Penang has long been assembling its Pentium microprocessor in its Penang factory, while Hitachi Semiconductors in Penang produces 16-megabit DRAMs (*Malaysian Business*, 1–15 Sept. 1992, p. 68). Texas Instruments has been manufacturing TIRIS (Texas Instruments Information and Registration System), a security system which utilized leading-edge electronic radio wave technology, in its Malaysian factory. Motorola Penang has been manufacturing second-generation digital cordless phones, then one of the latest and most sophisticated products in the telephone industry. It has also been manufacturing other sophisticated telecommunication equipment such as alpha numeric paging equipment, walkie-talkies and mobile radios. Quality Technologies has been manufacturing fairly sophisticated opto-electronics products, including opto-couplers, a form of semiconductor which performs high-speed switching operations using light rays. By 1992, Conner Peripherals, which completely transferred its manufacturing facilities to Penang in 1989, was producing its latest product (2.5-inch drives) in its Penang factory in addition to the 3.5-inch drives it had been producing there (*Malaysian Business*, 1–15 Sept. 1992, p. 68).

By contrast, consumer electronics manufacturers, particularly Japanese firms, seem to have concentrated on mature products. Most audio electronics manufacturers have only been producing cassette recorders and hi-fi sets. Some, such as Sharp-Roxy, manufacture very sophisticated CD players, but retain production of their most sophisticated products, such as CD players with writing as well as reading capabilities, in Japan. None the less, the complexity of products manufactured in Malaysia has been steadily increasing. In 1992, Sharp-Roxy began manufacturing a recently developed personal fax machine (a variation of those used by business), while Thompson Audio has been producing digital telephone answering machines in its Malaysian plants.

It is important to note that though products in Malaysia were less sophisticated than those manufactured in Japan, a number of Japanese firms manufactured even simpler products in countries such as China. For example, Santronics (a subsidiary of Sanyo) manufactures cassette recorders in Malaysia, but only very simple radios in China. According to its manager, products currently manufactured in Malaysia would be transferred to China to make way for the transfer of more sophisticated production from Japan.

The evidence affirms that the products manufactured by electronics TNCs in Malaysia have been quite sophisticated. In consumer electronics, a sort of product specialization has emerged with a regional division of labour, where countries like

China and Indonesia produce the least sophisticated products while Malaysia and Thailand produce slightly more sophisticated products. The TNCs from Europe and Japan produce their most sophisticated and latest products in their home countries. In the case of American semiconductor manufacturers, the specialization seems to be by function rather than product. Product R&D is done in the US, but even the manufacturing and assembly of the most sophisticated products have usually been carried out in Malaysia. There are a few exceptions to this pattern, however. Motorola Communication in Penang not only manufactures the most sophisticated communication products for the company world-wide, but has also been carrying out product research, design and development there.

Conclusion

In conclusion, foreign TNCs have contributed significantly to the process of technological upgrading in the Malaysian electronics industry. There has been a notable increase in backward linkages, which are now no longer restricted to low-cost component inputs. TNCs have also increased the proportion of indigenous staff to expatriates and undertaken significant upgrading of their Malaysian employees' skills at both managerial and technical levels. Finally, TNCs have deepened the technological sophistication of their Malaysian subsidiaries, achieving world-class capabilities in process technology, and even product R&D in certain cases. These achievements have occurred as TNCs have begun manufacturing increasingly sophisticated products in their Malaysian facilities.

These developments result from a combination of factors, including the country's conducive political and labour climate, the rapid growth currently being experienced in the region, the increasingly competitive environment facing the electronics industry world-wide, and last, but not least, the high absorptive capacities of Malaysians currently working for the foreign TNCs. As long as these factors prevail, there is no reason to believe that the foreign TNCs will not continue to perform an important role in the future technological upgrading of the country.

Notes

1 In 1994, the electrical and electronics sector contributed 63.6 per cent of Malaysia's total manufactured exports. The potential employment created from approved investments for the sector during the year was approximately 62,000 or nearly 50 per cent of the total for the manufacturing sector as a whole (MITI 1995: 272).

2 In 1994, foreign investments constituted 76 per cent of total approved projects in the sector. Foreign ownership of electronics assets is estimated to be more than 90 per cent.

3 The combined population of AFTA is 330 million people and the combined GDP of its member countries is US$293 billion, which is growing at 7 per cent a year (*Far Eastern Economic Review*, 16 April 1993, p. 48).

4 Interviews with managing directors of Audio Electronics and Thompson Audio.

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3

MANAGING INNOVATION IN MALAYSIA

Comparing Japanese and Malaysian companies*

Ong Fon Sim and Md. Nor Othman

Acquiring and adapting foreign technologies requires significant innovative capabilities. In this regard, technology *per se* is a necessary, but insufficient, condition for competitive success in the market. Once acquired, technology must be accompanied by growing abilities to apply it in production to improve profit margins. Product and process innovation contribute to higher value-added products and improved productivity respectively. This is true not only at the technology frontier, but also for incremental innovation, the basis upon which Japanese companies, for example, have emerged as world competitors. As international competition intensifies, recognition of technology's contribution to competitiveness has placed it at the core of firms' and nations' growth strategies.

Malaysia has enjoyed impressive economic, manufacturing and export growth for almost a decade. In view of Malaysia's aspiration to become an industrialized nation within the next few decades, it faces a considerable challenge in "catching-up", not only through technology acquisition but also in building capabilities to apply and adapt technology for incremental innovation. A major component of the challenge lies in strategically managing an expansion of R&D activities and in developing a sound system of innovation management.

Currently, R&D activities in Malaysia are largely driven by public funding and decision making, rather than by private sector activity. The scarcity of technological effort among the Malaysian private sector is an important weakness, since Malaysia cannot depend solely on multinationals for technology transfer. Thus, while the government has recognized the importance of fostering technology development, the challenge of engaging the private sector in innovation remains acute.

The purpose of this study is to examine innovation management in Malaysian companies. Benchmarking local experiences of Malaysian firms against those of Japanese MNCs in Malaysia, it assesses the propensity to innovate among Malaysian companies. The next section examines the experiences of Malaysian and Japanese companies in fostering innovation. The following section compares the innovation management systems of Malaysian companies with those of Japanese MNCs operating in Malaysia. The final section makes recommendations for policies to encourage Malaysian companies to invest in R&D to enhance their technological capabilities.

Innovation management: theory and Japanese experience

Technology and innovation management

In general terms, technology comprises all scientific knowledge deliberately and purposefully used for the production, distribution, consumption, and utilization of goods, services, and information, especially that which concerns mechanical apparatus and systems (Hayashi 1990). Long considered an exogenous "black box" factor in economic growth, technology and the innovation process at both the national and individual firm levels have attracted increasing attention from mainstream economists in recent years. A growing literature on national innovation systems considers the role of various national actors and institutions in influencing a country's technological performance (Lundvall 1992, Nelson 1993, Archibugi and Michie 1995, Freeman 1995, Metcalfe 1995, Hayashi 1990). Other authors (Quinn 1985, Schmitt 1985, Taylor 1990, Drucker 1985, Starr 1992, Ohmae 1994) examine how individual corporations in various industries have managed innovation as a competitive resource. A common theme in the literature on innovation is the need to adopt a broad definition of technology, involving not only machines and product designs, but also skills, management routines and organizational forms, and information about input and product market conditions (Hayashi 1990).

Innovation integrates all these factors in the search, discovery, experimentation, development, imitation, and adoption of new products, new production processes and new organizational set-ups (Dosi *et al.* 1992). According to Assael (1992), three types of innovation can be distinguished based on the degree of technological advancement:

1 A *continuous innovation* which involves an extension of existing products with little change in technology,
2 A *dynamically continuous innovation* which involves minor technological advances, and
3 A *discontinuous innovation* that involves a major technological advancement where a new product and new consumption pattern can be observed.

From a management perspective, fostering innovation requires creating an organizational environment conducive to the development of innovative ideas, the integration of R&D activities with other functional activities, and the commercialization of the innovative effort. Mansfield (1982) observes that the probability that deliberate efforts will produce innovative ideas is far higher than the probability for successful commercialization. Thus, the management of innovation entails much more than mere technical advances but also involves linkages with other functional activities such as manufacturing, marketing and distribution. Examples of failure due to factors such as the lack of complementarity of assets, inability to protect know-how, lack of marketing expertise, etc., are numerous and well documented (Rosenberg 1992, Porter 1990). In analysing the commercial failure of firms with ostensible "first-mover" advantages, Teece (1992) located the causes of failure in poor legal protection mechanisms, the specific nature of technological assets, the stage in the design cycle, lack of complementary assets, and in poorly conceived strategies to capture returns from technological innovation.

In light of the need for broader organizational effort to bring technical advances to successful commercialization, Ohmae (1994) has suggested a six-step approach in managing the innovation process:

Create the right climate
⇓
Develop the right attitude
⇓
Commit to a vision of innovation
⇓
Create an innovation centre
⇓
Communicate the excitement of innovation
⇓
Use outsiders to remove bottlenecks to innovation

It is clear from the above that organizations which aspire to remain competitive in the market must recognize the importance of innovation and technological advancement, and must manage innovation through deliberate and self-conscious organizational practices.

The Japanese experience

Japan's rise as an economic superpower has attracted global attention. Many have attributed its success to its unique management systems, characterized by lifetime employment, collective decision making, status equalization, job enrichment, etc. However, these practices must be understood in relation to the key source of Japanese competitiveness, namely its strong innovation performance, evident in the growth of R&D- and technology-intensive products and the progressive shedding of low R&D-intensity products (Kurth 1992). Innovation and successful commercialization have been the major factors in Japanese industrial success (Morita *et al.* 1987, Nakayama 1984, Parkinson *et al.*

1984). For example, Japan's Economic Planning Agency's growth accounting analysis found that technological advance contributed to about 45 per cent of growth between 1965 and 1979 (Nakayama 1984). Today, Japan is the leader in terms of R&D expenditure per capita (US$35,035 million), with Germany at a distant second spending US$14,402 million for the year 1992 (*Business Week*, 28 June 1993).

Immediately after the Second World War, however, Japanese industry confronted a vast technological gap between itself and the advanced industrial countries, particularly the US. Although it relied heavily on imported technology, Japan was able to adopt, stabilize, disseminate and finally improve foreign technology to suit its own history, culture and business environment. During the rapid growth period of 1955–64, Japanese firms laid the foundation for inter-firm cooperation in technology development, particularly in sharing technical information (Imai 1992, Porter 1990). Sharing of information critical for technology and innovation is widespread, especially among users and suppliers, sub-contractors, vendors and others, where long-term relationships exist. In addition, a management system that encourages status equalization, which eliminates status barriers, further facilitates information flows between management and employees (Urabe 1988).

Japan moved into the next phase of technological development with the oil crisis from 1973, an event that proved to be a blessing in disguise for Japanese industry. High energy prices accelerated Japanese firms' incremental innovation and strengthened the relationship between users and capital goods suppliers to restrain costs and facilitate adjustment. With strong inter-firm networks, flexible internal organization, and the intense flow of information among assemblers and suppliers and capital goods producers, incremental innovation led to the speedy development of new products, and Japanese firms' R&D expenditures increased substantially.

Innovation management in Malaysian companies and Japanese MNC subsidiaries

Four companies – two Malaysian-owned and two Japanese multinationals subsidiaries – were chosen for in-depth study.[1] The two Malaysian companies were selected from a list of Malaysian companies enjoying R&D tax incentives registered with the Malaysian Industrial Development Authority (MIDA). The companies are Pharmmalaysia Sdn Bhd, a pharmaceutical company, and OYL Electronics Sdn Bhd, an electronics company producing air-conditioner controllers. The Japanese companies selected are the Matsushita Air-conditioning Group of Companies, the world's leading producer of room air conditioners, and Kao Corporation, a manufacturer of toiletries and hygiene products.

Case 1: Pharmmalaysia

Pharmmalaysia Sdn Bhd (Pharm) was incorporated in 1975 with a paid-up capital of RM206,000. About 40 per cent of the equity was owned by Sarabai Chemicals from India, which provided technical and development support. Initially, Pharmmalaysia merely sold drugs imported from India, but began local manufacturing in 1978. In 1992, Pharmmalaysia became a public company pending listing on the Kuala Lumpur Stock Exchange (KLSE). Currently, it has a paid-up capital of RM20 million. Although it is in an industry characterized by research intensity, rapid innovation and often short product life cycles, Pharmmalaysia concentrates on the less risky manufacture of prescription pharmaceuticals whose patents have expired. Its product portfolio comprises over 190 products in the diverse therapeutic spectrum encompassing infections, cardiovascular, respiratory, gastrointestinal, genitourinary, dermatological and other conditions. Starting off in the 1970s as a supplier of pharmaceuticals to government hospitals and clinics, it has since grown to export to the South-east Asian and Middle East regions, and has an annual sales turnover of over RM20 million. In order to sustain growth, Pharmmalaysia must expand exports and become a global company catering to the needs of the international market.

The company's Kedah factory occupies a land area of 5 acres with a built-up area of 110,000 sq. ft. In recent years, the company has installed state-of-the-art manufacturing facilities, with 70 per cent automation of its production processes. The production facilities conform to the stringent requirements of Good Manufacturing Practices stipulated by the Drug Control Authority Malaysia, in line with guidelines established by the World Health Organization (WHO). Pharmmalaysia places a high priority on quality assurance; a quality control laboratory ensures conformity with international standards. Stringent testing and analytical procedures are applied, beginning from the stage of raw materials through intermediate and finished products in order to ensure the quality of the finished products.

With the increasing affluence of Malaysians, the pharmaceutical industry is enjoying a growth rate of about 12 per cent per annum, according to the Malaysian Pharmaceutical Trade and Manufacturers Association (MPTMA), exceeding GDP growth rate for the past three years. The pharmaceutical market is estimated at RM850 million, consisting of roughly 60 per cent (or RM500 million) prescription or controlled products, and 40 per cent over-the-counter (OTC) products. Rapid growth has led to intensified competition, with newcomers trying to build market shares and established producers seeking to consolidate their positions. The industry is dominated by multinational corporations (MNCs), namely Glaxo Wellcome Sdn Bhd, Smith Kline Beecham Sdn Bhd, Astra Malaysia Sdn Bhd, Merck Sharpe and Dhome and Janssen Pharmaceuticals. All the MNCs produce proprietary prescription drugs and invest substantially in R&D to create and patent new products. Faced with an enormous technological lag and a scarcity of R&D expertise, local manufacturers have, by contrast, concentrated on post-patented products. A total of thirty-five local manufacturers produce prescription drugs with only four of significant scale: Upha Corporation Sdn Bhd, Hor Yan Hor Sdn Bhd, Pharmmalaysia Bhd, and Zepa Soul Pattison Sdn Bhd. Although local firms are numerous, together they control only 30 per cent of the market.

Management of Pharmmalaysia

One of the four big Malaysian players in the local pharmaceutical industry, Pharmmalaysia is well poised to adapt to more intensive competition. It currently has 175 full-time employees, with fifteen managers. The strong emphasis on marketing and production can be easily discerned from the allocation of managerial staff: six in marketing, five in production and only two in R&D (see Table 3.1); eight managers were educated in the sciences and one in engineering (see Table 3.2).

Pharmmalaysia's emphasis on marketing results, in large part, from the fact that it not only produces medicines but is also the sole Malaysian distributor for several international companies, including Knowell of Canada, Trigene of the United Kingdom, IBV Enzyme GmbH of Germany, and Himalaya Drug Company and Sun Pharmaceutical of India. Pharmmalaysia's product portfolio includes analgesics, antiasthmatics, anticonvulsants, antihistamines, antimalarials, corticosteriods, haematenics, purgatives and vitamins. The pharmaceutical

Table 3.1 Pharmmalaysia: number of managerial staff by function and by level

	Finance	*Marketing*	*R&D*	*Production*	*Admin.*
Senior Management Level		1		1	
Middle Management Level	1	2	2	2	1
Junior Management Level		3		2	
Total	1	6	2	5	1
Grand Total			15		

Table 3.2 Pharmmalaysia: educational background of managers

	Engineering	*Science*	*Bus. Admin.*	*Arts / Soc. Science*
Senior Management Level		1	2	
Middle Management Level	1	5	1	
Junior Management Level		3		2
Total	1	9	3	2
Grand Total		15		

dosage forms cover a wide array that includes coated compressed tablets, capsules, injectables, syrups, suspension creams, ointments and oral rehydration salts.

Under the leadership of its present managing director, Pharmmalaysia has achieved impressive growth rates of about 50 per cent for 1989 and 1990, and thereafter, at about 20 per cent per year up to 1992. From 1993 onwards, varying growth rates were experienced. Pharmmalaysia has geared itself for the challenges ahead for the future growth and development of the company.

R&D management

Pharmmalaysia heeds the call of the Malaysian government for greater involvement in R&D and believes strongly that R&D activities will provide the cutting edge technology for its long-term development and growth in the domestic and export markets. The company signalled its commitment to R&D with the establishment of new R&D facilities in 1990. The research and development department caters for the development of new products and improvements to existing products, as well as productivity enhancement and regulatory compliance. Establishing the standard, specification and analytical procedures of new products forms an important component of its R&D activities. Since 1993, Pharmmalaysia has spent about 7.5 per cent of sales revenue on R&D. However, "social innovation" aimed at improving and upgrading the skills of workers is not emphasized. This "people" factor, which is fundamental for R&D, ultimately determines the organizational propensity to innovate. Pharmmalaysia has yet to focus on managing its human resources for R&D.

Innovation management

Pharmmalaysia's top management is positively oriented towards innovation as a basic component of competitive strategy, and the managing director (MD) is willing to assume a moderate degree of risk in innovation. The small R&D staff, who have significant experience in pharmaceuticals research, are given considerable discretion in pursuing technological improvements. However, decision making with respect to implementing innovations is not decentralized to involve lower staff, e.g. through worker suggestions and monitoring of quality improvement. The cautious stance taken by the company reflects prudence on the part of the company in conducting R&D.

Pharmmalaysia feels that it is only moderately innovative compared to competitors in the industry. As it only deals with post-patented products, it must undertake a patent search before embarking on new projects. The reasons cited for the sole emphasis on post-patented products are: minimal risk, technological disadvantages, including shortage of qualified manpower, avoidance of tedious processes of testing and application procedures for approval, costly investments with no certainty of payoffs as well as inability to compete with pharmaceutical "giants" in the world, where most new drugs are researched, patented and commercialized.

During the earlier phase of the company's development, technology was obtained through a joint venture with Sarabai Chemical (formerly Squibb) of India. Today, the most important source of technology acquisition is through outright purchase of technology licences. In addition, the company engages the expertise of a consultant who, from time to time, will advise Pharmmalaysia on the technical aspects of new products or in situations where a second opinion is needed. While these arrangements are well suited to Pharmmalaysia's current technology needs, further moves into higher valued-added products will require a more innovative approach to technology acquisition.

Process of innovation management

The flow of the company's innovation management process reveals a market-driven approach featuring efforts to constantly screen the market environment. The market potential of post-patented products is closely monitored with feedback from the marketing personnel. Products identified as having great potential are selected for commercialization, and the R&D team works on absorbing the necessary knowledge. Product prototypes are sampled to generate feedback on taste, appearance, etc., to be passed on by the marketing department to the R&D team. The R&D team will then rework these products until they are satisfied that the products are of a high quality and meet all requirements. Products are then sent to the Ministry of Health for testing and approval. Large-scale production and commercialization will only take place once the products meet with the approval of the relevant authority.

Pharmmalaysia is driven by economic necessity, bench-marking for best practice and market feedback for its innovative activities. As the company is new to R&D, it continues to lag behind the MNCs in terms of developing a more proactive and aggressive approach to R&D. As the present demand situation is very encouraging, however, the company is fairly complacent about the need to assume substantial risks and costs in developing original products.

Types of innovation

Pharmmalaysia concentrates on product and process innovation with minimal attention to social innovation aimed at upgrading the skills and knowledge of employees. Product innovation, by which existing products are modified and improved, is incremental. It also includes the introduction of products new to the company, but not necessarily to the market. Concentration on applied research has benefited Pharmmalaysia immensely in terms of product innovation. The R&D effort has been vital to the introduction of new products and for improvements to existing products. For example, the R&D team worked closely on incremental innovation on an antibiotic produced in 1989 and introduced it in the form of capsules and dry syrups of different strengths. The result was a tremendous increase in sales and, presently, the dry syrup for children remains the leader in the children's antibiotic segment. R&D activities by Pharmmalaysia have brought profits to the company, and are mainly driven by market need and competition, rather than the desire to develop "cutting edge" technology that will ensure market leadership.

Process innovation has also contributed to company growth in terms of cost reduction in existing product lines. If a process is not ready for large-scale production, the delay in competitively getting the product to the market might prove to be costly for the company as competitors will then have the chance to make the first move. Thus, the role of process innovation as a determinant of success is clear.

Unlike Japanese companies in Malaysia (Ong and Othman 1995) which give social innovation the utmost importance, Pharmmalaysia does not have a systematic programme to upgrade the skills and knowledge of its employees. For Pharmmalaysia, the most basic and important form of training is on-the-job training. Most of the Japanese companies in Malaysia implement a systematic programme involving both local and overseas training, not only for managers, but also for shop-floor workers. In the present situation of full employment, high mobility among workers as well as increasing production of higher value-added products, Pharmmalaysia should think seriously about training and development for its employees.

Thus far, Pharmmalaysia has successfully promoted lateral co-operation among various functions in the company with a high level of functional integration. Communication, which is critical, provides the necessary information in the form of feedback from marketing, production and quality control to the R&D team. Very often, personnel from the marketing department provide the lead for new product introduction as they are the ones in touch with the customers in the market. The end-of-year bonus is the major method of reward and recognition for employees' efforts in introducing new products.

R&D tax incentives

Pharmmalaysia is aware of the tax incentives available for R&D purposes. So far, the only incentive granted to Pharmmalaysia has been the double tax deduction for R&D expenses. The company feels strongly that tax incentives should be an effective means of encouraging R&D activities and suggests that more generous incentives should be granted by the government. In order to encourage greater use of the incentives provided, the government should waive the stringent requirements currently imposed for tax holidays for a new research-oriented company.

In summary, although Pharmmalysia has embarked on R&D, its efforts can at best only be considered as moderate. Its technological progress can be described as only being in stage two of Hayashi's model (1990) of technology self-reliance, in which simple operational mastery is augmented by abilities to maintain and extend acquired process and product technologies. Pharmmalaysia should consider a more aggressive method of technology acquisition, supported by a workforce able to absorb and adapt the new technology. This means that social innovation has to be stepped up. A more co-ordinated approach towards innovation management will be helpful for Pharmmalaysia instead of the present *ad hoc* arrangements.

Case 2: OYL Electronics Sdn Bhd [2]

OYL Electronics Sdn Bhd (hereafter OYL Electronics) was incorporated in 1991 with a paid-up capital of RM1 million. Its principal business activity is the manufacture of different models of air-conditioner controllers. OYL Electronics has about 140 full-time employees. Its emphasis on quality can clearly be seen from the composition of its management team. As seen in Figure 3.1, five out of six middle-level managers hold a science or engineering degree. It has a strong R&D unit comprising nine employees, the largest single segment of junior and middle management. Of these, three hold engineering degrees and two hold science degrees. Considering that OYL Electronics is a young company, the number of R&D employees holding either a science or engineering degree is commendable. Besides R&D, the company also emphasizes marketing, with four middle-and junior-level managers involved in marketing (as compared to six in the R&D unit). About 95 per cent of company revenue comes from new products (i.e. products introduced within the previous two years).

OYL Industries Berhad

OYL Industries Berhad is the parent company of OYL Electronics. It started operations in 1974 assembling gas cookers and Glem gas ovens (*Business Times*, 12 Nov. 1993). Over the years, the company has established numerous strategic alliances with other local and foreign companies and expanded its business to manufacture industrial air conditioners, refrigeration equipment and electronic components. Joint ventures have been established with ACMA Ltd (Singapore), Borg Warner Corporation (USA) and Mitsubishi Electric Corporation (Japan).

The company went public in 1985 and was listed on the Kuala Lumpur Stock

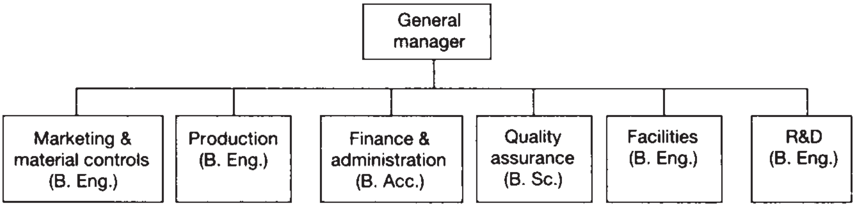

Figure 3.1 Organization structure of OYL Electronics Sdn Bhd

Exchange's main board in 1986. By 1990, OYL was exporting almost 60 per cent of its products to Asia, Australia, Europe and North America (*New Straits Times*, 19 Nov. 1991). By 1995, OYL's paid-up capital had increased to RM123 million, and the company had fifty-nine subsidiaries and affiliates employing more than 8,000 people all over the world. Its manufacturing operations number thirty-two facilities in ten countries, and its distribution network operates in nearly eighty countries. Table 3.3 shows the local subsidiaries of OYL Industries Berhad while Table 3.4 presents the foreign subsidiaries and affiliated companies of OYL Industries Berhad. Currently, OYL Industries is principally involved in the design, manufacturing, marketing, distribution and servicing of heating, ventilation and air-conditioning products, air-filtration products, refrigerators, freezers and electronic products. The OYL product portfolio includes established brands such as York, AC SON, Mitsubishi, ACMA, Dewpoint and other OEM (original equipment manufacturer) brands.

Table 3.3 Local subsidiaries of OYL Industries Berhad

Name of company	*Principal activities*	*Equity interest (%)*
OYL Manufacturing Company Sdn Bhd	Manufacture and sale of air conditioners	100
OYL Condair Industries Sdn Bhd	Manufacture and sale of packaged and plant air-conditioning units	51
OYL Appliances Sdn Bhd	Manufacture and sale of refrigerators, freezers and other related products	70
OYL Electronics Sdn Bhd	Manufacture and sale of electronic products	100
Anson Malaysia Sales & Service Sdn Bhd	Marketing and servicing of air conditioners, refrigerators, home appliances products and contractors for mechanical and electrical services	100
York (Malaysia) Sales & Service Sdn Bhd	Marketing and provision of technical support services for air conditioners	70
Group Associated (C&L) Sdn Bhd	Marketing and servicing of air conditioners, refrigerators and freezers	100
OYL Research & Development Centre Sdn Bhd	Research and Development on the manufacture of air conditioners, refrigerators and related electrical and electronic products	100
OYL Steel Centre Sdn Bhd	Steel processing	75
LeGuo Home Centre Sdn Bhd	Operation of chain of retail outlets for electrical products, furniture, and other home improvement products on cash and instalment basis	60

Source: OYL Industries Berhad, *Annual Report 1995.*

Table 3.4 OYL Industries Berhad's foreign subsidiaries and affiliated companies

Name of company	*Principal activities*	*Place of incorporation*	*Equity interest (%)*
OYL (BVI) Limited	Investment holding	The British Virgin Islands	100
OYL Overseas Limited	Investment holding	Jersey, Channel Islands	100
Shenzhen OYL Electrical Co. Ltd.	Manufacture and sale of air conditioners	China	51
AAF-McQuay Group Inc.	Investment holding	USA	100
AAF-McQuay Inc.	Manufacture and marketing of air filtration, heating, ventilation and air-conditioning equipment (HVAC)* and systems	USA	100
AAF-McQuay Holding Inc.	Investment holding	USA	100
Chengdu OYL A&R Engineering Co. Ltd.	Marketing and service of air conditioners, refrigerators and contractors for mechanical and electrical services	China	38
OYL Sales & Service (Singapore) Pte. Ltd.	Sale and service of air conditioners, refrigerators and contractors for mechanical and electrical services	Singapore	100
P.T. OYL Sentra Manufacturing	Manufacturing and sale of air conditioners	Indonesia	60
OYL (Philippines) Holdings Inc.	Investment holding	Philippines	100
Guoco Soylec Trading Company Limited	Sale of air conditioners, related raw material and spare parts	Hong Kong	51
OYL-J.M. Corp. Ltd.	Design, manufacturing and sale of electronic products	Taiwan	60
McQuay Asia (Hong Kong) Ltd. *(formerly known as Tsingtao Brewery (HK) Limited)*	Sale, service and installation of HVAC and mechanical and electrical contracting services	Hong Kong	80
Shanghai McQuay Air Conditioning Co. Ltd. *(formerly known as Shanghai OYL Welfare Air Conditioning Co. Ltd.)*	Sale, marketing and service of air conditioners and mechanical and electrical contracting services	China	51
McQuay Air Conditioning (Singapore) Pte. Ltd. *(formerly known as Belford Trading Pte. Ltd.)*	Sale, service and installation of HVAC and mechanical and electrical contracting services	Singapore	100
AAF-McQuay International, Inc.	Investment holding	USA	100

[*continued on p. 50*]

Table 3.4 OYL Industries Berhad's foreign subsidiaries and affiliated companies (continued)

Name of company	*Principal activities*	*Place of incorporation*	*Equity interest (%)*
AAF-McQuay Canada Inc.	Sale, service of HVAC	Canada	100
AAF-McQuay UK Limited.	Investment holding	United Kingdom	100
McQuay Europe S.r.I	Investment holding	Italy	100
McQuay Italia S.p.A	Manufacture and sale of HVAC	Italy	100
AAF-McQuay Netherlands B.V.	Investment holding	The Netherlands	100
AAF Luftreinigungssysteme Gesellschaft m.b.H.	Sale of air filtration products	Austria	100
AAF Lufttechnik GmbH	Sale of air filtration products	Germany	100
AAF (Asia) Pte. Ltd.	Manufacture and sale of air filtration products and of HVAC	Singapore	100
AAF-McQuay France	Investment holding and sale of HVAC	France	100
AAF-Limited	Manufacture and sale of air filtration products and of HVAC	United Kingdom	100
AAF S.r.I	Sale of air filtration products	Italy	100
AAF International B.V.	Manufacture and sale of air filtration products	The Netherlands	100
AAF, S.A.	Manufacture and sale of air filtration products	Spain	100
AAF International AG	Investment holding	Switzerland	100
AAF Pty. Ltd.	Sale of air filtration products	Australia	100
Wesper	Manufacture and sale of HVAC	France	100
AAF-SA	Manufacture and sale of air filtration products	France	100
AAF Hava Filtreleri ve Ticaret A.S	Sale of air filtration products	Turkey	100
AAF S.A de C.V	Manufacture and sale of air filtration products	Mexico	100
Purification de Aire Venezuelan, C.A.	Investment holding	Venezuela	100
AAF Environmental Control E.P.E	Sale of air filtration products	Greece	100
AAF-SA	Sale of air filtration products	Belgium	100
McQuay – Perfex Export Co.	Sale of HVAC and air filtration products	USA	100
McQuay Europe S.A.R.L	In liquidation	France	100
McQuay International S.A.R.L	In liquidation	France	100

Source: OYL Industries Berhad, *Annual Report 1995*.

Note

* HVAC – heating, ventilation and air-conditioning equipment.

Some of OYL Industries' overseas subsidiaries are leaders in their own market. For example, AAF International is the world's leading manufacturer of commercial, industrial and residential air filters. The company pioneered many of the current technologies in air-pollution control now in use. Its products and systems are found in thousands of installations world-wide. In its 1995 *Annual Report* (p. 11), OYL claims that it is "A Global Leader in Air Quality". OYL's chairman Tun Omar Yoke-Lin Ong says: "In its striving for excellence and quality, OYL will continue to prioritize R&D, productivity and quality improvement. We are proud to report that our Louisville headquarters (in the US), Reed manufacturing facility and OYL-Condair manufacturing facility have achieved ISO 9001 and ISO 9002 certifications respectively." Through a joint venture between McQuay Asia (Hong Kong) Limited (a subsidiary of OYL Industries) and a Chinese company, the group has established itself as a major manufacturer of air-conditioning and refrigeration products in China.

The electronics industry is the biggest contributor to Malaysian manufactured exports. In 1995, 64.5 per cent of Malaysian manufactured exports came from this industry (RM51.1 billion). Most of the major players in this industry are multinationals; OYL Industries stands out as one of the few large locally owned firms. In 1995, OYL Industries group turnover was RM2.5 billion, a sixfold leap in a single year from RM394 million in 1994.

As a group, OYL Industries Berhad's commitment to innovation is manifested in its establishment of R&D units in almost all its local manufacturing facilities. Each OYL subsidiary is expected to have its own R&D unit. OYL Industries Berhad realizes that without innovation, the company will not be able to compete. To co-ordinate its innovation activities, OYL Industries established a subsidiary called OYL Research and Development Centre Sdn Bhd in 1991.

The group is also committed to environmentally sound production, and has stepped up efforts to design environment friendly products. In fact, they have achieved breakthroughs that have enabled them to make many of their products CFC-free and more energy efficient.

R&D management

OYL Electronics set up an R&D Department at its inception in 1991. The R&D Department designs and develops different types of air-conditioner controllers. Since 1991, the company has spent about 3 per cent of sales annually on R&D, a proportion comparable to big Japanese electronics companies. OYL Electronics believes that its R&D activities will build its internal capabilities and lessen its dependence on its technology suppliers for new product innovation. R&D will also build the capacity to customize design.

However, the company faces a number of constraints in conducting R&D activities. The main obstacle is the lack of sufficient supporting technical staff due to the tight labour market in Malaysia. Another constraint is the limited R&D budget. Since the company is expanding very fast and capital is required for new production capacity, the R&D Department faces very tight capital expenditure control.

Innovation management

The managing director of OYL Electronics has a positive attitude towards innovation. As innovation is a risky undertaking, his willingness to take risks is moderate, an attitude consistent with the overall innovative culture of the OYL group of companies. The top management devolves adequate authority to lower management to implement innovation in the company, especially if the idea is relevant to the scope of the employees' responsibility. If an employee has some innovative idea beyond the scope of his/her responsibility, he/she has to bring these ideas to the attention of the relevant superior. These ideas will then be brought to an *ad hoc* team for "small group activities" (SGA).

Process of innovation management

The management of OYL Electronics feels that it is quite innovative compared to competitors in the industry. A number of factors are said to be instrumental for the current rate of technological advancement. One is the technical support from OYL Research and Development Centre Sdn Bhd (hereafter referred to as OYL R&D Centre), a subsidiary of OYL Industries Berhad established with the main purpose of co-ordinating the R&D activities of the group. Another is information from and demands of customers.

In the early phase of OYL Electronics' development, technology was acquired through licensing, especially through sister companies overseas. Over the years, OYL Electronics has jointly developed technology with these companies. Now, OYL Electronics has matured and has begun to develop its own technology.

The process of innovation in OYL Electronics starts with idea generation. The idea can come from various sources, including competitors, customers, the media and its own employees. The idea is screened by the heads of marketing and R&D and by the general manager. If the three managers approve the proposal, it is sent to the R&D unit for consideration. The company uses technical as well as business evaluation to screen and analyse new ideas. Technical evaluation gauges the feasibility of producing the new products at reasonable cost. If the new idea passes this stage, the company evaluates the potential market for the product, and conducts a cost-benefit analysis to compare the project with other proposed investments. Finally, the R&D unit develops a preliminary design.

Once a prototype of the product is developed, the marketing manager, production manager and the general manager examine the product for approval. Based on the feedback of the three managers, the R&D team redesigns the product before the decision to commercialize the product is made. In many cases, the product is custom-made according to customer specifications.

OYL Electronics believes that the level of innovation achieved by the company is largely due to the technical competence of its human resources. The company has an excellent pool of qualified engineers and scientists motivated to advance R&D. In addition, the company gains cross-inputs from its sister companies locally and overseas. This intra-group technology transfer means that the company does not need to reinvent the wheel. The company is also fortunate in having a very supportive top management committed to innovation.

Types of innovation

OYL Electronics views product innovation as the most important focus of its innovative efforts, followed by social innovation and process innovation respectively. The company feels that product innovation has contributed significantly to its success thus far while both social and process innovation have contributed moderately to the success of the company.

OYL Electronics gives two main reasons for ranking product innovation most important. The company believes that product innovation will provide a competitive edge in terms of cost, quality and performance. The company is also of the opinion that product innovation will support market expansion as products are becoming more varied and differentiated, with customized production rapidly becoming the norm.

Despite ranking social innovation as being of secondary importance, OYL Electronics seeks to augment the value of each staff through improved skills and competencies. Social innovation will also encourage the cross-fertilization of ideas and promote creativity and imagination. Although process innovation is ranked as least important, OYL does invest in process innovation to improve manufacturing efficiency and product quality. To inculcate an innovation culture within the organization, OYL Electronics occasionally sends its production and R&D staff to trade shows locally and overseas, seconds them to sister companies abroad, and sends them to visit customers to listen to their problems and to solicit ideas on product improvement and development. The company occasionally organizes internal seminars for engineers, designers and managers, conducted by internal resource persons or suppliers' engineers. Articles and publications relating to new products are frequently distributed for the attention of the relevant personnel.

To co-ordinate innovation management, four different departments – namely R&D, marketing, production and quality assurance – work hand-in-hand. Representatives from these departments meet to discuss issues relating to new product development. For strategic reasons, the company does not have a formal system for sharing information within the company, but rather confines information on new product development to the general manager, marketing manager, and R&D head. As new products are integrated into trial production, information is distributed under a Manufacturing Resource Planning (MRP) network under controlled access.

R&D tax incentives

OYL Electronics is aware of the tax incentives available for R&D purposes. The company has utilized the five-year tax-free pioneer status incentive since 1991. After the five-year period, the company will continue to do R&D regardless of the availability of the incentive. Being in the highly competitive electronics industry, the company has to innovate to achieve its competitive edge. The company strongly believes that the tax incentive is attractive enough to encourage most companies to set up R&D facilities in the country. However, the company is aware that some organizations are still not prepared to conduct R&D even with the incentives. The company believes that some further measures need to be taken to encourage companies to conduct R&D. One measure would be to enhance the strength of supporting industries so that they can also participate in R&D efforts. In addition, the government needs to upgrade the standards and laboratory facilities for test compliance in SIRIM. Lastly, government agencies dealing directly with the private sector need to improve their level of professionalism.

Case 3: Matsushita Air-conditioning Group of Companies [3]

Matsushita Air-conditioning Group of Companies (MACG) consists of four companies: Matsushita Industrial Corp Sdn Bhd (MAICO), Matsushita Compressor and Motor Sdn Bhd (MCM), Matsushita Air-conditioning Corp Sdn Bhd (MACC) and Matsushita Air-conditioning R&D Centre Sdn Bhd (MACRAD). MAICO, established in 1972, was the first company in the group to be set up, while MACRAD was established in 1991. As of 1993, the paid-up capital for the whole group stood at RM252.5 million. The parent company for the Matsushita Air-conditioning Group of Companies in Malaysia was the Air-conditioning Division (established in 1960) of Matsushita Electric Industrial Co. Ltd in Japan. The air-conditioning division has branches in Taiwan, the Philippines, Thailand, Indonesia, Malaysia, the United States and Ivory Coast. However, only the operations in Malaysia and Taiwan carry out R&D functions.

The four companies in the group have their own areas of responsibilities and specializations. By advancing technology, the group is transforming Malaysia into the world leader in room air conditioners, exporting to more than 120 countries world-wide, including Japan. The three basic functions of research and development, manufacturing and marketing management are integral to Matsushita's emphasis on product excellence and customer satisfaction. Continuous improvements in product quality, design, size and durability are the core strategy for market competitiveness.

Matsushita Industrial Corporation Sdn Bhd (MAICO)

MAICO was established to produce window-type room air conditioners. From the initial annual production of 100,000 units of air conditioners in the 1970s, production now stands at more than 1,000,000 units annually. The ultimate goal of MAICO is to become a comprehensive manufacturer of air conditioners and air-conditioning equipment, servicing every aspect of the market. MAICO's product technology and designs have undergone tremendous evolution in keeping pace with changing market needs.

To complement MAICO's product upgrading activities, MACTEC was set up in April 1992 to develop and manufacture dies and moulds. MACTEC also provides technical assistance to its own suppliers in order to increase local content.

Matsushita Compressor and Motor Sdn Bhd (MCM) was established in 1987 to meet the increasing world-wide demand for compressors and motors. Besides supplying MAICO and MACC in Malaysia, MCM's three factories also export compressors and motors, and command a 35 per cent share of the world market for compressors. MCM1 is the only factory in the world with comprehensive manufacturing facilities for production, from compressor motors to completed compressors. MCM2 produces air conditioners for motors and vacuum cleaner blower motors, while MCM3 began operations in October 1993 to produce hermetic motors and toroidal motors.

In 1990, Matsushita Air-conditioning Corporation Sdn Bhd (MACC) commenced production of split room air conditioners, ranging from the production of component parts to the finished products. The company sources 85 per cent of all inputs locally, and exports final products to Japan and other parts of the world. Its emphasis on efficiency is reflected in the use of state-of-the-art computer-aided product design, production control, and automation. MACC constantly introduces the most advanced equipment in order to improve the efficiency of its production line system, and to achieve total quality control.

Matsushita Air-conditioning R&D Centre Sdn Bhd (MACRAD) was established in 1992 to undertake R&D activities as part of the group's strategy to become a self-reliant production complex which, according to Matsushita, involves the three basic functions of research and development, manufacturing and marketing. MACRAD is well positioned to design and develop all the new models for MAICO and MACC for manufacture in Malaysia, as well as to play a larger role regionally by lending assistance to sister companies in ASEAN for state-of-the-art product development, product engineering and quality assurance systems.

Currently, the Matsushita Air-conditioning Group of Companies employs a total of 5,588 local employees and fifty-two Japanese, i.e. less than 1 per cent of total employment. Of the total work force, about 5 per cent (260) are managers employed at different management levels. A breakdown of managers by function and level is shown in Table 3.5. As the group carries out the manufacture of room air conditioners for the world market, it is not surprising that production employs the most number of managers at all management levels. With the increasing intensity of R&D activities, R&D now employs sixty managers, while marketing has a total of thirty-two managers.

Table 3.6 shows the educational backgrounds of managers by level. At the senior management level, forty-five of fifty-one managers (80 per cent) have engineering backgrounds. Among middle and junior managers, however, only 42 per cent to 47 per cent are engineers. This clearly indicates the group's commitment to manufacturing and R&D.

In Japan, a total of 3,660 employees are employed in the air-conditioning division. Of this number, 310 are engaged in R&D activities. Compared to the Malaysian operations, the percentage of employees in R&D in Japan is higher.

Innovation management

The setting up of Matsushita Air-conditioning R&D Centre Sdn Bhd (MACRAD) in 1992 signified a major step forward in the transfer of technology from Japan to Malaysia. With its pursuit of a self-reliant production complex, MACG can now perform the three essential functions of R&D, manufacturing and marketing. R&D activities and innovation management will be more co-ordinated and integrated compared to the previously *ad hoc* performance of R&D activities in Malaysia. MACRAD is well positioned to design and develop all new models of room air conditioners for MAICO and MACC for the Malaysian as well as

Table 3.5 Number of managers by level and function

	Management functions					
Management level	*Finance*	*Marketing*	*R&D*	*Production*	*Personnel*	*Total*
Senior	4	2	11	36	3	56
Middle	2	10	32	28	3	75
Junior	20	20	17	61	11	129
Total	26	32	60	125	17	260

Table 3.6 MACG: educational background of managers by level

Management level	*Engineering*	*Science*	*Computer Science*	*Bus. Admin.*	*Arts/ Soc. Sc.*	*Others*	*Total*
Senior	40	–	–	–	5	6	51
Middle	18	1	–	3	–	25	47
Junior	54	11	5	7	4	53	134
Total	112	12	5	10	9	84	232

the South-east Asian markets. MACRAD is also working hard on the localization of parts and components, and has begun to file patents in Malaysia as well as abroad, reflecting the importance of the innovation performed locally.

In its strategy for intra-firm co-ordination of R&D, the approach taken by MACRAD resembles a "country-centred" approach which concentrates all R&D activities in one country, even though R&D is undertaken on a global scale for many countries. The company spent about 5 per cent of sales turnover on R&D during 1992 and 1993, with both growing at a rate of around 20 per cent in the second year. As Matsushita is the world leader in room air conditioners, its technological level is well ahead of the industry norm. Innovation provides the competitive edge for Matsushita air-conditioning division of Japan and the Matsushita Air-conditioning Group of Companies in Malaysia.

In line with its hi-tech operations, the manufacturing system is highly automated. However, Malaysia still lags behind Japan in terms of automation of manufacturing processes. The strong will and desire to improve has led to the formulation of MACRAD's mid-term objective of "Let's catch up with Japan". The unity in purpose of the MACG in Malaysia should be a strong motivating factor that can lead the company to create a learning organization in terms of technology adoption, adaptation and innovation.

The company believes that the three essential elements for any company to become excellent are the product, manufacturing and sales. Since improving these elements is impossible without good quality human resources, however, the company places a great priority on social innovation, involving training and skill upgrading of employees.

Product innovation

For product innovation, Matsushita pays attention to two factors: (i) market trends, in terms of customers' tastes and needs, and (ii) technological seeds. It adopts the market-driven attitude as R&D isolated from the market is unlikely to develop products that will meet commercial needs. Therefore, the majority of the allocation for R&D (90 per cent) is spent on applied research. At the same time, it cannot afford to ignore the importance of technological "seeds" or emerging trends. The balance of ten per cent of R&D funding goes to basic research. For most R&D activities conducted in MACRAD, decision making is highly decentralized. However, for new product planning, consultation with the parent company in Japan is absolutely necessary, especially for products for the export market.

Matsushita's leadership in the room air-conditioner industry is testimony to product innovation efforts. For example, it developed the scroll-type compressor, which reduces vibration to one-tenth of the vibration level of the conventional rotary-type compressor, greatly lowering noise emissions. An outdoor split air conditioner, 20 per cent smaller than the original model, was introduced in 1992 to the Japanese market. It was so well received that competitors such as Toshiba and Hitachi were unable to produce air conditioners to compete with it. Innovation is also key to the MACG's ambitious effort to penetrate the competitive US market. For this, the company will introduce a next-generation air-conditioning model, while reducing costs sharply through process innovation. The integration of engineering and production functions is important to meet such stringent specifications.

Process innovation

Process innovation is equally important in order to ensure high product quality. At MCM, stringent quality inspections are performed everyday under actual operating conditions at every stage of the production process. Process innovation runs parallel to product development in order to rapidly translate new product designs into full-scale production. In addition, other benefits of process innovation include cost reduction and improved productivity, which will translate into greater profitability for the company.

Social innovation

Man, machine, and money are required for production. The importance of social innovation is evident from the human resource development programmes initiated by the MACG. In its human resources development policy, the MACG states: "We make people before we make products." To further facilitate training, the MACG established an in-house training institute known as the Masters Institute of Technology (MIT). Both on-the-job and off-the-job training are conducted simultaneously to allow employees to benefit from the interactive effects of these two types of training. Employees are also sent to Japan for skills and knowledge upgrading. The MACG has retained its employees; to-date, only one employee has resigned after having completed his training in Japan. This contrasts with the frequent complaints of other Japanese MNCs that employees often leave the company after receiving training in Japan.

Apart from the formal training programmes, small group activities – such as quality control circles (QCC) – are an important part of the skills development programme. QCC presentations are held three times a year in order to motivate and encourage continuous improvement in performance. For the technical staff, competitions in welding, technical drawing, etc., are also conducted to encourage constructive competition among staff to further improve their skills and creativity. Monetary rewards are given to employees who develop new technologies for which patents are filed. This recognition has proved to be successful for new idea generation, development and innovation.

Information sharing system

In this hi-tech era, availability of information at the right time and the right place is vital for decision making in management. Similarly, for innovation management, information is crucial. The MACG's parent company in Japan compiles and summarizes technical reports, patent registration reports, etc., and disseminates them to Malaysia. Counterparts in Malaysia will then request detailed reports if necessary. This arrangement helps to keep the MACG informed of the latest developments in the industry.

New product development

The process of new product development involves eight stages before a new product is marketed. Based on market trends and data analysis, new ideas incorporating the latest developments are analysed. New product features will then be created according to market trends, demand analysis reports and final results of research activity. The third step involves research using computer simulations, where propositions are formed on how the main components – such as compressors, heat exchangers, fans and electronics devices – can work more effectively. Subsequently, the fourth step, basic product characteristics of the refrigerant circulation system, air flow system and structural strength, etc., are developed and designed. At the stage of prototype sample making (the fifth step), the product begins to take shape. At this step too, the prototype is subjected to experiments and extreme tests to gauge its viability. After having passed this stage, the next stage (the sixth step) is evaluation, in which various environmental tests are carried out using hi-tech experimental equipment to ensure reliability before specifications are determined and confirmed. For example, high humidity testing is conducted to test the water disposal performance of the product. The noise level is also tested in order to ensure that the air conditioners operate at a minimum level of noise. Next (the seventh step), precision machines with CAD/CAM are used in the production of dies and moulds. Mass production, in which products are manufactured for world-wide distribution, is the final stage of the new product development process (see Figure 3.2). It is clear that process innovation is critical during the last two stages of new product development, as it can determine the success of large-scale production and commercialization.

The systematic approach to new product development enables the company to avoid the "go" error and the "drop" error which are undesirable for product development as any of these errors could incur great losses to the company. At the same time, this model also demonstrates the importance of functional integration of R&D, manufacturing and marketing. Senior management in the MACG pays close attention to every aspect of innovation. Product, process and social innovation are not left to chance but carefully planned. For product innovation, the MACG concentrates on continuous product innovation to improve overall performance of room air conditioners to meet consumer demand that is

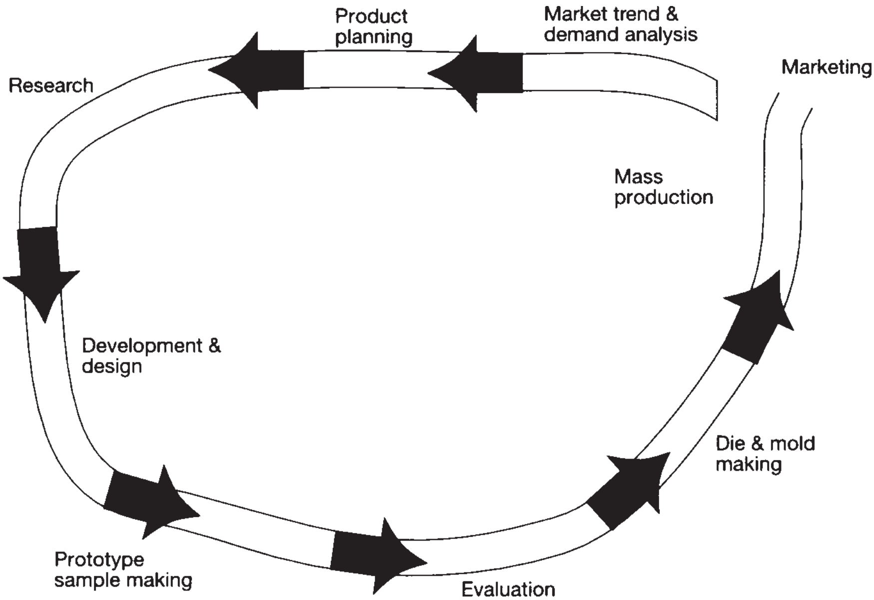

Figure 3.2 New product development process

becoming more sophisticated. Process innovation bolsters quality assurance, ensures smooth and efficient production, and works towards progressive cost reduction. The aim is to produce products with high value-added at minimum cost.

The international technology strategy of the MACG can be best described as being in the fourth stage, in which MACRAD embarks on new product development (Sakakibara and Westney 1992). The R&D facility in Malaysia epitomizes what is generally defined as the internationalization of R&D. It would be safe to predict that MACRAD will eventually move on to the stage in which strategic mandates encompass basic research.

Marketing management

Marketing management plays an important role in the successful commercialization of products. For effective marketing management, the Matsushita Air-conditioning Group of Companies practises geographical segmentation and uses multiple distribution channels to reach its customers. MAICO handles all domestic sales while the air-conditioning division of the parent company in Japan handles export sales. At the domestic level, two categories of dealers can be distinguished. The first category consists of the National Shops that exclusively sell Matsushita products. The second type of distribution is through the appointment of dealers who carry a mix of brands. A total of 250 dealers have been appointed for the distribution of room air conditioners in Malaysia. For export sales, the parent company sends sales personnel to markets all over the world to get orders, fix prices and close transactions. Sales transactions are transmitted to Malaysia where goods are exported directly to end buyers. In this case, the end buyers can be dealers or agents depending on the system of distribution in the buyer country.

R&D tax incentives

MACRAD is aware of the tax incentives provided by the government under the Promotion of Investment Act, 1986. However, the process of applying and obtaining approval for the incentives is tedious and time consuming. For indirect tax benefits such as tax exemption on the importation of machines for making prototypes which is crucial for R&D activities, the process is equally time consuming. These machines, which are hand made, are only available in Japan. Any delay in importation will delay the process of new product development. The case of Matsushita clearly demonstrates the attempts made to transfer technology to Malaysia. However, institutional constraints can be detrimental to the process and frustrate the progress of technology transfer.

The Matsushita Air-conditioning Group of Companies is able to command market leadership as the group has an effective system of marketing management, an emphasis on R&D and innovation, and the co-operation of the manufacturing function. With these three functions operating in an integrated manner, the MACG can be considered self reliant and comprehensive in its management system.

Case 4: Kao Corporation [4]

Kao Corporation was founded in Japan in 1890 by Mr Nagase with "Kao toilet soap" as its first product. The company was then known as Nagase Shoten. Kao Soap Company Ltd was formed in 1954 with the merger of two affiliated Kao companies. Although Kao first started as a soap manufacturer, it soon expanded its product line to include Kao Shampoo and Beads, a powdered laundry soap. During Japan's rapid economic growth in the 1960s, further expansion of product lines took place to include an entire line of cleansers for use throughout the home.

Kao's expansion into overseas markets began in 1957 when the company first exported Feather Shampoo to Thailand. Its involvement in overseas markets was restricted to South-east Asia until 1986, when it first established Kao Corporation of America in North America. Today, Kao has over fifty offices around the world, and focuses its activities in four regions: Japan, South-east Asia, Western Europe and North America. For the fiscal year ending 31 March 1993, net consolidated sales reached a total of US$6,631.7 million (*Annual Report 1993*) compared to US$3,926.8 million three years earlier (*Annual Report 1990*), representing an increase in performance of 69 per cent, with all the major products recording increases in sales. In fact, according to Kao Corporation, it has the number one or two position in virtually every market in which it competes. From its humble beginnings as a soap manufacturer, Kao has grown into a transnational corporation with a wide spectrum of diverse activities. The products manufactured by Kao can be broadly classified into two: (1) household products, including personal care, cosmetics, cleaning products, shampoo, etc., and (2) chemical products, including edible fats and oils, specialty chemicals, polyurethane systems and additives, plasticizers for synthetic resins and polyester resins; floppy disks form another component of this product category.

Kao's corporate philosophy claims it should contribute to the enhancement of people's lives by offering products which improve the quality of their lives. Consistent with this philosophy, Kao Corporation wants to offer products which generate new growth and expand the market horizon. The way to achieve this mission is through its emphasis on research and development to drive new product development and strong sales. Kao's organizational principles stress that all individuals deserve the same respect, regardless of differences in their positions or roles. In promoting the sharing of ideas and creating the desire to improve performance at all levels, Kao strives to move away from a pyramid-type organization to a more flexible corporate management structure.

Kao (Malaysia) Sdn Bhd

Kao (Malaysia) Sdn Bhd was established in 1973 with a paid-up capital of RM8 million. Its major shareholders are Kao Corporation Japan (45 per cent), Boustead Holdings (45 per cent), and the Felda Corporation (10 per cent). Today, it is one of the leading manufacturers and distributors of toiletries and hygiene products in Malaysia. The rapidly growing local demand for Kao's products has necessitated expansion programmes, including a new factory costing RM12 million in Port Klang. In 1988, Kao Corp. also formed a joint venture, Fatty Chemical (Malaysia), with Palmco Holdings to develop palm oil operations; this venture is becoming one of the Kao Group's key global suppliers of intermediate materials.

Management of Kao (Malaysia) Sdn Bhd

Figure 3.3 shows the formal organizational structure of Kao Malaysia. The company is organized into six functional departments: EDP, sales department, manufacturing and production, R&D, logistics and sales administration, and finance and administration. Currently, there are 280 full-time employees in Kao (Malaysia), with a total of 26 managers at different levels of management (Table 3.7). Despite having only one manager for R&D at the senior level, R&D remains an important activity carried out within other divisions. In terms of professional qualifications and educational backgrounds, managers are drawn from diverse educational backgrounds, as shown in Table 3.8. All top managers have either engineering or science qualifications, while six out of the ten middle managers have similar backgrounds.

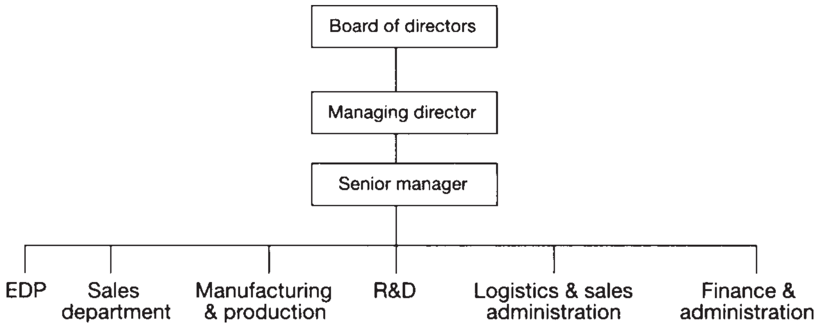

Figure 3.3 Kao's organization structure

Table 3.7 Kao Malaysia: number of managers by level and function

	Management functions					
Management level	*Finance*	*Marketing*	*R&D*	*Production*	*Personnel*	*Total*
Senior	1	–	1	2	1	5
Middle	1	4	–	4	1	10
Junior	1	5	–	4	1	11
Total	3	9	1	10	3	26

Research and development management

Kao believes that research and development is integral to its ability to deliver meaningful and superior products to consumers. Kao has seventeen laboratories world-wide, and four in Japan, each of which specializes in different areas of research. The R&D headquarters at the main office plays an active role in overseeing and co-ordinating their activities in order to maximize the effectiveness of their functions. The establishment of R&D facilities in Malaysia in 1975 indicates Kao's internationalization of technology for over two decades. However, the types of R&D activities conducted in Malaysia are limited to quality assurance and product development for the local market without any basic product research.

In order to co-ordinate research activities around the world, Kao has adopted an approach known as the "pooled" approach in which R&D activities are conducted at several overseas bases, with half the research being initiated by each base, making for simultaneous, parallel R&D within the company (Rosenberg 1992). In this manner, Kao is able to benefit from the intra-firm co-ordination of dispersed R&D activities.

Table 3.8 Kao Malaysia: professional qualifications and educational backgrounds of managers by level

Management level	*Management functions*					
	Engineering	*Science*	*Business Admin.*	*Arts/ Social Sc.*	*Others*	*Total*
Senior	2	3	–	–	–	5
Middle	4	2	4	–	–	10
Junior	–	–	2	5	4	11
Total	6	5	6	5	4	26

Its commitment to research and development is also evident from the composition of its staff. About one-quarter of the staff is involved in R&D performing high-level basic and applied research, product development, and manufacturing technology research and development. In Malaysia, eighteen of 280 employees are involved in R&D functions. Although this is low compared to the ratio in Japan, Kao Malaysia has access to the technology developed in Japan. This benefits the receiving country in terms of technology transfer and maintains Kao's competitiveness globally.

Researchers in Kao are given wide latitude in their research activities. For example, 80 per cent of the activities conducted are transparent to top management, while the remaining 20 per cent of the research, known as "warming up under the table", is concealed from top management. Top management will be informed when the ideas being experimented with show potential for commercial success. Such flexibility given to researchers has enabled them to carry out their activities without fear of failure.

In addition, R&D conferences and workshops are held regularly, with both management and research staff genuinely engaging in discussions. With the strong emphasis on research and development, Kao's technology development can be described as very advanced compared to its competitors. The strategic thrusts of the company's R&D activities are in-depth basic research, inter-disciplinary research, and the fusion of science and technology (see Figure 3.4).

Adopting a market-driven approach, Kao constantly conducts consumer surveys to screen ideas in order to avoid "go" error and "drop" error. Joint meetings are then conducted with the various departments in order to achieve cross-functional integration for successful product development. As indicated in Figure 3.5, the integration of production, marketing and R&D functions has led to the development of innovative products that meet customer needs.

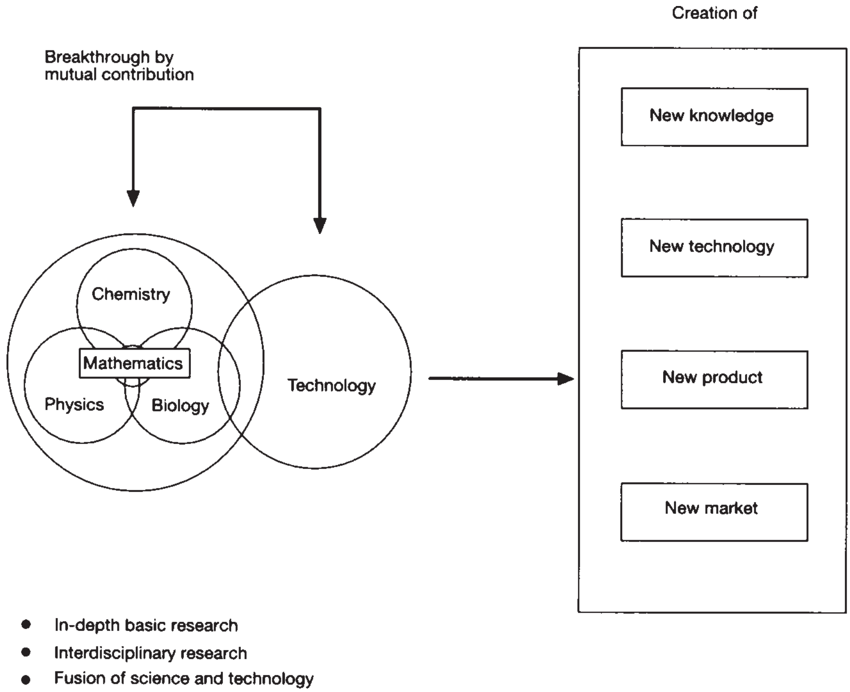

Figure 3.4 Interdisciplinary research and fusion of science and technology
Source: Yoshio Maruta (1992) *The Pursuit of Learning Through Mind and Body*, Japan: Kao Corporation, p. 119.

Types of innovation

The most important type of innovation carried out by Kao is social innovation, followed by product innovation. Process innovation is relatively unimportant to the company's competitive strategy. The strong commitment to social innovation rests on the belief that the entire organization cannot be better than its staff. Under product innovation, the three types of product innovation, continuous innovation, dynamic continuous innovation and discontinuous innovation, share almost equal importance in terms of contributions to corporate success. However, dynamic continuous innovation, which involves major changes in an existing product, is ranked as the most significant.

New product development

In order to maximize the potential of new products, Kao places great importance on the management of new product development. During the technical development phase of a new product, five frequently asked questions are:

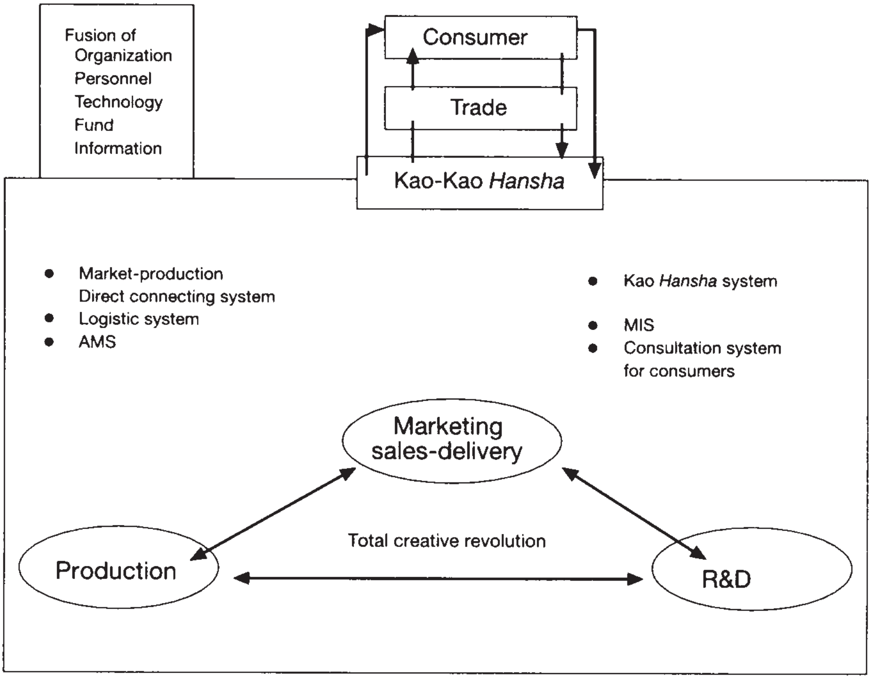

Figure 3.5 Total Integration
Source: Yoshio Maruta (1992) *The Pursuit of Learning Through Mind and Body*, Japan: Kao Corporation, p. 121.

1 Is the product really useful?
2 Does it make use of Kao's own creative technology?
3 Does performance justify the cost?
4 Can the product gain support in consumer tests?
5 Is the product compatible with existing retail distribution systems?

A product that fails to measure up to any of these criteria will be held back for further development. In this way, Kao is confident that it develops products that can expand the market horizon.

Information sharing is viewed as critical in achieving success for the company and this is exemplified by the system in Kao where managerial and non-managerial staff have access to the same information. This open communication, transcending organizational lines, is consistent with the company's philosophical commitment to equality among its employees. This helps in promoting the sharing of ideas and creating the desire to improve performance at all levels. In addition, any employee in the organization is given the freedom to suggest innovative ideas at meetings or even through personal discussions with the managing director who maintains an open door system of management.

Since social innovation is accorded prime importance, great attention is given to human assets. Training programmes are tailored towards the promotion of innovation, and include training in Japan, on-the-job training and formal training by outside consultants. In addition, small group activities are found to be effective for idea generation.

Marketing management

The successful commercialization of new products requires more than just superior products. Effective marketing programmes form another important ingredient that will ultimately enhance the financial performance of any corporation. In this regard, Kao is committed to consumer marketing by effectively and constantly communicating with its consumers about the benefits of Kao's products.

Apart from its commitment to consumers, Kao has also successfully maintained a strong, long-term relationship with its distribution network to ensure that the products reach the ultimate consumers in a prompt and reliable manner. For example, in Japan, Kao can simultaneously ship new products to 300,000 retail outlets or deliver products the day after a retailer places an order. This is made possible through the introduction of an innovative sales strategy in Japan known as *Hansha*. *Hansha* are independent sales firms that exclusively handle Kao products (Figure 3.5). The ten Kao *hansha* handle about 80 per cent of sales directly with retailers, acting not only as a wholesaler and mediator of product distribution but also providing consultation on matters such as merchandising, display, sales promotion and renovation of shops. Figure 3.6 illustrates the distribution system under the *hansha*. In addition to its effective distribution system, an automated information system called the Kao Logistical Information System (KAOLIS) has been implemented to further boost the efficiency of Kao's operations. About 900 large retail stores are directly connected to *hansha* via an on-line computer system which strategically integrates Kao's marketing activities with its manufacturing operations and distribution system. With this integration of manufacturing, distribution and sales, Kao is able to establish efficient delivery and manufacturing systems well suited to the fast-paced and constantly fluctuating consumer market. In summary, the success of Kao clearly reflects the importance of R&D, the fusion of technology and the integration of R&D with other management functions such as marketing and production.

Innovation management: a comparison

This section identifies key differences between the Malaysian companies and the Japanese MNC subsidiaries. The case studies indicate major differences in innovation management between the locally owned companies on the one hand, and the Japanese MNC subsidiaries on the other. The differences seem to lie in terms of four factors: length of production experience, management philosophy, approach towards R&D, and innovation management and structure.

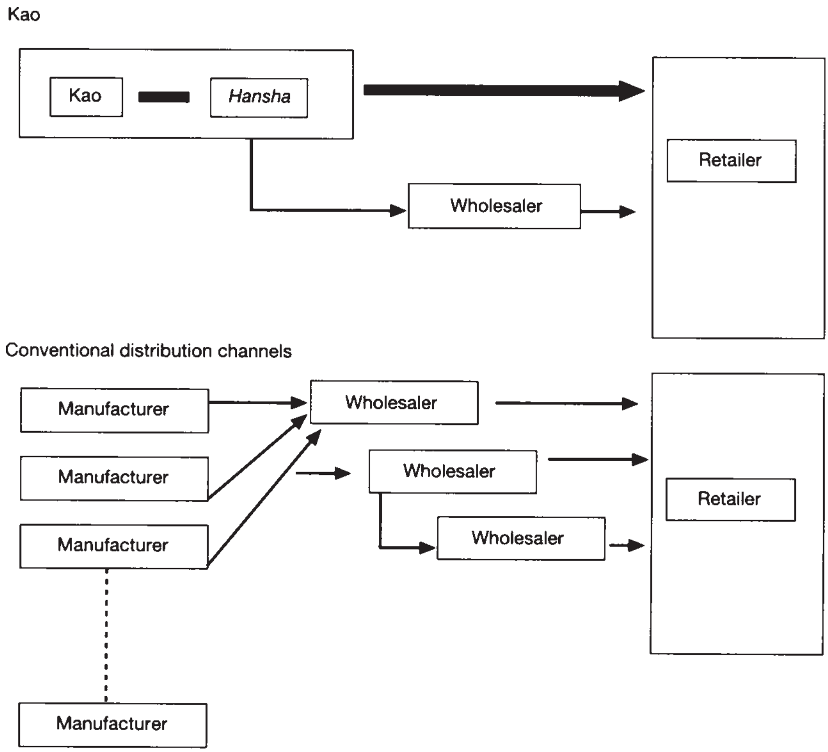

Figure 3.6 Kao conventional distribution channels
Source: Kao Corporation Annual Report, 1993, p. 16.

Length of production experience

Japanese MNCs draw on the technological resources and managerial experiences of their parent companies, who have been in business for decades. Through such linkages, Japanese MNCs derive tremendous benefits in building management systems which support high performance in cost and quality in areas such as input sourcing, manufacturing efficiency, R&D and technology development. Moreover, many Japanese MNC subsidiaries operating in Malaysia are themselves as old as most local companies, and have built up innovation management capabilities through long experience.

Management philosophy and approach to R&D

Japanese MNCs share a very positive attitude towards R&D, and innovation is a core tenet of their corporate cultures. Malaysian companies, however, are only beginning to engage in R&D, although OYL Electronics and its parent company have already made great strides. Most local companies have yet to incorporate innovation as part of their corporate culture.

The scale, size and type of R&D activities also differ in the local companies and the Japanese MNCs. In addition to a primary focus on applied research for continuous incremental improvement, Japanese MNCs also carry out some components of more strategic R&D, contributing to discontinuous product innovation. Among the local companies, R&D is concentrated in applied areas with no commitment to more basic research. Local firms point to their lack of human and capital resources; yet, overcoming such obstacles and investing in product innovation will be key to future success.

The Japanese corporate philosophy towards R&D has also resulted in greater flexibility for their employees in R&D. For example, in the case of Kao Corporation, research staff enjoy the autonomy to explore and to develop. Among Malaysian companies, limited staffing and R&D budgets make exploratory research an unaffordable luxury. Yet, an overly focused research environment may turn out to be counter-productive as such conditions tend to stifle creativity and innovativeness.

Innovation management and structure

Although product innovation appears important to both sets of companies, the intensity of their focus is different. In addition to incremental innovations, the Japanese corporations are also working hard on new product development to expand their market shares. The local companies, on the other hand, lack capabilities for original product innovation and can only manage incremental innovations. The case of Pharmmalaysia, which develops post-patented products rather than original drugs, offers a good example.

Another area of significant difference between the Japanese MNCs and the Malaysian companies lies in the emphasis on "social innovation" as a component of human resource development. Companies that are strong in R&D, regardless of country of origin, have long recognized the importance of constant training and retraining to create a "learning organization". The case studies indicate that Malaysian companies are not paying sufficient attention to social innovation. Their fear that, in the tight labour market, employees will resign after extensive training outweighs their estimation of the benefits from staff training and development. This has resulted in an exclusive emphasis on "on-the-job" training, usually on an *ad-hoc* basis. Malaysian companies must realize that "on-the-job" training may be crucial, but it is continuous learning that makes the difference in terms of firm capabilities to innovate.

With regard to process innovation, neither set of companies is particularly strong. Process innovation is usually pursued in support of new production introductions. In other Japanese MNCs, such as Toshiba (Ong and Othman 1995), incremental process innovation is undertaken to smooth the production process while saving labour.

Another important aspect of innovation management is information flow. The obvious difference between the Japanese MNCs and the local companies is the open attitude adopted by the Japanese MNCs and the control-oriented approach of the local companies. In the latter, information management seems to begin with "mistrust" rather than "trust", whereas the Japanese MNCs believe that their employees can and will perform better if informed of company goals and processes. This suggests that local companies need to re-examine information management practices to enable employees to participate more effectively in innovative efforts.

Private sector imperatives

From discussions with the private sector companies, the obvious sources of innovative ideas are mostly market driven, i.e. from customers, suppliers, competitors, and rarely from the search for patents. Patent search can be a very useful source of information for innovation and, at the same time, it is time and cost saving as it prevents reinventing the wheel. Local companies must be aware of this useful source of information.

Japanese MNCs have a strong corporate culture that emphasizes R&D. Local companies, on the other hand, do not have a strong R&D culture, which tends, anyway, to be limited to the top and middle management levels. Therefore, they should emulate Japanese companies by incorporating the R&D culture into their organizations, which will in turn help to facilitate innovation as well as the diffusion of innovation.

Before innovation can take place, local companies must be prepared to spend more on R&D; otherwise, they must be prepared to lose market shares. As the future trends indicate, technology and innovation will remain key competitive tools. As such, local companies must begin to take cognisance of the serious consequences if they choose to ignore this signalling in the environment. Active acquisition of technology – which can include acquisition of innovative companies, joint ventures, licensing agreements, etc. – must be a priority of local companies in their corporate planning.

With regard to innovation management, incremental product innovation can be a good strategy. Even if slowly, the companies must progress towards the development of new products. This means that the other two types of innovation – process and social innovation – must be integrated into the process of innovation management. Local companies must pay more attention towards social innovation, which involves the training and development of workers. This will, in turn, improve their skills and absorptive capacity, healthy for the promotion of R&D and innovation. The HRDF should be exploited to prioritize skill training for workers.

Conclusion

Intense competition has made the development of new products and processes with high efficiency, quality and speed imperative for competitiveness in domestic and global markets. Increasingly, competition is driven by quality and speed to the market with new innovations, rather than cost factors alone. Malaysian companies must pursue a clear strategic competitive focus and innovate to improve product quality and flexibility.

This study investigated the innovation management practices of local companies and Japanese MNCs. A comparison between these two sets of companies serves as an effective benchmark for local companies in the areas of corporate innovation, culture and innovation management. Companies in the private sector should inculcate the innovation culture in their management philosophy. They must incorporate technology strategy in their business planning and strive to develop long-term advantages through the accumulation of innovative capabilities.

Notes

* This study utilizes both secondary and primary sources of information, including company brochures and annual reports, which provide useful information and are extensively referred to for the purpose of our case studies. The primary source of information comprises of in-depth interviews with company officials (especially the managing director or chief executive officer). A questionnaire was developed for the interviews which covered the following areas:

- Company information (e.g. name of company, paid-up capital, number of branches world-wide, number of full-time employees, and educational background of managers);
- Amount spent on R&D;
- Level of technology sophistication (e.g. as compared to industry norms);
- Types of innovation;
- Innovation management (e.g. different types of incentive programmes to promote innovation, techniques to generate and screen innovative ideas, management philosophy on innovation, etc.).

1 The case studies presented are organized in the following manner. First, the cases present basic corporate profiles for each company, and then describe their growth strategies in the context of their particular industries. Next, R&D management and organization is discussed, highlighting corporate philosophy with regard to innovation and R&D, as well as the numbers and educational backgrounds of R&D managers. Third, the cases describe the management of the innovation process, beginning with idea or project generation, and analysing the extent to which R&D is integrated with other corporate functions. Then, the cases identify the *type* of innovation which each company emphasizes, including product, process, and "social innovation", e.g. constant skills upgrading and involvement of staff in innovation decision making. Finally, the impact of government R&D incentives is evaluated.

2 This section is heavily based on the OYL Industries Berhad 1995 *Annual Report*, articles in newspapers and magazines, and an in-depth interview with a manager of OYL Electronics Sdn Bhd.

3 This section is based on the *1993 Annual Report* of Matsushita Electric Industrial Co. Ltd, in-depth discussions with top executives of MACG as well as the following brochures by MACG-Matsushita Electric: *Annual Report 1993 Japan*; MACC, *Factory Guide*, Matsushita Air Conditioning Co. Sdn Bhd; MAICO, *Factory Guide*, Matsushita Industrial Corp. Sdn Bhd; MACG, "Introduction to MACRAD & MACTEC: Management Strength Through HRD Training Courses Book 1994", Matsushita Air-conditioning Group of Companies.

4 This section is based on an in-depth discussion with the managing director of Kao (Malaysia) Sdn Bhd, various issues of Kao Corporation's *Annual Reports*, and the following publications:

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4

UNDERSTANDING INNOVATION IN ELECTRONICS IN MALAYSIA*

Michael Hobday

Our understanding of the nature, sources and extent of innovation in East and South-east Asia is very poor. In spite of the astonishing rates of growth of countries such as Malaysia, South Korea, Taiwan and Thailand over the past two to three decades, there remains a large gap in our knowledge of the part innovation has played in the process of growth and technological catch-up.[1]

Until the recent crisis, Malaysia was one of the fastest growing economies in the world for over two decades.[2] Unlike Taiwan and South Korea, Malaysia (like other South-east Asian economies) has depended for much of its industrial export growth on large transnational corporations (TNCs). Has growth been accompanied by innovation and technological change within the TNCs? If so, what kind of innovation has occurred? How important has innovation been to Malaysia's success? What would motivate foreign TNCs to transfer skills and technology or prevent them from doing so? Have the subsidiaries encouraged headquarters to transfer technology and, if so, how?

This chapter seeks to address these questions by examining Malaysia's progress in electronics and electrical (EE) goods.[3] EE has represented a large proportion of total industrial exports and the fastest growing industrial sector in Malaysia. The country is the world's largest exporter of semiconductors and a major proportion of Japanese TV set production is now carried out in Malaysia. Almost all EE exports take place through Japanese, American, European, Taiwanese and other TNCs. The aim of this chapter is to illustrate the nature, depth and breadth of innovation, focusing mainly, but not exclusively, on the TNCs. A survey of recent innovations is presented, together with evidence on technological progress and motivations for upgrading. The chapter also touches on technological strengths, weaknesses and future prospects for the industry's development. With few exceptions, the subject of firm-level innovation in the newly industrializing countries (NICs) has received relatively little attention in the literature. The most revealing studies have tended to examine general processes of technological change at the industrial level (e.g. Lall 1982 and 1992, Dahlman *et al.* 1985, Westphal *et al.* 1985, Fransman and King 1984). Some studies analyse government policies for industrialization, again mostly at the industry level (e.g. Wade 1990, for Taiwan; Amsden 1989, for South Korea). Other work examines the economic conditions for successful growth (Riedel 1988, World Bank 1993).[4]

Recently, important new work has drawn attention to the part played by technology in Malaysian industrialization, focusing on inter-firm linkages (Rasiah 1994), the progress of EE in Malaysia (Hamzah Kassim and Ismail Salleh 1993, O'Connor 1993), cross-industry innovation (UNDP 1993) and foreign technology transfer (Guyton 1994, Capannelli 1994). By focusing on innovation progress at the transnational firm level, this chapter hopes to contribute to this growing body of literature on technology and industrialization.

The first two parts briefly analyse the contribution of electronics to Malaysia's economic growth and illustrate recent structural changes in the industry. The third part presents new evidence on innovation based on in-depth interviews with twenty EE companies, twelve of which were large TNCs, to indicate the scope and depth of innovative activities in EE in Malaysia. To explore the character of intra-firm innovation in more depth, the next part presents an illustrative case study of SEH (Shin-Etsu Handotai) of Japan, a major TNC producer of silicon wafers for export. The case helps to enrich the survey results by illustrating how innovation occurred and the motives behind technological improvements. EE innovation in Malaysia can only be understood within the context of the global strategies of the TNCs. Therefore, the fifth part develops a simple strategic model to illustrate the innovation position of TNC subsidiaries in Malaysia, both in relation to parent plants abroad and to subsidiaries in other competing locations. The final part presents a brief analysis of the opportunities and problems facing the EE industry in the future.[5]

Electronics in Malaysia: growth and structural change

As noted above, the EE sector has made a major contribution to Malaysia's industrial growth and economic development. Manufacturing overall grew very rapidly during the 1970s and 1980s, overtaking agriculture in terms of contribution to GDP, employment generation and foreign exchange earnings. In 1993, manufacturing constituted around 30 per cent of total GDP and 71 per cent of export earnings, while agriculture accounted for 13.6 per cent of GDP. In 1993, Malaysia became the world's nineteenth largest exporter (up from twenty-second in 1992), overtaking smaller developed countries such as Australia, Austria and Denmark.

In 1993, total exports reached RM121 billion (around US$48 billion), of which RM90 billion (US$36 billion), or 74 per cent, were manufactured goods. Within manufacturing, EE accounted for RM55 billion (roughly US$22 billion), about 61 per cent of total manufacturing, and around 45 per cent of Malaysia's total exports. Most other manufacturing exports were minor in comparison (e.g.

textiles and clothing comprised 6.2 per cent, wood products 5.4 per cent and rubber products 2.7 per cent). Within electronics, the largest export group in 1993 was electronic components (mostly semiconductors), which amounted to around RM18.7 billion (US$7.5 billion), 34 per cent of EE exports and just under 21 per cent of total manufactured exports.[6]

The EE industries began in Malaysia in the 1960s under the importsubstitution policy. Matsushita of Japan became the first major foreign investor in 1966, supplying the local market. Other foreign firms from Japan, the US and Europe entered to assemble radios, black-and-white TVs and electrical appliances. They also produced simple electronics parts such as dry cells, cables, lamps and batteries.

In the 1970s, the industry took off. Under the early export-led policies, semiconductors (or chips) and other components were produced in large volumes, providing badly needed employment and exports. The EE industry grew rapidly as TNCs relocated chip assembly activities. Low-cost labour, combined with the ten-year pioneer status, made Malaysia an attractive location for foreign direct investment (FDI). Most TNCs engaged in labour-intensive assembly in free trade zones (FTZs) and licensed manufacturing warehouses. An early US investor was National Semiconductor, which started up in Penang in 1971. Many other large TNCs followed. Motorola, which employed around 13,000 staff in Malaysia in 1995, began chip assembly in Kuala Lumpur in 1972. Intel, another large TNC, began the assembly of integrated circuits in 1972 in the Bayan Baru FTZ, with around 100 employees.

During the 1980s, EE exports continued to expand rapidly. During this decade, electronics exports (excluding electrical goods) grew more than sixfold, rising from around US$3.2 billion in 1981 to US$7.1 billion in 1986 and to US$22.1 billion in 1990 (Hamzah Kassim and Ismail Salleh 1993: 16). In 1987, electronics became Malaysia's largest export. In that year, US semiconductor producers alone employed around 36,700 people and contributed around 8.6 per cent of Malaysia's total manufactured exports. Total EE employment rose from 57,000 in 1986 to around 144,000 in 1990, representing roughly 12 per cent of Malaysia's manufacturing workforce. In 1986, the industry was heavily dependent on semiconductor testing and assembly, which still accounted for 82 per cent of exports.

During the second half of the 1980s, the structure of electronics output changed markedly with a broadening of the product base. The share of electronic components in total EE output fell steadily from around 81.5 per cent in 1986 to 57.6 per cent in 1990. At the same time, the share of consumer electronics grew from 12.3 per cent to 23.2 per cent of total production, while industrial electronics increased from 6.2 per cent to 19.2 per cent (Hamzah Kassim and Ismail Salleh 1993: 16).

The trend of declining dependence on semiconductors and other components continued into the 1990s. In 1993, components exports amounted to US$6.8 billion (45.7 per cent of total electronics exports), while consumer goods increased to US$4.2 billion (26.0 per cent) and industrial electronics rose to US$3.9 billion

(28.3 per cent) (*Electronic Business Asia*, June 1994: 11). The diversification trend continued in 1994 and 1995 with new investments in disk drives, computing and consumer goods. By that time, a large proportion of Japanese colour TV manufacturing was carried out in Malaysia. Following the relocation of US disk drive production into Malaysia in the early 1990s, the second half of the 1990s is likely to witness the growth of the computer industry led by US and Taiwanese producers.

However, progress was not without its setbacks. For example, as a result of deep international recession in 1991 and 1992, Japanese corporations, such as Matsushita, Sony, NEC and Toshiba, reported falling profits (in some cases, losses) and declining sales for the first time in their history. Japan was also affected by the impact of yen appreciation. The impact on Malaysia was immediate. In the first five months of 1992, Japanese EE investment fell to just RM401 million (roughly US$160 million), a sharp decline on the previous year. Similarly, US FDI fell back considerably. As a result, total investment in electronics (excluding electrical goods) fell from the peak of US$1.7 billion in 1990 to US$0.5 billion in 1993 (*Electronic Business Asia*, June 1994:11).

However, despite the fall off in FDI, growth in exports continued rapidly from 1990 as previous investments added to export capacity. In 1993, electronics exports increased by 18 per cent over 1992 to around US$15 billion, boosted by a slight recovery in investment in 1993. Figures for the first nine months of 1994 showed a partial recovery in overall manufacturing FDI from the low of 1993, with investment from Taiwan, Singapore and Hong Kong making up for the decline in Japanese and US FDI.

Strategic groupings of companies in electronics

Strategic orientation of firms

There is little detailed systematic evidence on the EE industry in Malaysia as commonly found in other countries (e.g. Singapore, Taiwan, Japan, the US and South Korea). Basic data on leading companies, chief product lines, market shares, and export performance by product do not appear to be available. Therefore, as a basis for understanding the industry, this section develops a rough guide to the strategic groupings of electronics firms in Malaysia, by ownership, export orientation and company size, largely based on interviews with firms and policy makers, and the existing literature (e.g. O'Connor 1993, Kam 1992, Ngoh 1994).

Group 1: first- and second-tier TNCs

Figure 4.1 identifies four major groups of EE firms (which overlap to some extent). By far, the largest segment in terms of output is Group 1 TNC exporting firms. This group can be sub-divided into (a) direct exporters of semiconductors,

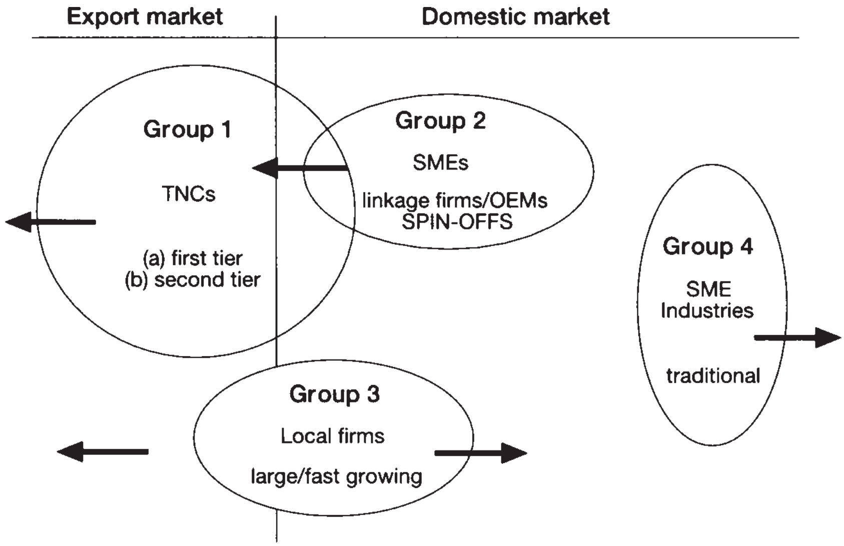

Figure 4.1 Major strategic groupings in the Malaysian electronics industry

disk drives, other components and equipment, and (b) second-tier TNC suppliers of sub-systems, components and OEM (original equipment manufacture) services to the first-tier companies. Some of the recent Japanese and Taiwanese investments fall into the latter group. Other TNCs provide OEM/original design and manufacture (ODM) supplies directly to buyers abroad (e.g. Centronix of Taiwan).

Besides Japanese TNCs, systems producers from Singapore, Taiwan and Hong Kong have relocated to Malaysia as their costs rose and, in some cases, due to currency appreciations. Major US disk drive investors include Conner Peripherals and Maxtor, who began investing in hard disk drive operations in Malaysia in the late 1980s. Sony began producing floppy disk drives in 1989. Other Japanese disk drive producers include Kobe Precision and Hitachi Metals. Some of the larger firms also make components for disk drives.

Most of the consumer goods producers are Japanese-owned, although a few European companies (including Grundig, Thomson/GE and Philips) produce in Malaysia. Ten or so major TNCs make TV receivers, of which half produce solely for export. Very large quantities of standard colour TVs (14 inches and above) are assembled. NEC of Japan and Ericsson of Sweden produce telecommunications switching equipment for domestic use. Both have joint ventures and both export sub-assemblies of switching systems. TRT, the French subsidiary of Philips, has supplied point-to-point microwave radio systems to households and public utilities since 1985.

Ericsson began making mobile cellular telephones in the mid-1980s. Motorola is a very large exporter of telephone equipment, having designated Malaysia as its Asia design centre for cordless telephone production (including the new CT2 model). Some smaller TNCs have upgraded from simple handsets to answering machines and key systems (e.g. Centronix). Northern Telecom (of Canada) in Penang exports telephone hand sets, private automatic branch exchanges and components including transformers, capacitors, fuses, receivers and printed circuit boards. Several other firms produce handsets for the local market.

Group 2: SME linkage/spin-off firms

Closely tied to the TNCs is Group 2 – small and medium-sized enterprise (SME) linkage firms. This includes the new firms which have spun off from the TNCs by forming their own operations, often supplying (in the first instance) their former employees (e.g. Globetronix). Each of the TNCs visited reported important spinoffs, and several leading local companies had spun off from the TNCs. The TNCs often provided start-up assistance, ongoing technical support and valuable user–producer interaction. Benefits to the TNCs included low-cost suppliers of materials, components and services, and the ability to shift out of low-end production to higher value-added goods. The SMEs in Group 2 tend to be pulled forward technologically by the needs of the TNCs. Such SMEs are locked into the demands of global export markets, and often have access to (with some following) best international management and technology practices.

Other Group 2 linkage firms include larger traditional companies who have converted much of their operations to supply the TNCs (e.g. some of the larger plastics and machine tool suppliers including Sanda Plastics and LBSB respectively). Again, these firms tend to progress technologically alongside the TNC export sector.[7]

Locally owned firms are generally much smaller than the TNCs and lag behind technologically. Some Group 2 companies carry out a little research and development (R&D), mostly centred on process and product development. For example, PK Electronics operates a small R&D department for developing uninterruptible power supplies, air conditioning controls and consumer peripherals. However, such firms are exceptions. Most SMEs employ very small numbers of technical staff, and engineering is focused on production efficiency.

Many local firms conduct sub-contracting and OEM for finished products and sub-assemblies. Some produce simple metal parts such as aluminium the castings for disk drives and plastic parts. Eastrade, a Motorola spin off, designs its own electronic toys and radios, and also provides OEM/ODM services to Sony and others. Penshin Components produces capacitors and car stereos under OEM/ODM. Sub-contracting to demanding TNC buyers often improves the product quality and technological capability of local companies.

Group 3: Large, fast-growing local firms

Group 3 includes the relatively new, fast-growing large local firms (e.g. Sapura, Likom, HIL and UNISEM). These firms supply both the domestic market and the export market. They are nationally owned companies which are high technology in practice and aspiration. They have forged technological partnerships with major companies abroad and view themselves as high value-added competitors in national and international markets. Some supply OEM/ODM services directly to overseas markets, much the same as some of the second-tier TNCs. In some cases, Group 3 firms have acquired high-technology firms overseas in order to directly access foreign technology and markets.

To some extent, Group 3 firms overlap with Group 2 linkage firms. However, in contrast with Group 2, a large proportion of their output is for direct export (and, in some cases, the domestic market) rather than via the TNCs. Group 3 companies are able to reach directly into leading edge international technology sources, bypassing the TNCs. They represent a major potential vehicle for building R&D capabilities and undertaking high-risk developments in Malaysia. These new firms illustrate the opportunities for entry and rapid growth in electronics at Malaysia's current stage of development.

Group 4: traditional, locally owned SMEs

Group 4 represents the large number of traditional low-technology SMEs in Malaysia, largely oriented towards the domestic market. Group 4 firms supply goods and services which relate both to electrical goods and electronics, but tend to focus on low-quality, low value-added activities. Management practices are poor, technology lags behind the other groups, and investments in training are low. These firms represent potential, rather than actual, contributors to the exporting sector.

Some of the traditional SMEs sell a small proportion of their output to TNCs (usually low value-added goods and services), overlapping with Group 2 companies. However, the majority of Group 4 firms supply low-technology indirect materials and services, such as packaging supplies, freight services, brackets, speakers, TV cabinets, power cords and cables.

Despite some professionalization of management in recent years, the large bulk of Malaysian-owned SMEs have tenuous connections with the dynamic EE exporting industry. Most SMEs face problems of small size, capital shortages, lack of technical and marketing expertise and poor product quality. Most conduct little or no in-house training, and many are dependent on one or two main buyers. According to Kam (1992:29), around 84 per cent of EE SMEs were engaged in fairly low-technology activities, mostly destined for the local market.[8]

TNC innovation: sources, character and directions

TNC strategies for innovation

The aim of this section is to analyse the character of, and strategies towards, innovation and to show how far innovation has progressed since the start of the industry. The focus is chiefly on technological innovation. However, managerial and organizational innovations are also touched upon. TNC motives for transferring technology are discussed, as is the technological dimension of the relationships between the TNCs and spin-offs (Group 2 firms).

Method and sample

Table 4.1 presents the sample of twenty firms (twelve foreign and eight local) interviewed over a five-week period during 1994 and 1995. The sample of twenty firms was structured on the basis of company size, ownership, sector and date of entry. The sample includes: (a) the major sectors within electronics (semiconductors, telecommunications, consumer goods, electrical goods, support industries, disk drives, etc.); (b) large, medium and small firms; (c) foreign (US, Japanese, European and Taiwanese) and locally owned companies; (d) early and recent entrants; (e) types of activity (systems manufacture, OEM/ODM, sub-contracting, specialized services); and (f) three of the four major strategic groupings of EE firms as described above.[9]

Managing directors, R&D directors, engineers and other staff were interviewed, with around forty interviews in total. Although the number of company interviews was small in number, the sample amounted to around US$7.3 billion in output in 1993 or 1994, equivalent to roughly 32 per cent of total electronics exports.[10] Total employment of the sample firms was 63,465, a significant proportion of total EE employment. In addition, to check the results, a further twenty or so interviews were conducted with representatives of government agencies, academic institutions and other organizations concerned with electronics, technology and education (including the Ministry of International Trade and Industry, the Federation of Malaysian Manufacturers, the Penang Skills Development Centre, the Selangor Human Resource Development Centre and the Ministry of Science, Technology and the Environment).

Innovation activities of EE firms

Table 4.2 presents a profile of engineering and technical staff of the sample companies, with a small sample of examples of recent innovations by each firm. As the data show, TNC R&D departments tend to be small, and R&D is a small proportion of total technology activity.[11] In leading companies (e.g. Motorola Penang with 130 R&D staff), significant R&D departments exist. For most companies, the main technological activities were carried out by technicians and engineers. Although not reported in Table 4.2, most firms also had substantial budgets for training and skills development.

Although the data in Table 4.2 are not strictly comparable (company definitions were used), they show substantial technical support for production and near-term technological needs, ranging from 1,300 engineers and technicians (16.2 per cent of the workforce) at Sony, to 120 (18.8 per cent) at MEMC, to just

Table 4.1 Sample profile: electronics, components, electrical and supporting industries

Firm	*Product area (principal)*	*Principal activities*	*Ownership*	*Start-up Malaysia*	*Employment/turnover (1994)*
Strategic Group 1: TNCs, first and second tier					
Intel, Penang	Semiconductors	Assembly, test	US	1972	2,600/n.a.
Motorola, Penang	Mobile communications	Manufacture, design	US	1974	2,660[1]
Matsushita	Air conditioners	Manufacture	Japanese	1972	24,700[2]/US$2,500m[3]
SEH (Shin-Etsu)	Semiconductors	Wafer manufacture, preparation	Japanese	1973	1,350/US$196m
Sony Electronics	CD players, radios, cassettes, hi-fi	Manufacture, design	Japanese	1987	8,000/US$1,059m
Sony Mechatronics	Floppy disk drives (3.5″)	Manufacture	Japanese	1989	3,900/US$830m
Centronix	Audio and telecommunications	Assembly, OEM/ODM[4]	Taiwanese	1988	700/US$29.5m
Iventec	Telephones, calculators, pocket organizers	Manufacture, design	Taiwanese	1987	3,000/US$240m
Grundig	Audio, hi-fi, cassette recorders	Manufacture, design	German	1988	900/US$90m
MEMC	Semiconductors	Wafer manufacture, preparation	German	1972	640/US$86.8m[5]
Siemens	Optoelectronic components	Manufacture, design	German	1972	1,560/US$128m
Philips/JVC	VCRs, TVs, audio electrical appliances	Manufacture, design	Dutch/Japanese joint venture	1988	3,190/US$400m

Strategic Group 2: SME linkage firms / spin-offs					
L.S. Technology	Semiconductors	Electro-plating	Local	1990	200/US$3.0m
Globetronix	Semiconductors	Assemnbly, testing, burn-in	Local	1991	800/n.a.
Oris (Orisystems)	Semiconductors	Wire bonding	Local	1994	15/US$0.23m
Sanda Plastics	Plastic housings and components	Injection moulding	Local	1974	360/US$0.98m
LBSB (Leong Bee Soo Bee)	Semiconductors	Cutting/grinding tools for wager manufacture and trading	Local	1921	150/US$7.8m
Strategic Group 3: large/fast-growing independent local firms					
Likom	Electronics (microcomputers, disk drives)	OEM/ODM	Local	1992	3,300/US$500m
Sapura	Telecommunications handsets/ payphones	Manufacture, design	Local	1975	4,500/US$392m[6]
UNISEM	Semiconductors	Assembly, testing	Local	1991	1,100/n.a.

Notes

1 Total Motorola employment in Malaysia in 1994 amounted to 13,000 in five factories. Total investment in Malaysia exceeded RM1 billion (roughly US$400 million).

2 Based on exchange rate of US$1.0 = RM2.55.

3 Includes all five Malaysian plants.

4 Original equipment manufacturer/own design and manufacture (i.e. the company produces for brand name purchasers according to general design specifications).

5 Estimated from data on MEMC corporate turnover per employee.

6 Includes total group turnover (1994) of Uniphone, Sapura Telecom and other companies.

Table 4.2 Engineering, technical support, R&D and recent innovations[1]

Company	*Total employment*	*Engineers/technicians*	*% of employment*	*R&D[2] Dept/staff*	*Recent innovation examples*
Intel Penang	2,600	n.a.		40	Reliability analysis breakthrough: development of new jigs, fixtures, machinery: new SPC[3] techniques
Motorola Penang	2,600	300[4]	11.5%	130	Cordless phone design (CT2); changes to advanced manufacturing equipment; simple ASIC designs; new product design for manufacture
Matsushita	24,700	n.a.		40	Numerous split air conditioner design changes (e.g. voltage, style); die and mould development; design for manufacture
SEH (Shin-Etsu)	1,350	50/100	9.0%	10	Capital goods, e.g. new automated etching and slicing machines (patented); total quality management modification
Sony Electronics	8,000	500/800	16.2%	30[5]	Design specs for Sony Discman (portable CD), development of capital goods; prototypes for new hi-fi systems
Sony Mechatronics	2,900	80/150	7.9%	n/a	Continuous improvements to processes; minor changes to locally purchased inputs
Centronix	700	30/58	12.6%	10	Telephone handset designs: new tooling specs: design for manufacture
Inventec	3,000	130/134	8.8%	10	Calculator model designs (including LSI chip); manufacturing specs for telephone handset
Grundig	900	54/35	9.9%	38	Product designs for hi-fi and cassette recorders, design for manufacture
MEMC	640	60/60	18.8%	—[6]	Re-engineering of production lines into cellular form, including integration of R&D into production: improvements to wafer saw and other equipment
Siemens	1,560	50/110	10.3%	8	World centre for Siemens opto production and design; applied new approach to TQM[7]; development of new bonding machines with foreign suppliers
Philips/JVC	3,190	32/40[8]	2.3%	11	Design for manufacture; continuous improvements to production processes
L.S. Technology	200	2/6	4.0%	—	Unique mini-rack plating machine (exported); chemical process improvements; changes to capital goods

Oris (Orisystems)	15	4[4]	27.0%	—	Development new low-cost gold wire bonding machine; substantial refurbishment and re-engineering of depreciated equipment
Globetronix	800	50[4]	6.3%	—	Develoed new burn-in ovens for chip testing soon to be sold under own brand name; substantial refurbishment and re-engineering of depreciated equipment
Sanda Plastics	360	2/20	6.1%	—	Continuous line process improvements; just-in-time production; re-engineering of material flow system
LBSB	150	6/5	7.3%	—	Design and development of saws and grinders for wafers; redesign of production processes for simplification
Likom	3,300	270/700	29.4%	45[9]	Own design PC for local schools (Atom project); design and specification of computer parts for buyers (ODM); improvements to production processes
Sapura	4,500	1,500[4]	33.0%	40[10]	New software platform licensed out to foreign TNCs; early development of precision engineered goods; many new telecom products
UNISEM	1,100	20/80	9.1%	—	Designed assembly plant (layout equipment, etc.) from scratch in six months (a world record); substantial equipment re-engineering; advanced SPC application

Source: (unless otherwise stated), company interviews, annual reports and miscellaneous published material.

Notes

1 Not exhaustive (illustrative examples only); innovations are defined as commercially exploited ideas, new to the firm and/or to the country (not necessarily to the market or to the world); technological and organizational innovations are included.
2 R&D refers to technical staff; note that R&D, engineers and technicians are not strictly comparable across firms, as company definitions differed.
3 SPC = statistical process control.
4 Total engineers and technicians combined (separate details not available).
5 Planned to expand to 70 by 1997.
6 R&D activities integrated into production under new cellular approach to production.
7 TQM = total quality management.
8 This firm applied a very strict definition of "engineer" (at least a bachelor's degree holder) and of "technician" (diploma holder); therefore, technical support staff are probably understated, relative to other firms in the sample.
9 Plus a further 90 R&D staff in overseas acquisitions.
10 Data for Sapura Research Sdn. Bhd. (SRSB), a wholly owned subsidiary of Sapura (reported in *Malaysian Business*, 1–15 July 1933, pp. 14–15).

four at Orisystems, representing 27 per cent of the workforce of this small new local company.

In terms of recent innovation examples, these span all categories of firms and most types of near-market innovation, embracing technological, managerial and organizational improvements. It is a mistake to think that TNCs (and other firms) in Malaysia are merely assemblers of goods for export (or "screwdriver" plants), although a small number may be. A great deal of innovative activity is carried out, not only in changes to products and processes, but also in the design and application of organizational changes (e.g. total quality management and business process re-engineering had yielded substantial productivity gains at Siemens, MEMC and SEH).

As Table 4.2 shows, significant near-term product and process innovations are commonly undertaken, both by the TNCs and other strategic groups of companies. In no case was long-term or basic research (e.g. into new materials, novel designs or advanced software engineering) undertaken locally. In a few cases, research related to product design and process developments was carried out by the largest TNCs and local firms.

Several firms carried out product design work (mostly for new models within a standard range) including prototyping. In larger companies, substantial design-for-manufacture was conducted to ensure that new models could be mass-produced efficiently. This often required learning about product design software, how to make modifications to products, and how to utilize computer automated manufacturing techniques.

Extensive process re-engineering (including improvements to new equipment) was carried out by virtually all firms in the sample, as was technical support for manufacturing, including maintenance and modifications to older capital equipment. In a few cases, this had resulted in patents and own brand sales (e.g. SEH and L.S. Technology), meeting the strict definition of an innovation as new to an industry world-wide.

In Group 1 (first- and second-tier TNCs), Intel boasted important reliability analysis breakthroughs, the development of new capital machinery and the modification of new statistical process control (SPC) techniques.[12] Motorola Penang had been designated Asia's corporate centre for cordless telephones, had designed a series of new products for manufacture, and had made improvements to advanced manufacturing equipment. Although a more recent entrant, Sony Electronics had been designated a corporate centre for the Sony Discman, had designed several new hi-fi products and made important modifications to capital goods. SEH, another Japanese TNC, had developed its own automated etching and slicing machines (already patented), leading to significant productivity and quality gains (see below).

Many firms had introduced important managerial and organizational innovations, resulting in continuous improvements to processes. MEMC, the German wafer manufacturer, had developed its own modular manufacturing system which had gained it a world-wide reputation for productivity gains, delayering, cost reduction and personnel empowerment. Similarly, Siemens Penang had enthusiastically adopted and reshaped a total quality management (TQM) system, involving virtually all of the workforce. The company received regular visits from managers from Siemens Germany wishing to learn more about the TQM system in place. Siemens Penang, designated as the world corporate centre for optoelectronics, had designed many new opto devices and developed new bonding machines with foreign suppliers.

Inventec, a major Taiwanese company, employed substantial numbers of technicians and engineers for improving processes and developing new calculator model designs. Virtually all of Inventec's new calculator designs were carried out in Malaysia and the firm's parent planned to transfer more complex design and development functions for other products (e.g. push button telephones) to the local plant.

Not surprisingly, most innovation was incremental, rather than radical, in character. Almost all examples of process innovation derived from the needs of production, rather than from experimental R&D. Innovation occurred in small companies (e.g. Orisystems, L.S. Technology and LBSB) as well as large TNCs. At the heart of Malaysian electronics innovation was improvement to manufacturing processes for enhancing competitiveness. In some cases, this had led to product–process innovations, new product designs, prototyping, R&D, and modifications to capital goods. Generally, most innovative activity remained focused on process improvement, reflecting the stage of development of the industry.

Motives for technological upgrading

Several of the issues raised in the introduction, including motives, triggers and requirements for successful technology transfer, were investigated during the research. Most firms indicated that parent companies were commercially motivated to transfer technology. However, technology transfer depended on the building up of local plant capabilities. Without sufficient local competencies to receive the knowledge, specifications and machinery involved, the transfer process would be hindered and new investments risked.

By contrast, with domestic competencies in place, plant start-up times and costs could be reduced, production lead-times shortened, down-times minimized and productivity gains achieved. In our sample of TNCs, local engineering capabilities had improved the process efficiency of the subsidiaries and enabled them to respond more quickly to changes in market demand.

A key trigger for technological advance was the influx of automation and semiautomation activities into Malaysia during the 1980s. This generated the need for substantial new skills and technical services. Machinery had to be set up, adapted, improved and maintained in order to achieve production efficiency. Such new demands called for additional in-house competencies. Local chip assemblers increased productivity by improving chip handlers, tapers, markers, burn-in ovens, solder plating processes and die bonding materials. Equipment modification capabilities embraced simple jigs, automated machinery, specialized tooling, stamping dies for lead frames, cutting tools for trimming lead frames and moulds for injecting epoxy resin for integrated circuit packages.

Firms such as Siemens, Sony Electronics and MEMC introduced best practice management tools such as TQM, just-in-time (JIT), MRP11 and a range of SPC techniques. Managerial innovations improved productivity and process control, raised quality and quickened turn-around time. Such soft technologies diffused hand-in-hand with automation systems.

The progressive upgrading of local technology was motivated by the highly competitive environment and proceeded alongside (and contributed to) industrial growth and rising factor prices. In addition, TNCs transferred skills to local firms, as engineers and managers left to set up independent vendor operations.

Backward linkages and technology development

One of the key features of successful industrial growth is backward linkages. Although this issue cannot be dealt with in detail in this chapter, the generation of linkages has been an important part of industrial clustering and a central part of growth in countries such as Taiwan and Hong Kong. The latter show that local interaction with TNCs can lead to an explosion of backward linkages and encourage more TNCs to enter to benefit from the growing supply infrastructure. In Taiwan, the linkage process led to a self-sustaining, robust pattern of industrial development, the creation of higher value-added jobs, the integration of TNCs into the industrial fabric of the economy and a surge in local technology development (Hobday 1995).

According to interviewees, because of automation, the TNCs required constant improvements to machinery and materials. This encouraged companies like Grundig and Intel not only to deepen their competencies but also to sub-contract out activities to capable local companies. Local sourcing by the TNCs generated backward linkages, enabling local companies to learn from the TNCs. Several Malaysian engineers had created spin-off firms by leaving their TNC employers to start up their own companies, often beginning by supplying their former employers.

Several of the Group 2 firms visited had upgraded their capabilities in order to qualify as vendors and then strove to meet ever higher standards set by the TNCs. Some of the linkage firms had adopted new precision equipment (e.g. electrostatic discharge machines) and SPC techniques in order to qualify as vendors. Firms such as L.S. Technology, LBSB, Oris and others had gone on to develop semi-automatic die bonding machines, precision jigs, burn-in test ovens and other equipment, partly as a result of the demands placed upon them by TNCs.

More detailed research shows that although still in its early stages, this process of inter-firm linkage and learning has become a significant feature of the dynamics of the Malaysian electronics industry. Rasiah (1994), for instance, illustrates how local machine tool suppliers developed to supply TNC component producers, partly influenced by the needs of automation during the 1980s. A UNDP (1993) survey showed that seven out of (a sample of) ten owners of metalworking firms in Penang had past employment experience with TNCs, most of whom they continued to supply. Several engineering firms in Penang grew to become medium-sized suppliers of specialized tooling equipment, providing role models for other potential linkage firms. The latter study showed that almost all vendors found that supplying the TNCs created a cycle of improvements to local technology, management and training (UNDP 1993: 115–16). Working with demanding foreign firms fostered a culture of quality and reliability among local suppliers, while the movement of staff from TNCs to linkage firms provided a direct skill input.

Despite the evidence of some linkages, overall, it appears that linkage forming is still at an early stage in Malaysia, and that too few local firms are involved to generate the clustering seen, for example, in Taiwan. Most major linkage firms are other TNCs which have followed the first-tier TNCs into Malaysia. The majority of locally owned firms supply indirect materials and services, packaging and freight services (UNDP 1993, Hamzah Kassim and Ismail Salleh 1993, Kam 1992). Although some backward linkages have formed, most TNCs remain insulated from the local economy and domestic electronics suppliers. This is a concern for the future as linkages are necessary for the EE industry to move up the value-added chain and to higher levels of technology.

Technology transfer from parents to subsidiaries

The above evidence on innovation is confirmed by general surveys which show that in electronics in Malaysia, the TNCs have transferred foreign technology (and more so than in other sectors). For example, a study of formal technology transfer agreements registered by TNCs over the period 1976 to 1992, covering a total of 1,023 agreements in overall manufacturing, of which 400 (39 per cent) were in the EE sector (including components), was conducted by the UNDP using MITI/MIDA data (UNDP 1993:26). Despite difficulties of measurement, the data show (in contrast to earlier studies) evidence of technology transfer in the areas of operational and manufacturing technologies, with the EE sector exceeding most other industries (UNDP 1993:25). There was less evidence of advanced innovative capability transfer overall, although the study suggested that the EE sector performed better than most in transferring the ability to maintain and improve equipment and to improve upon and design products. Focusing on the more recent period, 1986 to 1992, the study also showed that overall technology transfer in Malaysia had gained momentum during the 1980s, largely due to the performance of the EE sector.

The UNDP study probably understates the degree of EE technology transfer to foreign-owned affiliates because many important transfers from parent to subsidiary occur without formal agreements. Other (probably more important) methods of transfer include training (on-the-job and formal), personnel transfers, visits to foreign plants, senior management interactions (between local and foreign managers at home and abroad) and the joint installation of plant and equipment. For some firms, sub-contracting and OEM are also important mechanisms of technology transfer. Nevertheless, the indication of weakness in advanced technology transfer illustrated by the UNDP is broadly consistent with the stage of development of EE operations and the principal activities involved (assembly, manufacturing and testing).

Dynamics of TNC innovation: the case of SEH (ShinEtsu Handotai)

To understand the dynamics of innovation in Malaysia's EE industry in more historical depth, it is helpful to "go behind" the survey data to examine progress at the company level. In this section, a case example is used to illustrate the innovation path of a single company, Shin-Etsu Handotai (SEH), a Japanese firm with over two decades of experience in Malaysia.

Although no single case study can be truly representative, this particular example reveals general features of the industry, including: (a) the gradual nature of technological accumulation in electronics; (b) the surprising extent of local capability achieved by some plants; (c) the complexity of some, apparently simple, production technologies; (d) the painstaking effort needed to build up capabilities. The case illustrates the reasons why a Japanese TNC might be motivated to transfer technology from headquarters.[13] The company is also chosen because it is less well researched and publicized than, say, Intel and Motorola (Lim 1991, Ngoh 1994).

Corporate profile circa *1994*

SEH (Shin-Etsu Handotai), a major Japanese-owned semiconductor wafer manufacturer, has operated in Malaysia since 1973. By 1994, it had an annual output in the region of RM500 million (US$200 million) and employed 1,350 staff. The company began as a joint venture in Malaysia, and recently became 98 per cent Japanese-owned.

The company is part of the SEH Group which includes 31 subsidiaries and affiliates, which supply chemicals and related products, plastics and silicon materials. In 1995, wafers were still produced in Japan, but the Malaysian plant capacity was larger (with a capacity of 1.3 to 2.0 million wafers per month). The group also produced wafers in the US and Europe, claiming a 30 to 40 per cent world market share in wafer supply overall and the largest capacity for the latest 8-inch (leading edge) wafers. The company's main competitors were MEMC (part of the Hughes Corporation) which also operated a large plant in Malaysia, ODC (from Osaka in Japan) and POSCO Hughes, the Korean–US joint venture.

In 1995, the main Malaysian plant (hereafter SEH) supplied between 8 and 9 per cent of the total world consumption of wafers. A new Malaysian plant under construction (the largest in the world) was to produce around 40,000 pieces of 8-inch wafers per month. Total capital invested amounted to RM450 million; the new plant was to cost a further RM500 million. Customers included most leading semiconductor makers: NEC, Hitachi (the largest customer), Toshiba, Harris, Hyundai, Motorola, TSMC, UMC, TI, Micron and Samsung. SEH dealt with all non-Japan East Asian sales and exported all of its output (to Singapore, Taiwan, Korea and so on). There were no local sales because wafer diffusion was not yet carried out in Malaysia in bulk.

Malaysia within the international division of technology

In 1995, large centralized R&D laboratories in Japan carried out the main R&D, including crystal research and evaluation. In the US, a group R&D laboratory specialized in epitaxial research. In the Malaysian plant, there were thirteen Japanese from the parent plant carrying out a variety of tasks (some were on very short stays, others were on permanent staff), working together with local SEH staff. Of the thousand staff in the main SEH plant, there were around a hundred technicians and thirty development engineers (mostly mechanical engineering and physics trained) plus twenty process engineers. Two smaller SEH plants employed 250 and a hundred staff respectively. As shown below, the main tasks of the local engineers and technicians were to support and develop process technologies (etching, slicing and so on). This is to be contrasted with the materials research, advanced capital goods development and product R&D carried out in the home country and US R&D facilities.

Complexity of local technological activities

Wafer production demands highly purified silicon which, in turn, requires a deep knowledge of essential chemicals and materials. The four main steps in wafer preparation, carried out in the local SEH plant, were slicing, lapping (or flattening to produce even surfaces), etching (to remove damage after lapping) and polishing. Core in-house activities included process engineering and improvement. An R&D department had been set up to carry out process research, mostly made up of Malaysian engineers. Machinery was mainly imported from Japan and the headquarters were in overall charge of technology and marketing strategy, including the choice of equipment used by the subsidiary. The process demanded deep knowledge of wafer flattening and cleaning processes and methods of minimizing wafer oxygen content. Parameters varied, both according to customer specifications and product generations. The latest 64 M-bit DRAM devices imposed the most stringent requirements on SEH's processes.

Examples of local innovations

SEH has contributed an abundance of innovations over the years, leading to several US patents and exports of new capital equipment from Malaysia. Technological advance was a difficult and lengthy process involving the hiring of new, qualified staff as well as formal and on-the-job training (see below). The gradual build-up of skills and competencies was critical to successful technology transfer from Japan. Local skills were needed to develop new equipment, to master the use of materials and to enable productivity and quality improvements. Triggers for innovation included the need to improve automation equipment to increase productivity. Innovation also occurred in response to constant pressures on the company to reduce cycle times and to meet ever higher customer specifications.

Following a start-up period of five years or so, the firm made early improvements to the slicing process, contributing to its rapid growth in the late 1970s. In 1981, the lapping machines were retooled using local skills and know-how. This technology was then transferred to a sister company in the US and to the parent in Japan. Many other capital goods improvements occurred, including the development of a new automated etching bath (or drum) which, again, was produced by local staff and later patented. A modified jig, also patented, was central to the new etching bath design. The etching system developed by SEH, which simplified and transformed the process, was one of the core technologies to be used in the new local plant. Parts for the auto-etching machines had been made locally and sold abroad to other plants. Some Japanese engineers visited SEH in order to assimilate the technology developed in Malaysia.

In the area of wafer polishing, a new method had been developed, improving the process by removing the use of wax, which was in the process of being patented in 1995. This innovation was the first world-wide to introduce wax-free polishing of wafers. A range of soft technologies had also been applied locally and linked to employee incentive schemes, including TQM, SPC and quality circles (for machine maintenance).

The R&D department

As noted above, a centralized R&D department had been set up in 1981 to coordinate technological process improvements and other innovation tasks. By 1995, the R&D department was carrying out three basic functions: (1) research into new processes (both thin and thick film), focusing on long-term customer requirements; (2) process engineering, including technical back up for production and the introduction of new automation systems; and (3) materials development and characterization, including quality control and trouble shooting.

A local R&D manager, originally hired in 1977 to work in the process engineering department, began the R&D department with three technicians in 1981, then one of the first TNC R&D units in Malaysia. Because many of the Japanese processes could not be directly transplanted to Malaysia, the company decided to upgrade the process engineering department to an R&D unit. By 1994, the department had expanded to thirty engineers, including one PhD in physics (formerly with ITT) and three Master's degree holders.

Backward linkages to local vendors

SEH participated in the Malaysian government's Vendor Development Programme and had transferred technology to local companies over a fairly long period. Etching machines were produced by local manufacturers (including one large machinery company). Domestic firms also co-operated closely with SEH on the conceptual design and development of relatively simple equipment, including cleaning banks and air-conditioning equipment. Equipment was purchased both from Malaysian-owned companies and foreign firms based in Malaysia. The R&D department worked with suppliers to ensure quality and on-time delivery. Advanced new machines were usually sourced from abroad, although many needed further modification in-house. Many chemical inputs were purchased locally, but the super-pure specialist chemicals were purchased from abroad or from local importers.

Training and skills development

The company generated a substantial amount of engineering competence through formalized training programmes. Around 2 to 3 per cent of SEH's annual turnover was spent on training. Most operator training was conducted onthe-job. However, R&D staff all received formal training. Some spent around a year in Japan and others participated in a variety of Japanese exchange programmes. Training programmes were designed for process engineers to learn SPC and other modern production techniques. Engineers and technicians were usually promoted from within the company after they had gained company-specific training and experience.

In the future, SEH felt it would require more skilled engineers in an increasing range of subject areas, including mechanical engineering, computer sciences, factory automation, CAD, human-computer interfacing, software engineering and production management. These would become more important as automation and growth proceeded.

The hard slog of technological learning

While several surveys hint at the extent of technological capability of EE TNCs in Malaysia (Hamzah Kassim and Ismail Salleh 1993, O'Connor 1993, UNDP 1993), most are unable to capture the painstaking, often long-term, process of building up skills needed to acquire local competencies to enable the transfer of technology from overseas. The SEH case, as well as others in the study (e.g. Intel, Motorola and MEMC), illustrate the gradual assimilation of important technological competencies. In contrast with the idea of a one-off leapfrog to new technology, the evidence demonstrates a hard slog of technological learning.

SEH and other parent TNCs were commercially motivated to transfer technology, but effective technology transfer depended on local capabilities. With the latter in place, SEH was able to reduce plant start-up times, control operating costs, reduce production lead times and enhance operating productivity. Local engineering capabilities enabled firms to respond more quickly to changes in customer requirements and contributed to the overall efficiency and success of SEH in Malaysia.

Technological positioning of Malaysia's TNCs: a simple model

Despite the significant achievements of the leading local TNC subsidiaries, it is important to view local technological activities within the overall structure of global TNC activities, usually determined by decisions at corporate headquarters. Indeed, in SEH and the other TNCs, most basic research, long-term development work and core product design were mainly carried out in the company's host country.

Taking Intel as an example, despite its R&D advances, Intel Penang lagged behind the technology frontier set by the advanced countries, and NIEs such as South Korea and Taiwan. The latter had, by the early 1990s, extended their capabilities deeply into chip fabrication and carried out core design work for new products. In Penang, there was little forward R&D into new products and processes. Most development work was focused on the short-term needs of local assembly and testing, and design of less complex products. The core of Intel's global technological activity was located in the advanced countries, mostly in the US. The company invested around US$2.4 billion in wafer fabrication alone in 1994, and very little of the company's R&D budget of US$1.1 billion in 1994 was spent in Malaysia. Core chip designs such as the x86, and new products such as the Pentium and its successor processors (codenamed P6 and P7), were generated in the US. Most of Intel's R&D and marketing activities were carried out in the US in close alliance with PC producers such as Compaq and operating systems software suppliers (notably Microsoft). Intel Penang, SEH and other TNC subsidiaries were, to a large extent, dependent on their parents' headquarters for strategic decisions, including major investments, choice of capital goods, design work and so on.

To capture the complex structure of the technological activities of the TNCs in relation to Malaysia, Figure 4.2 provides a rough technology profile of a typical large electronics TNC and the positioning of Malaysian subsidiaries within it.[14] This simple model helps to highlight several key features of TNC global strategies and Malaysia. The first is that R&D (as defined by the OECD, cited in MASTIC/MOSTE 1994: 3–4) is a tiny proportion of the total technological activity of the global

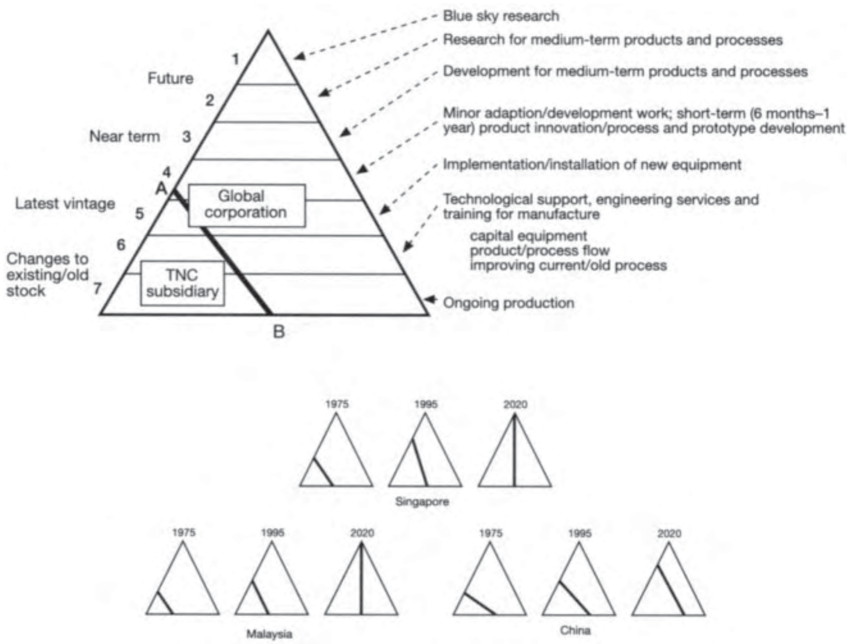

Figure 4.2 Technology positioning of electronics TNCs in Malaysia

company. Strictly speaking, R&D is the "tip of the iceberg" in Figure 4.2, principally areas 1, 2 and 3. R&D spending for most electronics companies is usually under 15 per cent of turnover, and often less than 10 per cent. Frequently, much of the reported R&D activity is near-term D work (category 3), rather than R.

The bulk of technological activity involved a variety of engineering and operating tasks, essential for the competing firm (areas 4 to 7). Continuous improvements in areas 4 to 7 are essential for TNC market effectiveness and the requirements of areas 4 to 7 usually drive much of the corporate R&D investment strategy. Put another way, areas 4 to 7 provide much of the demand for R&D in areas 1, 2 and 3. Rather than "blue sky" experimental research, most corporate R&D is carried out in response to competitive needs and near-term products and processes.[15] In addition, core R&D activities tend to be located in the headquarters of the parent company, as already emphasized.

The technology positioning of TNC subsidiaries in Malaysia constitutes one part of overall TNC operations. Usually, major investments are determined by the corporate-level strategy taking into account the costs and benefits of competing investment locations and likely future changes. A typical technological profile of a Malaysian subsidiary, *circa* 1995, is shown in the area A to B. As indicated in the diagram, the subsidiaries have progressively integrated upwards (or "verticalized") into higher stages of technological activity, especially early entrants such as Motorola, SEH and Intel. At the subsidiary level, as the preceding discussion showed, verticalization required substantial technological learning efforts, involving automated equipment, new materials, and effective company policies for skills, training and education.

Verticalization can be facilitated or hampered by government policies, especially those affecting the macroeconomy, industry, technology and education. For example, in Singapore, TNCs were encouraged to verticalize by appropriate education policies, macroeconomic stability, rapid economic growth, rising wage and land costs and competent government. TNC subsidiaries are far less likely to verticalize under conditions of high inflation, economic instability and inefficient government.

Verticalization often, if not always, requires that the domestic TNC management gains greater control over local operations, including manufacturing and process technology. However, verticalization also requires an upgrading of other essential, related capabilities, especially marketing, management and finance. Technological upgrading can only occur if these related competencies are developed in tandem, as the experiences of TNCs in England, Scotland, Singapore and other countries have shown. Put simply, the move to higher value-added requires the integration of technology with other important skills and resources.

Malaysian EE operations tend to be situated between higher technology operations in countries such as Singapore and the UK, and lower-cost countries such as China (see Figure 4.2).[16] While early entrants tended to verticalize gradually, recent entrants have tended to enter at more or less the current profile, reflecting the general level of technological development and the cost structure of the economy.

One of the key implications of the positioning model is that to verticalize upwards in the future, the TNC subsidiaries and their suppliers will need to build up further technological capabilities, especially in precision engineering, prototype building, and product design and development. Although this is already taking place to some extent as firms move to higher value-added production, several major difficulties confront the industry, as discussed in the next section.

Technological challenges and opportunities in EE

Industry weaknesses and barriers to progress

Even before the current crisis, Malaysia's EE industry suffers from both structural and technological weaknesses. One major weakness was the dislocation of much of the TNC sector from the rest of the local economy. During the 1980s, more local firms began to supply the TNCs, partly due to government encouragement under the Vendor Development Programme. However, the supporting infrastructure of locally owned firms, especially the SMEs, remains weak and lags far behind the backward linkage industries of Hong Kong and Taiwan, either today or at similar stages of development.

The result of TNC dislocation is a low overall local content contribution to exports and a lack of technological progress among domestic companies. The shortage of dynamic local firms restricts the integration of the TNCs into the industrial infrastructure of the economy, preventing them from deepening their roots to the extent they might otherwise want to. To some extent, the location of second-tier TNCs in Malaysia is helping companies to overcome this problem.

Despite the achievements of some leading firms, most TNCs are weak in new product design capabilities, let alone capital goods manufacture, R&D and key components. At the process level, wafer fabrication has yet to take place in any significant volume, although the presence of a large number of chip testing and assembly firms and two world leaders in silicon wafer manufacture (SEH of Japan and MEMC of Germany) may stimulate progress in this area in the future.

This study could find no evidence of independent application specific integrated circuit (ASIC) design companies in Malaysia, as found in abundance in Taiwan and Hong Kong. Although a few may exist, and some larger firms do have such facilities (e.g. Motorola and Likom), the lack of independent ASIC vendors is generally a cause for concern, given the large size of the domestic EE industry and the desire for its progress towards more advanced technology and higher value-added production.

Another challenge facing the industry is low-cost competition from other countries. In an increasing number of low-end areas (e.g. low-price tape decks and hi-fi equipment), it is no longer feasible to source new TNC production in Malaysia due to rising wages and competition from China, Vietnam and other low-cost regions. Companies such as Philips and Grundig have already begun to relocate some production in these countries, while potential new investors look critically at rising land, labour and transportation costs in Malaysia.

Rising wages and shortages of skilled engineers and technicians also confront the industry. All the companies visited faced these problems to a lesser or greater extent, and staff turnover rates of 25 per cent per annum (at operator and technician levels) were common. In response, some firms had created or supported their own training organizations, including the Penang Skills Development Centre and the Selangor Human Resource Development Centre. The latter was recently set up by Western Digital, MEMC, Texas Instruments, Motorola, Matsushita, the Selangor State Government and other organizations. Other initiatives may also assist, but the problem is widespread and concentrated in the key EE production regions.

Malaysia cannot take its healthy flows of FDI for granted. The fall off in FDI from US$1.7 billion in 1990 to US$0.5 billion in 1993 was largely unexpected. Although data for 1994 and 1995 show a continuing recovery, the heavy dependence on FDI for export growth is likely to continue for the foreseeable future. This position exposes Malaysia to international recession in advanced country markets, changing corporate strategies regarding global investments as well as low-cost competition from Southern China and other regions, as experienced in Penang in mid-1996.

Technological advantages and opportunities

It is important not to exaggerate the problems facing the EE industry. It is quite possible that many of the above difficulties will be resolved by actions by firms and government (e.g. new skills and training programmes; see Bell *et al.* 1995). Over the years, many daunting problems, including the extreme dependence on semiconductors, have been overcome, and there appears to be no lack of awareness of Malaysia's problems on the part of firms or policy makers.

Malaysia currently boasts a range of important competitive advantages. As a result of sustained TNC investment, the country is a world centre for technology in semiconductor testing and assembly. Many of the local subsidiaries have built up leading-edge competencies in mechanical engineering, advanced manufacturing technology and many other fields. With the diversification of the industry, new competencies are rapidly emerging. For example, the growing disk-drive industry has brought with it highly advanced, complex new capabilities in thin film disk manufacture.

The evidence shows that since the early 1970s, investors such as Motorola, Intel, Matsushita and SEH have gradually built up mechanical, electro-mechanical and precision engineering skills and important management competencies. As low-end manufacture shifted from Malaysia to cheaper East Asian locations, recent investors have entered at higher technological levels.

While the amount of R&D carried out in Malaysia is still very low, there is abundant evidence of significant innovations, including improvements to capital equipment, innovations in production processes and incremental product design. Several firms have product development capabilities in low-end and medium-range electronics goods, including many large TNCs as well as leading local firms such as Sapura, Likom, Globetronix and HIL Industries.

Overall, the Malaysian EE industry is extremely dynamic, as recent growth rates show. Malaysia is a favoured location, not only for the US and Japan, but increasingly for Taiwan, Singapore and Hong Kong as well. Taiwan is today the leading foreign investor in Malaysia, while Singapore and Hong Kong together now rival Japanese investment in the economy. The growing importance of the three NIEs as investors in Malaysia is partly due to the rush of second-tier suppliers of components and parts into Malaysia to supply the larger first-tier TNC producers of TVs, consumer goods and other electronic products. The presence of so many competing firms provides opportunities for industrial clustering, sustained export growth and a growing participation of locally owned firms as sub-contractors, service suppliers, software providers and parts suppliers.

In the future, wafer fabrication could take place in Malaysia if the planned investment by Hualon Microelectronics in Kedah State is successful. In 1995, Fujitsu was reported to be planning a US$180 million investment for the assembly of advanced flash memory chips, currently produced in Japan, which would also give impetus to the chip industry in Malaysia. Several TNCs carry out wafer probes locally, which could provide a useful link between fabrication and assembly and testing. Although some wafer fabrication inputs could not be sourced locally (e.g. gold and aluminium wires, specialized alloys and ceramic substrates), most could be fairly easily imported via Singapore or other neighbouring locations.

The higher cost structure of Japan, Taiwan and Singapore suggests that more TNCs will look to Malaysia to source production of disk drives, computers and other higher value-added goods in the future. Other investors may follow in the footsteps of the Japanese colour TV industry, if low-cost engineering, efficient infrastructure and technical support continue to be available.

Conclusions and implications

Innovation has been an important feature of industrial progress in Malaysia and, although difficult to measure precisely, has contributed significantly to productivity, industrial growth and export success in electronics. Although the economy has depended for much of its export growth on TNCs, technology has been transferred and the subsidiaries have learnt to innovate in a wide variety of ways. At the heart of TNC technological innovation are improvements to assembly and production processes, involving machinery, materials, work organization and, more recently, design-for-manufacture and product design.

In contrast with R&D-based innovation, local TNC innovation in Malaysia has been incremental and continuous. Firms gradually learnt to make products more efficiently and with greater autonomy. Today, some of the leading subsidiaries are able to design new products and to ensure that products are designed to optimize manufacturing productivity. The evidence suggests that intra-firm innovation has been a painstaking and difficult process, involving trial-and-error, strategies for training and engineering investments and, above all, a great deal of human skill and effort.

Although important in its own right, TNC innovation in Malaysia has to be understood within the wider context of TNC technological activities, global investment decisions and, in particular, competing investment locations in advanced countries and other NIEs. A simple model was developed to illustrate the strategic positioning of TNC subsidiaries in Malaysia and to indicate the desired future direction of technological progress.

The evidence on Malaysia's EE industry suggests that many important areas of technological innovation do not directly involve R&D, and that to focus too much attention on R&D can be misleading when attempting to promote competitiveness in NIEs. Only recently and only selectively, has R&D played a part in innovation in Malaysia. More broadly, the study suggests that firms have important opportunities for innovation from behind the technology frontier set by R&D-centred innovations.

The case of electronics in Malaysia may have important implications for other developing countries and for theories regarding the location of production. Although TNC headquarters may be motivated to transfer technology to enhance and expand profitable operations in developing countries, this cannot occur efficiently without the accumulation of skills and capabilities on the part of the local plant. Although the Malaysian evidence indicates that production tended to first occur in simple, relatively mature products, and to then progress to more complex, technology-intensive goods, this was by no means an automatic consequence of an international product life cycle (Vernon 1966). On the contrary, to be effective, local subsidiaries had to skilfully build up the competencies to enable foreign technology transfers to occur, often in advance of new investments.

More often than not, the process of technology transfer has involved significant learning and innovation at local sites. This is not difficult to understand. Any serious weaknesses in local innovative capabilities would impact adversely on new plant start-up times, factory productivity, flexibility of response to new market demands and, ultimately, overall company performance. Factory managers in Malaysia were motivated to build up local competencies to ensure the TNCs remained in the country and, sometimes, to compete with the parent's subsidiaries in other countries for new corporate investments. Over the long term, evidence of sustained TNC investment in new electronics export capacity in countries such as Malaysia is probably a good indicator of the building up of local innovative capabilities.

For other developing countries, this finding suggests that policies (e.g. towards education, industrial training, skills and FDI) should try to support local subsidiaries in their efforts to innovate as a necessary condition for technology transfer, capacity expansion and export growth in export industries such as electronics. Policies which fail to support local innovation may reduce the desire of the TNC parents to invest in new operations and gradually lead to an overall decline in FDI.

Finally, the evidence has shown that major difficulties confront progress in EE in Malaysia, not least the competition from lower-wage NIEs and Southern China. Weak TNC linkages with the local economy are also a major problem. However, many of the TNC plants now have mature capabilities across a range of production-related electronics activities, and there appears to be ample scope for continued competitive progress. Although the current economic crisis has introduced major new uncertainties, as long as the local subsidiaries are able to build on their innovative achievements and move up the chain of higher value-added production, they could play an important part in future export-led growth.

Notes

* Some of the data in this chapter appeared in an article: "Innovation in South East Asia: Lessons for Europe?", submitted for publication in a special edition of *Management Decision*, 34(7), 1996. This chapter was written as part of the UK Economic and Social Research Council (ESRC) Pacific Asia Research Programme (project reference: L32453023 – Technological Dynamism in Pacific Asia: Implications for Europe). In-depth field research was made possible by the World Bank, the British Council and the Ministry of Science, Technology and the Environment (Malaysia). The author would like to thank Martin Bell, Norlela Ariffin and Sanjaya Lall for helpful comments and advice. The author is also grateful to Viswanathan Selvaratnam and William Rees

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1 This chapter focuses primarily on technological innovation involving processes and products. Process innovation can be defined as technological change which reduces the cost or time of making an existing product or which enhances the quality or performance of a product. By contrast, a product innovation involves the development of a new or improved good. Traditionally, the acid test of an innovation is the successful introduction of a new or improved product to the marketplace or the commercial use of a new manufacturing process (Dorfman 1987:4, SPRU 1972:7, Kamien and Schwartz 1982:2). However, this strict definition fails to capture very important industrial and corporate transformations which occur in firms in developing countries (and elsewhere). The latter, almost by definition, operate from behind the technology frontier. Therefore, following Myers and Marquis (1969), Schmookler (1966) and Gerstenfeld and Wortzel (1977:59–60), this chapter defines innovation as a product or process new to the firm, rather than to the world or marketplace. When a company produces a new or improved good or service, or applies a new method or material, it makes a technical change and an innovation has occurred. As Myers and Marquis argue, many firms have grown and succeeded as a result of innovations new to the company, although not new to the world (cited in Gerstenfeld and Wortzel 1977:60). It is also worth stressing that innovation is often a long-term process, rather than a once-and-for-all event. In addition, non-technological innovations, including managerial and organizational improvements, are also very important for exploiting technology and, more generally, for achieving competitiveness (Garvin 1993, Stata 1989, Senge 1990). Some important organizational or "soft" innovations are identified later.

2 The economy grew at 6.7 per cent per annum over the period 1971–90, while manufacturing grew by 10.3 per cent per annum. During the early 1990s, economic growth rose to above 8 per cent per annum and manufacturing exceeded 12 per cent (Lall 1994:2). Growth in 1994 and 1995 was just under 9 per cent (*Financial Times*, Malaysia Survey, 19 September 1995, p. 3). Before the recent crisis began, electronics played a major part in overall growth performance.

3 This chapter deals with electronics and electrical goods, focusing mainly on semiconductors and electronics systems, but also taking into account other components, electrical products and related support industries. The terms "EE" and "electronics" are used interchangeably as shorthand to describe the above group of industries.

4 Earlier studies of TNCs show the importance of international product life cycles (Vernon 1966, 1975) and the determinants of production location (Dunning 1975). However, these studies were mainly concerned with "top down" corporate location decisions, rather than the actions of local subsidiaries in building innovative capacity and influencing corporate location decisions.

5 It is beyond the scope of this chapter to examine the implications of the current economic crisis in Malaysia, or other policy matters in detail. Implications for government policies for 2020, including education, skills development and technology transfer, are contained in Bell *et al.* (1995).

6 The above figures are derived from official data in MITI 1994:34–6, 43, 56–7.

7 One interviewed industrialist estimated that there were more than two hundred locally owned OEM/component suppliers to the electronics TNCs in Malaysia.

8 Kam (1992) reviews the status of the traditional SME sector and offers strategies for upgrading them.

9 Although this chapter focuses primarily on TNCs, results concerning the large local firms and backward linkage small firms are presented in Bell *et al.* (1995).

10 Note that output in 1994 was only reported by sixteen of the sample firms. This amounted to roughly US$6.5 billion. Estimating a further US$0.8 billion for the four companies for which output figures were not available (based on a calculated average output per employee of US$115,400), total output of the sample was roughly US$7.3 billion.

11 This is characterized in the strategic model developed later.

12 See Lim (1991) for further details of the progress of Intel.

13 The question of the extent of Japanese (*versus* US and European) technology transfer cannot be dealt with here. However, some authors complain that the Japanese prefer not to transfer technology and restrict flows to offshore plants (e.g. Guyton 1994). Sometimes, criticisms of Japanese practices (especially in recent consumer goods areas) fail to take into account that technology transfer involves a long-term painstaking process of capability building on the part of the local subsidiary. Many Japanese firms world-wide (e.g. in Scotland and the US) do, in fact, transfer technology when commercially motivated to do so. Other Japanese firms in our sample (e.g. Matsushita and Sony Electronics) had also made substantial headway in transferring technology.

14 The model is largely based on interviews with companies in Malaysia and previous research (e.g. Hobday 1995). In theory, the precise distribution of resources could be measured according to expenditures on technical activities or the number of personnel employed by technical category. In practice, many of the activities overlap considerably.

15 This is in contrast to theories which place R&D at the start of the competitive process or which suggest that the natural flow of activity is from R&D to production. Although this is the case in some areas, in many cases, the reverse is true. Among the most successful firms, there is a great deal of feedback in both directions.

16 The term "high" in high technology can be defined as the degree to which new knowledge is required to develop a new product or manufacturing process.

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5

TECHNOLOGY UTILIZATION LEVEL AND CHOICE

The electronics and electrical sector in Penang, Malaysia

Lai Yew Wah and Suresh Narayanan

Multinational corporations (MNCs) in Malaysia have been alternatively credited and criticized for transferring technology of various levels of sophistication to local firms. Recent studies of the electronics and electrical sector (UNDP 1994; Narayanan *et al.* 1994; Abibullah *et al.* 1994; Rasiah 1995), the food processing sector (Lai and Gan, in progress) and the plastics sector (Cheah 1994), for example, have found evidence of substantial technology transfer, though the extent of transfer varies in these sectors. A related area of interest is the level or sophistication of the technology being introduced *within* MNCs and the factors which determine their technology choice. To date, this has not been investigated rigorously, despite its obvious policy relevance. We focus on this issue through an examination of the electronics and electrical (EE) sector in Penang State in north-western Peninsular Malaysia.

We rely on a sample of firms in the EE sector in Penang, home of the largest concentration of electronics and electrical firms in the country. As part of a larger United Nations Development Programme (UNDP)-funded study[1] on technology transfer, questionnaires were mailed out to 160 firms in the EE sector and supporting activities in the Penang Development Corporation (PDC) industrial estates. Due to the poor response, a stratified sampling procedure was used to select a smaller sample of fifty firms, comprising thirty-five EE firms and fifteen firms providing support services. The questionnaire was then canvassed through personal visits to these firms. The representativeness of the EE sector sample can be gauged from the fact that the sample firms accounted for 88 per cent of sales, 85 per cent of fixed assets and 63 per cent of employment of all EE firms that responded to the 1992 PDC Industrial Survey (PDC 1993). The lack of comparable PDC data on firms providing supporting services to the EE firms in the state precludes an evaluation of representativeness of the supporting firms' sample.

Our findings indicate a relatively high level of technological attainment within MNCs, particularly in the electronic components sub-sector (ECS). This suggests that earlier studies finding only low levels of technological development are misleading or out of date. We also find that the quality or sophistication of a company's product is the most important influence on the level of technology it employs. The factors identified in other studies, including factor-cost pressures, the national origin of MNCs, and export-orientation *per se*, are not major determinants. Rather, the markets which the companies seek to serve, particularly sophisticated and quality-sensitive product niches, largely determine the firms' choices of technologies.

Level of technology in use

For the purposes of our study, we looked at production technology, which may be defined as the accumulated knowledge and know-how required for manufacturing a final product or for processing intermediate products (Eridilek 1986:51). This knowledge is embodied in any given machinery or process.

An important issue in technology transfer is the level or sophistication of the processes being introduced. It was frequently asserted that the MNCs in the electronics and electrical sector were transferring limited technology of low levels of sophistication in the 1970s (see, for example, Ariff 1984; Fong 1988; Mehmet 1986; Jomo and Edwards 1993). However, the studies attempting to measure the extent of transfer during this period lacked a holistic framework for analysis. The few studies that attempted to assess such transfers resorted to *ad hoc* and unsatisfactory measures (see, for example, Chee and Chan 1982; Fong 1988; Natarajan and Tan 1992). A recent work attempts to address this problem by providing a more satisfactory framework to evaluate technology transfer (Narayanan *et al.* 1994). But the general point remains valid; it was felt that MNCs were only contributing minimally to skill formation in the economy during the 1970s.

In light of these concerns, we attempted an assessment of the sophistication of the technology being utilized in the EE sector and its supporting firms. Our approach was to ask firms to describe their respective production processes and to rate them as either high, medium or low, in relation to their particular sub-sectors of operations. While this self-evaluation method could bias the findings, we also did an independent check with industry contacts to minimize such biases. Interestingly, the levels of technological sophistication claimed were found to be correct in almost all cases. Moreover, since self-assessment was made relative to the specific industries in which firms operated, it had the virtue of controlling for differences in the average level of sophistication among different industries or production activities.

The level of technology: foreign vs. local firms

The level of technology utilized in foreign and local firms in the EE sector and its supporting firms is shown in Table 5.1. Overall, almost 47 per cent of the firms are using high-level technology, 41 per cent medium-level, and only 12 per cent are utilizing low-level technology. It is clear that the EE sector and its supporting firms are largely made up of high- and medium-tech enterprises.

The table also suggests that foreign firms are more likely to have installed high-level technology relative to their local counterparts. Whereas foreign firms comprised just under two-thirds of the sample, they accounted for 74 per cent of the firms using high-level technology. In contrast, the share of local firms using low-and medium-level technologies exceeded their share in the sample. Only in the case of low-level technology, installed in only 12 per cent of the firms, was there an even distribution of foreign and local firms.

Following Khanthachai *et al.* (1987), who studied technology transfer in Thailand, a simple regression procedure was used to test the proposition that there is a significant difference in the *level* of technologies used by local and foreign firms in the total sample, even if the underlying production function used by both may be the same. We combined the EE and supporting sector data to avoid the problem of matrix singularity in the separate estimation procedures. This arises because of the small number of local firms in the EE sector and the small number of foreign firms among the supporting firms.

A Cobb–Douglas (CD) production function was fitted to both the foreign and local firm data. Two separate equations were used, which assumes an unequal error variance structure in both foreign and local firms (Pindyck and Rubinfeld 1991).

The model was as follows:

$\ln Q_i = ß_0 + ß_1 \ln L_i + ß_2 \ln K_i + \varepsilon_i$ for foreign firms
where $i = 1, \ldots, 31$
and
$\ln Q_j = \gamma_0 + \gamma_1 \ln L_j + \gamma_2 \ln K_j + \mu_j$ for local firms

Table 5.1 Penang: level of technology in foreign and local EE firms

Level of technology	*Foreign firms*	*Local firms*	*Row total*
High	17 (74%)	6 (26%)	23 (47%)
Medium	12 (60%)	8 (40%)	20 (41%)
Low	3 (50%)	3 (50%)	6 (12%)
Column total	32 (65%)	17 (35%)	49 (100%)

where j = 1,. . ., 16
Q = output in RM million; L = employment and K = investment in fixed assets in RM million.

We first sought to establish the hypothesis that the underlying production functions of foreign and local firms are the same. Hence, the null hypothesis tested was that there is no difference in the set of coefficients in the production functions of the foreign and local firms (Chow 1960). With the assumption of the null hypothesis, the model is reduced to:

$$\ln Q_i = ß_0 + ß_1 \ln L_i + ß_2 \ln K_i + \varepsilon_i \text{ for all the firms, } i = 1, \ldots, 47$$

Running the three different regressions yielded the following results:

(1) Foreign firms: n=31 R^2=0.659 F=27.07
$\ln Q$ = -1.910+0.730* ln L+0.414* ln K
(1.211) (0.223) (0.154)
(2) Local firms: n=16 R^2=0.507 F=6.69
$\ln Q$ = -2.304+0.733* ln L+0.471 ln K
(1.708) (0.386) (0.433)
(3) All firms: n=47 R^2=0.743 F=63.76
$\ln Q$ = -2.311*+0.756* ln L+0.458* ln K
(0.893) (0.185) (0.133)
* significant at the 5 per cent level.
(Figures in parentheses are standard errors.)

The appropriate F statistic, under the Chow test, with 3 and 41 degrees of freedom is: $F_{3,41} = 0.16009$. Since the F statistic is less than the critical value of the F distribution at the 5 per cent level (3.84), we do not reject the null hypothesis that local and foreign firms have the same production function structure.

Having established that the production functions utilized in foreign and local firms are the same, it is valid to examine the value of the technical efficiency parameters in their respective equations to see if there is a difference in the level of technology used. The results are consistent with the observation that foreign firms utilize higher levels of technology than local firms.[2] It is worth adding that tests on constant returns to scale show that both foreign and local firms are subject to constant returns to scale.

The finding that the EE sector and its supporting firms are largely dominated by high- and medium-tech firms contrasts sharply with the earlier view that electronics firms have been dominated by low-technology activities. Several factors may account for this difference. First, dramatic changes in the global electronics market (and, particularly, in the components segment) in the mid-1980s heightened the need to cut costs and improve quality well beyond what was possible with manual processes alone. Competition was bidding prices down but without compromising quality. These developments have spilled over to foreign plants in Penang and hastened their technological upgrading (Narayanan and Rasiah 1992; Kamal and Young 1989). Second, the dramatic growth of the Malaysian economy since 1988, recording annual growth rates in excess of 8 per cent, has made it a virtually full-employment economy. Penang has experienced parallel growth, and between 1990 and 1995, registered a 12 per cent average annual rate of growth. More importantly, the state's manufacturing sector grew even faster (14.4 per cent) during the period (Tan 1996). These developments have contributed to a labour crunch which has, in turn, prompted firms in the EE sector to automate (see Narayanan 1991). Rising labour costs are contributing to a gradual movement away from low-tech, labour-intensive activities in the state. Finally, in segments like consumer electronics, which have been subject to less intense competitive pressures, rising expectations of value and quality are forcing firms to upgrade their plants. If MNCs are to serve world markets from Penang, they will be less inclined to install out-moded technologies.

Level of technology by national origin

Foreign-ownership is disaggregated in Table 5.2.[3] It has been argued that the nationality of MNC parent companies may reflect different strategies or attitudes regarding the types of technologies that are transferred. Kojima (1978), for instance, suggests that there is a basic difference between US and Japanese firms in terms of the technology they transfer to host economies: the former transfer high-level technology in order to further strengthen their (monopolistic) positions in the world market, while Japanese firms transfer more "appropriate" technologies to take advantage of the comparative advantage of host economies, implying that Japanese firms tend to install less sophisticated, more labour-intensive processes compared to US firms.

It is clear from Table 5.2 that almost all US firms were using high-level technology, compared to only a quarter of the Japanese firms. Also, there was a

Table 5.2 Penang: equity ownership and level of technology in the EE sector

Level of technology	*US*	*Japan*	*Other foreign*	*Local*	*Total*
High	9 (90%)	1 (25%)	4 (31%)	2 (29%)	16 (47%)
Medium	1 (10%)	3 (75%)	7 (54%)	3 (42%)	14 (41%)
Low	0	0	2 (15%)	2 (29%)	4 (12%)
Total	10 (100%)	4 (100%)	13 (100%)	7 (100%)	34 (100%)

higher proportion of local and other foreign-owned firms involved in high-tech activities, compared to Japanese firms. While this finding appears consistent with Kojima's hypothesis, it is not conclusive because the number of Japanese firms in the sample was small.

US companies have been concentrated in the generally more sophisticated electronics components sub-sector (ECS) (see Appendix 5.2). The ECS market world-wide has been extremely competitive. Consequently, their use of high-level technology may well have been guided not only by the nature of the output but also by market pressures. In comparison, their Japanese counterparts were somewhat more evenly spread out in all three electronics sub-sectors and this may well explain their greater reliance on medium-level technology. However, there was no low-tech Japanese firm in the sample. Other foreign-owned firms[4] relied on a wider range of technologies than those used by their US or Japanese counterparts. About 30 per cent of the foreign-owned firms utilized high-level technology, slightly more than half used medium-level technology and about 15 per cent were in low-tech activities. This wider range of technology use was also evident among the local firms,[5] though they were less likely to be using high-level technology than their foreign counterparts (with the exception of Japan). It is worth noting that low technology was only utilized by local and other (non-US or Japanese) foreign-owned firms. The single local firm using high-level technology was engaged in integrated circuit opto-electronic components manufacturing.

Table 5.3 shows the distribution of supporting firms, classified by ownership status and level of technology. Whereas three-fourths of all non-local firms were in high-tech activities, local firms were engaged in a broader range of activities. Interestingly, however, there was a larger proportion of high-tech and mediumtech local firms in the supporting sector, relative to the EE sector. Additionally, there was a lower proportion of supporting firms using low-level technology than in the EE sector proper.

These findings reflect the fact that many local firms, especially those serving the ECS, have had to upgrade their technological expertise to keep pace with the requirements of the MNCs they served. And quite a few reported getting direct

Table 5.3 Penang: equity ownership and level of technology among supporting firms

Level of technology	*Japan*	*Other foreign*	*Local*	*Total*
High	2 (100%)	1 (50%)	4 (40%)	7 (50%)
Medium	0	0	5 (50%)	5 (36%)
Low	0	1 (50%)	1 (10%)	2 (14%)
Total	2 (100%)	2 (100%)	10 (100%)	14 (100%)

assistance from the MNCs in these efforts (Teh 1989; Narayanan *et al.* 1994; Rasiah 1995).

Level of technology by sub-sector

Table 5.4 shows the level of technology by sub-sector in the EE sector. It suggests that technology choice is influenced by the markets the firms produce for. The highly sophisticated nature of the electronics components sub-sector (ECS) is clear from the data; almost three-quarters of the firms operating here used highlevel technology. In striking contrast, no firm in the electrical products sub-sector (ELPS) utilized sophisticated technology as most firms were involved in the assembly of basic consumer appliances and the like. The electronics products sub-sector (EPS) was somewhere between the two in terms of technological sophistication: about 29 per cent of the firms used high-level technology. The ECS was, therefore, clearly a magnet for high-level technology in Malaysia.

Among supporting firms, the metal supporting sub-sector (MSS) seemed to have the largest proportion of the high-tech firms (57 per cent) as well as all the low-tech firms (Table 5.4). This not only reflects the range of services it provides the EE sector firms, but also the nature of its growth. Many MSS firms in Penang have seen rapid development in the recent past by serving as sub-contractors and metal-parts suppliers to the MNCs. They have thus had to upgrade themselves in tandem with the upgrading occurring in the MNCs themselves. Some of the MSS firms that have forged links with the MNCs have in turn fostered second-and third-tier firms to undertake their less sophisticated work (Rasiah 1995).

The small number of firms in the sample cautions against generalization, but it appears that the electronics supporting sector (ESS) uses high-level technology

Table 5.4 Penang: level of technology in different EE sub-sectors

Sub-sectors	*Level of technology*			*Total*
	High	*Medium*	*Low*	
EPS	2 (29%)	3 (42%)	2 (29%)	7 (100%)
ECS	14 (74%)	5 (26%)	0	19 (100%)
ELPS	0	6 (75%)	2 (25%)	8 (100%)
ESS	3 (100%)	0	0	3 (100%)
PSS	0	5 (100%)	0	5 (100%)
MSS	4 (57%)	1 (14%)	2 (29%)	7 (100%)

while the plastics supporting sector (PSS) depends entirely on medium-level technology, i.e. leaving tremendous room for upgrading.

Level of technology by degree of export-orientation

The degree of export-orientation of a firm suggests the extent to which it is exposed to competition in the global marketplace. It might even be expected that the greater the export-orientation of the firm, the more sophisticated the technology utilized. Table 5.5 sets out the relationship between the level of technology and export orientation in the EE sector sample. Slightly more than half the firms (55 per cent) produced exclusively for export, using high-level technology, while none of the firms that exported less than 50 per cent of their output were high tech. However, it must be noted that none of the firms with low exportorientation used low-level technology, while 9 per cent of the exclusively-for-export firms were low tech. This is indicative of the wide range of activities that firms in the free trade zone were involved in.[6] The sample data do not therefore demonstrate a clear relationship between export-orientation and the level of technology utilization.

The situation among supporting firms was similar, as shown in Table 5.6. A larger proportion of wholly export-oriented firms utilized high-level technology, relative to low-export firms. But unlike low-export firms, there were also low-tech producers among the exclusively export-oriented firms. Among supporting firms, exports consisted of components and parts shipped to EE MNC subsidiaries in the free trade zones (FTZs).

Only two of the twelve reporting firms exported less than 50 per cent of their products. They were mainly engaged in manufacturing plastic goods for the domestic market and providing plastic injection moulds for firms manufacturing electrical and electronics consumer products.

Table 5.5 Penang: export orientation and level of technology in the EE sector

Level of technology	*Sales exported (%)*		
	0–50%	*51–99%*	*100%*
High	0	3 (60%)	12 (55%)
Medium	4 (100%)	1 (20%)	8 (36%)
Low	0	1 (20%)	2 (9%)
Total	4 (100%)	5 (100%)	22 (100%)

Table 5.6 Penang: export orientation and level of technology among supporting firms

Level of technology	*Sales exported (%)*		
	0–50%	*51–99%*	*100%*
High	1 (50%)	0	6 (67%)
Medium	1 (50%)	0	2 (22%)
Low	0	1 (100%)	1 (11%)
Total	2 (100%)	1 (100%)	9 (100%)

Table 5.7 Penang: firm size and level of technology in the EE sector

Level of technology	*Fixed asset investments (RM million)*		
	0–35	*35–100*	*>100*
High	2 (29%)	7 (64%)	7 (78%)
Medium	5 (57%)	4 (36%)	2 (22%)
Low	2 (14%)	0	0
Total	9 (100%)	11 (100%)	9 (100%)

Level of technology by firm size

Firm size may also influence the level of technology. The size of a firm largely determines its command over resources and influences the market niche it seeks to serve which may, in turn, affect the technology utilized; thus, larger firms may be more likely to be high tech. The hypothesis that firm size – proxied here by fixed asset investments – is positively related to the level of technology utilization appears to be supported by the EE sample (see Table 5.7).

Seven of the nine large-sized firms (with fixed asset investments exceeding RM100 million) in our sample reported using high technology. In comparison, only two of the nine small-sized firms (with investments in fixed assets not exceeding RM35 million) had high technology. Similarly, small firms also utilized low technology, while the large firms did not.

In the case of medium-sized firms (with investments in fixed assets between RM35 and RM100 million), the proportion of high-tech firms lay in between those found among the small and large firm samples. Medium-sized firms, like large ones, did not install low-level technology.

Turning to supporting firms (Table 5.8), the relationship between size and technology utilization is less clear. Many of the firms with low investments in capital equipment claimed to be utilizing a high level of technology in their production processes. These firms were largely concentrated in the metal (MSS) and electrical supporting (ESS) sub-sectors, engaged in producing high-precision tooling parts, telecommunications components and electronics modules. Small firms that claimed to use high-level technology were often recently established ones whose accumulation of fixed assets had hardly begun. Given time, they will increase their capital investments, especially since there is evidence of strengthening linkages between the supporting firms and the EE firms (see UNDP 1994).

Factors affecting technology utilization level

In standard textbook expositions, dealing implicitly with closed economies, the choice of technology is a function of factor prices. The firm in a labourabundant economy opts for labour-intensive technology while the firm in a capital-abundant environment uses capital-using technology. In the context of the globalization of production, MNCs are no longer constrained in their technology choice by the relative factor prices in their home economy. An MNC is free to allocate all or part of its total production and related activities in different parts of the globe to take advantage of local strengths. Thus, factor prices *per se* cannot be an important consideration in technology choice, though it might still impact on where the MNC locates different aspects of its production activity. What factors determine technology choice? We posed this question to the firms in our sample, a good proportion of them MNC-affiliates.[7]

Interestingly enough, the technological sophistication of the product, rather than factor prices (of labour or capital), loomed as most important.[8] Product sophistication was ranked first by more than half of the thirty-four firms. Viewed differently, 64 per cent of the twenty-eight firms that cited product sophistication

Table 5.8 Penang: firm size and level of technology among supporting firms

Level of technology	*Fixed asset investments (RM million)*		
	0–35	*35–100*	*>100*
High	6 (46.2)	1 (100.0)	0
Medium	6 (46.2)	0	0
Low	2 (14.3)	0	0
Total	14 (100.0)	1 (100.0)	0 (–)

ranked it as the most important factor. On the other hand, of the twenty-five firms that cited machine price, 40 per cent gave it a low ranking. Similarly, one-quarter of the twenty-six firms that mentioned labour price felt it had only a small impact on technology choice.

What determines the sophistication of the product that a firm opts to produce? Obviously, this will be fashioned by demand in the market niche that the firm chooses to compete in. Hence, the level of technology needed to produce an electrical product (say, a portable radio-cum-tape recorder) will vary, depending on whether the firm wants to compete at the cheaper, lower end of the market, or the more sophisticated segment. And even after the choice is made, the firm must respond to the continuing need to maintain its edge. The market thus drives the firm to upgrade its technology level, especially in a dynamic environment.

The choice of market niche, on the other hand, will depend on knowledge about the market, ease of access and the resources available to acquire and operationalize the necessary technology. A firm with greater resources is more likely to compete in sophisticated and highly lucrative market niches.

Another determinant of the choice of technology is the volume of annual output the technology is capable of producing. Of the thirty-four first choices, 12 per cent ranked output capacity as most important. About 72 per cent of the twenty-five firms that cited this factor ranked it between one and three in importance. Again, this is a factor determined by the market that the firm serves. And once the decision to serve a large market is made, the firm will presumably opt for a more modern technology that can produce the required volume efficiently. Hence, high-tech firms may also (though not necessarily) be firms producing a larger volume of output.

In order to test the hypothesis that product sophistication and volume of output affect the choice of the level of technology, we use a logit model. The model allows us to estimate how the probability of a firm opting for high-level technology varies with specified independent variables. The model is of the following general form:

$$\ln \frac{P}{1-P} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n + u$$

where P is the probability of the firm operating high-tech processes and the Xs are the variables hypothesized to influence the probability of the firm utilizing high-level technology. Thus, the left-hand side of the equation is the log of the odds ratio (or logit) of the firm being high tech.

Of the three broad categories of output produced by the firms in the sample, the ECS category is clearly more sophisticated. To capture the impact of product sophistication, we created a dummy variable, ECS, that was assigned a value of 1, if the firm was in the ECS, and 0, if otherwise. It is postulated that since the sophistication of the products in the ECS is high, a firm in the ECS is more likely to use high technology, other factors being constant. In order to proxy the effect of the volume of output on technology choice, we had to rely on annual sales data. While the total sales and total output of a firm may not correspond perfectly, they generally have a strong degree of correspondence. The SALES variable was measured in millions of ringgit.

There are other factors that we expect, *a priori*, to influence technology choice, including degree of export-orientation, ownership status and firm size. The earlier tabular analyses suggested that these factors may be positively correlated with the likelihood of a firm being high tech; we sought to establish if the effects of these variables were independent and significant. In order to capture the extent of competition faced by firms, we used the EXPORT variable, which measured the proportion of sales exported. To capture different firm policies between US and non-US firms, we introduced a dummy variable US, which was assigned a value of 1 if the firm was US-owned, and 0 otherwise. Since there were only four Japanese firms in our sample of MNCs, we were unable to test for differences between US and Japanese firms. Finally, to account for different access to resources, we used SIZE, i.e. investment in fixed assets (in million ringgit).

In estimating the final model, SIZE was dropped because the initial result suggested multi-collinearity between SIZE and SALES; the coefficients of both proved to be insignificant, but when either was dropped, the coefficient of the other became significant. SALES was retained because it proxied output volume, one of the main explanatory variables hypothesized as influencing technology choice. However, SALES probably captures the effect of firm size as well. The results of the estimation[9] exercise are summarized in Table 5.9.

The signs of all the coefficients conform to *a priori* expectations. However, apart from ECS and SALES, the remaining variables did not exert a significant, independent effect on the likelihood of a firm utilizing high technology. The results lend support to our hypothesis that product sophistication influences the choice of technology level. The more sophisticated the product, the more likely the firm will be high tech. The results are also consistent with the contention that the volume of output influences technology level, although the SALES variable may be capturing the effect of firm size as well.

The lack of significance of the EXPORT variable is not altogether surprising. The majority of firms in the EE sample (71 per cent) produce exclusively for export. Consequently, there is insufficient variation in the data to independently capture this effect. Additionally, the impact of export orientation is probably

Table 5.9 The estimated logit model on factors affecting technology choice

Variable	*Coefficient*	*Std Error*	*T-Stat*	*2-Tail Sig*
Constant	−11.469	9.629	−1.191	0.243
SALES	0.004	0.002	0.842	0.075
US	1.139	1.164	0.978	0.336
ECS	3.451	1.511	2.283	0.030
EXPORT	0.077	0.095	0.810	0.425

subsumed in the ECS variable since most firms in the ECS are also export producers. US ownership also failed to be significant; the impact, if any, is probably blurred by the fact that most firms in the ECS were US-owned.

The results suggest that being in the ECS, *ceteris paribus*, increases the log of the odds ratio of the firm being high tech by 3.451, while a million ringgit increase in sales raises the log of the odds ratio by only 0.004.[10] To estimate the impact of these variables on the probability of a firm with given characteristics using high-level technology, it is necessary to use a set of values for the explanatory variables in the estimated equation and to solve for P.[11] The overall predictive power of the model appears to be satisfactory; if we assume that a firm is high tech when the computed probability is equal to or exceeds 0.5, the model yields correct predictions for 86 per cent of the cases in the sample.

The predicted probabilities are shown in Table 5.10, and refer to firms producing exclusively for export since they account for a large proportion of our sample. The table shows that given firms are producing exclusively for export and have big annual sales (RM200 million), firms located in the ECS (proxying product sophistication) have a higher probability of being high tech than firms outside this sub-sector. Thus, in the US sample, firms in the ECS had a 83 per cent chance of being high tech, compared to only a 14 per cent chance outside the ECS. In the non-US sample, the probability of a firm in the ECS utilizing high-level technology is 62 per cent, compared to those outside this sub-sector. It is also evident that US firms in the sample have a higher probability of being high tech than non-US firms. Controlling for sales volume, the probability of a US firm being high tech was almost 1.3 times greater than a non-US firm within the ECS; the difference in probability rises further (2.8 times), in favour of the US firms, outside the ECS.

The sophistication of the output produced exerts a more significant impact on the probability of a firm utilizing sophisticated technology than does sales volume. In the US firm sample, the probability of a firm, with an annual sales volume of RM200 million, opting for high tech is almost six times greater than its counterpart outside the ECS, with an identical sales volume. In the non-US sample, this difference is doubled. In sharp contrast, the impact of sales volume is less dramatic; in the US sample, a firm in the ECS with a sales volume of RM200 million a year only had a probability that was 1.2 times greater than a firm with a lower

Table 5.10 Computed probabilities of a firm using high-level technology

Firm characteristics	*ECS*	*Non-ECS*
US-owned; large sales* 100% export	0.83	0.14
Non-US-owned; large sales 100% export	0.62	0.05
US-owned; small sales* 100% export	0.71	0.07
Non-US-owned; small sales 100% export	0.44	0.02

Note
* Large sales = RM200 million per annum; small sales = RM20 million per annum.

annual sales volume (RM20 million). Among the non-US firms in the ECS, the difference in probability among firms of different sales volumes is marginally higher. Sales volume has a larger effect on probabilities outside the ECS; in the non-US sample, firms with the larger sales had a probability that was two-and-a-half times greater than firms with the smaller sales. Among US firms, the difference was only twice.

In sum, our findings support the hypothesis that product sophistication and sales volume influence the choice of technology of firms in our sample.

Conclusion

Our findings contradict the findings of studies of the EE sector done in earlier periods. A large majority of the firms in the EE sector and their supporting firms utilize medium- or high-level technology. But firms that use high technology are more likely to be large and foreign-controlled, with the US-owned firms leading the pack. High-tech firms were concentrated in ECS, while there was a wider dispersion in the level of technologies used outside this sub-sector. This is not unexpected since the ECS is extremely market-driven and requires regular upgrading of production technology to produce sophisticated components for end-products that have a short shelf-life.

It is, however, unclear if the positive finding regarding the level of technology utilization in the EE sector and its supporting firms in Penang can be generalized. Penang has several unique characteristics not found elsewhere in the country. The state is home to some of the oldest and most mature MNCs in the EE sector; hence, it has had a longer time to reflect the technological upgrading in the industry. Additionally, Penang has attracted a larger share of the bigger firms in the ECS, which utilize higher-end technologies due to the nature of the market niches they serve. Even the technological upgrading observed in the supporting firms in Penang may reflect the fact that these firms were among the first to have developed linkages with the MNCs. Besides the geographical proximity of the supporting firms and the EE firms, that has permitted close rapport between the two, the dominance of Malaysians drawn from a single ethnic group (Chinese) at the decision-making and operational levels of both the EE sector and supporting firms has also helped foster these ties.

An important policy concern arises from the findings. Although MNCs play a leading role in providing access to higher-end technologies, the technologies have tended to remain with them. While some indirect spill-over benefits have accrued to Malaysian firms in a supporting role – in the sense that they have been forced to upgrade their capabilities to serve the increasingly sophisticated demands of the MNCs they are linked with – there is little evidence of direct investment in high-level technology by non-ancillary Malaysian firms serving local or foreign markets.

Our findings suggest that the sophistication of the products produced and the volume of output play key roles in determining the choice of technology utilized.

Viewed from this perspective, it is clear that the relative backwardness of technology in Malaysian firms stems from the fact that they have not yet ventured into competitive market niches that require them to invest in higher-end technologies. It is important to ascertain why. Possibly, these firms lack the resources or the expertise to serve competitive markets abroad. If this is indeed true, there should be incentives to make it attractive for Malaysian firms and MNCs with such expertise to go into joint ventures. Malaysian firms should also aggressively seek strategic alliances with global companies to widen the quality and scope of their markets. In the case of supporting firms, it is essential that they look beyond their immediate dependence on MNCs and strike forth on their own to serve market niches around the world. Already, one or two home-grown supporting firms from Penang have become international players. At the policy makers' level, it is time to hone incentives to achieve specific objectives, rather than merely to attract foreign investment *per se*. Incentives to encourage and support Malaysian firms to become big players in the international marketplace are also desirable.

Notes

1 Other colleagues who collaborated in the study were K.G. Cheah, Abdul Fatah Che Hamat, Ismail Omar and B.N. Ghosh, all of Universiti Sains Malaysia (USM). The study was headed by Dato Chet Singh of the Innovation and Consultancy Centre at USM. We thank all of them for their support, and the UNDP for permission to draw on the data.

2 The Thai study on technology transfer (Khanthachai *et al.* 1987) reported similar conclusions.

3 In the EE sample of thirty-five firms, there were ten US, four Japanese, eleven other foreign-owned, four local, two foreign-majority and four local-majority firms. Other foreign include Taiwanese, French, German, Australian, Swiss and some joint ventures.

4 Includes two firms with foreign-majority control.

5 Includes four firms with Malaysian-majority control.

6 Most of the EE sample firms were located in the FTZs and enjoy tax exemptions on output exported.

7 The full results are presented in UNDP (1994).

8 Respondents frequently cited "product quality". On further inquiry, we realized that it was being used synonymously with technological sophistication of the product. We have thus opted for the latter terminology since it is more appropriate.

9 The log of the likelihood function had a value of -11.853. The null hypothesis – that the partial slope coefficients are all equal to zero – was rejected at the 1 per cent level of significance. The pseudo $R^2 = 40.1$.

10 While the rate of change in any X has a constant impact on the logit (likelihood) of the firm being high tech, it does not exert a constant impact on the probability of the firm being high tech. The effect of the Xs on probability of the firm being high tech depend not only on the value of their coefficients, but also on the probability itself, which is a function of X.

11 Note that $P = 1 / \{1 + e^{-(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots + \beta_n X_n + u)}\}$

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Appendix 5.1 Sample selection

Sub-sectors (MIC Code)	*Total no. of firms*	*No. of firms in sample*	*Sampling ratio (%)*
Electronics products sector (EPS):			
38321	28	7	25.0
38322	3	1	33.3
Electronics components sector (ECS):			
38329	52	19	36.5
Electrical products sector (ELPS):			
38310	12	5	41.6
38330	6	3	50.0
Electronics supporting sub-sector (ESS)	7	3	42.8
Plastic supporting sub-sector (PSS)	16	5	31.2
Metal supporting sub-sector (MSS)	36	7	19.4
	160	50	31.2

Appendix 5.2 Profile of products of the sample firms

Sub-sectors	*No. of firms*	*Main products*
EPS	8	Radios; cassette and hi-fi equipment; car stereos; magnetic heads.
ECS	19	ICs; disk drives; disks; head stacks; calculators; telephones; 2-way radios; lead frames; inductors; capacitors; telecommunications equipment.
ELPS	8	Transformers; adapters; coils, cooling towers; diodes; rectifiers; consumer appliances.
ESS	3	PCB assembly; flex circuit boards; voice coils; electronic modules and components.
PSS	5	Plastic moulds.
MSS	7	IC moulds; stamp metal components; disk-drive components; die and tooling parts; jigs and fixtures.

6

THE SEMICONDUCTOR INDUSTRY IN MALAYSIA*

Goh Pek Chen

Malaysia is the world's second largest exporter of semiconductors to the USA after Japan, and was the world leader until 1986. Despite occasional fears that the industry's performance was unsustainable, production and exports have grown at rapid rates year after year. Many observers celebrate Malaysia's semiconductor industry as an example of successful high-tech industrialization in the developing world and predict further success. An examination of the industry's structural characteristics, however, reveals critical weaknesses that create important dilemmas and place the industry's long-term prospects in doubt.

This chapter analyses the Malaysian semiconductor industry in a comparative context. It argues that the growth of the semiconductor industry in Malaysia has not been accompanied by the development of a strong technological base. The absence of indigenous technological capabilities jeopardizes the prospects for technological upgrading and long-term development. In order to illustrate this argument, this chapter identifies three critical structural problems confronting the Malaysian semiconductor industry: foreign domination, low technology and poor integration. Following that, it reviews the experience of the first-tier newly industrializing economies (NIEs) – South Korea, Taiwan, Hong Kong and Singapore – in promoting semiconductor industry development, drawing key contrasts with Malaysia. Major factors that have prevented Malaysia from developing an indigenous presence in semiconductors will also be discussed.

A brief profile

The semiconductor industry is one of the three sub-sectors of the electronics industry. Different types of semiconductor devices (as shown in Figure 6.1) constitute the "lifeblood" for the other two sub-sectors: consumer and industrial electronics. With semiconductors, electronics goods have been miniaturized and have had their capacity increased. Semiconductors have also contributed significantly to productivity increases and product innovations.

Semiconductors were first developed to meet military demands in the USA

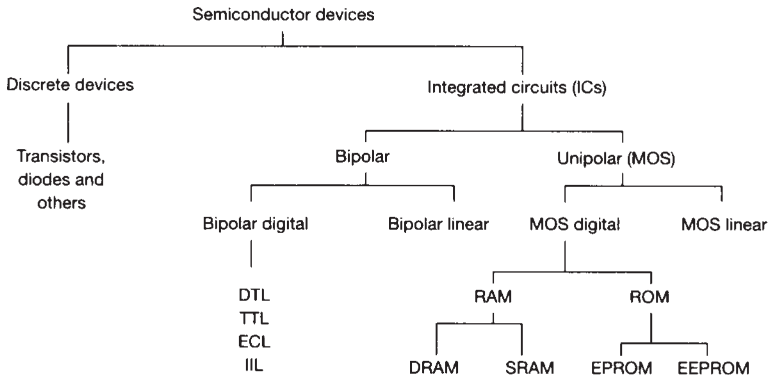

Figure 6.1 Types of semiconductor devices
Notes DTL: diode-transistor logic
TTL: transistor-transistor logic
ECL: emitter-coupled logic
IIL: integrated injection logic
MOS: metal oxide silicon
RAM: random-access-memory
ROM: read-only-memory
DRAM: dynamic-random-access-memory
SRAM: static-random-access-memory
EPROM: erasable-programmable-read-only-memory
EEPROM: electrically-erasable-programmable-read-only-memory

about five decades ago. The use of semiconductors for consumer and industrial electronics resulted in rapid growth of the semiconductor market. Semiconductor production rose from about US$400m in the early 1960s, to US$5bn in 1974 and to US$20bn in 1983 (OECD 1985:21). Though sales dropped by about 17 per cent in 1985,[1] recovery was fast, and strong demand pushed sales reaching US$60bn in 1991 (Forester 1993:45). In 1995, 40 per cent growth was recorded, with sales reaching US$150bn *(Asahi Shinbun,* 8 Jan. 1996:13).

With favourable forecasts for further growth of the semiconductor industry, producers are racing to expand existing plants as well as to set up new ones. In addition to a net profit margin which could range from 25 to 50 per cent *(Financial Times,* 15 Aug. 1995:16), another motivation for expansion is that mastery of necessary technology gives a crucial edge in technological competition. Such technology is crucial in determining competitiveness of a firm, and, arguably, of countries. Both developing and developed countries have, therefore, given priority to establishing this high-tech industry.

Malaysia's semiconductor industry was established in the early 1970s, due to a "coincidence of interests". Malaysia saw semiconductor assembly as offering potentially large job creation, particularly for unskilled labour, one of its highest policy priorities then. Coincidentally, the multinational corporations (MNCs) were looking for cheap production sites for simple assembly jobs as competition between the American and Japanese producers began to heat up. MNCs therefore responded with interest to host-country incentives, and the result was a massive relocation of semiconductor firms to Malaysia. By the early 1980s, there were fourteen MNC semiconductor firms (excluding subsidiaries) operating in the country (see Ernst 1985: Table 3). Malaysia became the single largest Third World site for offshore semiconductor firms.

The jobs created were particularly important to Penang, which thus became the "Silicon Valley" of Malaysia. In the early 1980s, a total of 20,498 workers was employed in the industry (Rasiah 1993:63). Today, this industry is one of the major employers in the manufacturing sector with about 48,000 employed nation-wide.

During this time, semiconductor production increased rapidly. The ratio of semiconductor output to gross domestic product (GDP) was 3 per cent in 1976, increasing to 14 per cent in 1990 and 18 per cent in 1994. Besides job creation, the industry was also promoted to increase exports. In 1980, the ratio of semiconductor exports to total manufactured exports was 36 per cent. Though this ratio dropped to 25 per cent in 1990 and 21 per cent in 1994, semiconductor exports overtook crude oil to become the biggest export item from 1987. By exporting US$800m worth of semiconductors to the USA in 1981, Malaysia became the biggest semiconductor exporter to that country.[2] The government and business community have been proud of this "achievement", often implying that Malaysia has become a high-tech producer. However, a closer look at the situation reveals a dilemma, as the discussion below will show.

Structural characteristics

Foreign domination

Since the semiconductor industry is capital-intensive and usually utilizes state-of-the-art technology, few firms have the necessary prerequisites to enter the industry. Until the 1980s, the giant semiconductor firms that dominated the world market were mainly from the USA and Japan. Nevertheless, semiconductor firms in Europe have been trying to capture bigger market share, while newcomers from South Korea and Taiwan have successfully joined the competition since the late 1980s.

Malaysia, on the other hand, lags far behind. Despite having a quarter century of experience in producing and exporting semiconductors, there are few indigenously owned semiconductor firms. At present, there are sixteen semiconductor firms in the country (excluding subsidiaries):[3] eight are owned by American firms, four by Japanese, two by Taiwanese, one each by West German and Dutch. (List 1 shows the semiconductor firms operating in Malaysia.) Although the government claims Malaysia is one of the world's major semiconductor producers, it serves primarily as a production platform for foreign MNCs.

List 1 MNCs' semiconductor firms in Malaysia

Name of firm	*Ownership*	*Name of firm*	*Ownership*
1. Advanced Micro Devices	USA	9. Motorola	USA
2. ASE Electronics	Taiwan	10. National Semiconductor	USA
3. Fujitsu Microelectronics	Japan	11. NEC Semiconductor	Japan
4. Harris Semiconductor	USA	12. SGS Thomson Microelectronics	Netherlands
5. Hewlett-Packard	USA	13. Siemens	Germany
6. Hitachi Semiconductor	Japan	14. Texas Instruments	USA
7. Intel	USA	15. Toshiba Electronics	Japan
8. Janway Industry	Taiwan	16. Western Digital	USA

There have long been dire predictions that the industry is "footloose", with firms relocating elsewhere sooner or later, but these predictions have turned out to be exaggerated. Malaysia has remained attractive for MNCs producing semiconductors because the government has been always sought to accommodate their demands.[4] For instance, in 1981, the government exempted the electronics industry from a provision of the Employment Act (1955).[5] Furthermore, as cheap labour was considered necessary to attract MNCs, the government has refused to allow a national union for electronics industry workers and to enact equal pay for equal work legislation, as 78 per cent of the total work force in this industry are women. Though the ban on trade unions was lifted in 1988, only in-house or company unions were allowed in the electronics industry, although a National Union of Electronic Workers (NEW) sought registration. Workers were often threatened by employers to prevent them from joining any union (Kuruvilla 1995:50).

Today, the same tactics to lure MNCs may be less effective. The rapid economic growth of the past eight years has caused severe labour shortages and consequent increases in labour costs. From 1987 to 1991, wages for skilled and unskilled labour in the electrical and electronics industry increased by 12 and 20 per cent, respectively (World Bank 1995:111). So far, however, the increase in labour costs has not posed a serious problem to most semiconductor firms interviewed. The major reason is that growing automation has reduced direct labour costs to only about 10 to 15 per cent of total production costs. However, productivity has been affected by the difficulty of finding and retaining workers. High turnover rates of workers in the electrical and electronics industry were reported by the Federation of Manufacturers Malaysia (FMM). In 1994, the average turnover rate of engineers was 24 per cent, while the corresponding ratios for semiskilled and skilled labour were 21 and 14 per cent, respectively *(Malaysian Industry,* September 1995:10).

The shortage of skilled labour actually began in the mid-1980s when the industry went through some restructuring. With increasing automation, more skilled labour is needed to handle the more sophisticated machines. Unfortunately, the necessary skills take time to develop, and the lack of appropriate training measures has resulted in more serious labour problems. Not surprisingly, many firms interviewed expressed their concern at the difficulties in finding skilled labour. Such problems will most certainly be taken into consideration as MNCs consider their future moves.[6]

The domination of Malaysia's semiconductor industry by MNCs renders it an "ersatz" industry from the standpoint of long-term national development. Though previous fears of relocation have not proven out, MNCs' continued presence remains uncertain because it depends on various changing factors that affect Malaysia's competitiveness as a site for off-shore production. The main way to retain such industry is probably through indigenization. The contrasting experience of the first-tier NIEs is important in this respect. Indigenous semiconductor firms in these NIEs started as sub-contractors for MNCs as original equipment manufacturers (OEMs). After building up their technological capability, they began to design and produce their own semiconductors.

Though this trend did begin in Malaysia, it has been truncated mainly due to lack of government support. Some ethnic Chinese who were former employees of foreign semiconductor firms established companies such as Carsem, Unisem and Globetronics,[7] which became sub-contractors for MNCs. By assembling semiconductors for MNCs on a contract basis, however, their survival depends on the MNCs. Unfortunately, so far, there is no sign of these firms producing their own semiconductors or other evidence of upstream integration.

Low technology

Semiconductor production can generally be divided into four stages: research and development (R&D), wafer fabrication, assembly and testing (see Figure 6.2). Beside inputs, each stage requires different levels of capital, technology and skill. R&D is the most upstream stage which involves concept development and new circuit designs. This is the most technology-intensive stage which requires highly qualified and creative engineers and scientists. After a new circuit design pattern is determined, it is formed on a photo mask; this mask-making is still considered part of R&D. Due to the complications of circuit designs, this process

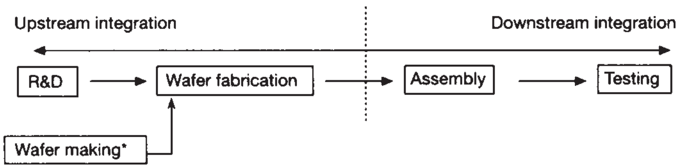

Figure 6.2 An integrated semiconductor industry

Note

* Wafer making involves the making of silicon wafers by chemical manufacturers and is distinct from semiconductor production. It is not a technology-intensive stage, but, so far, there has been no backward vertical integration by semiconductor manufacturers into the production of wafers.

has to be delicately done by highly skilled technical labour. Any defect in the pattern formed in the mask will result in low yield (percentage of usable chips per wafer) and, hence, higher unit costs.

Semiconductors with new circuit designs have to be produced on silicon wafers through a process known as wafer fabrication. Because of the delicateness of semiconductors, production requires the use of pure water and oxygen, as well as dust-free operating rooms with a very reliable power supply. Using photolithography techniques, scientists and engineers etch the desired electrical circuits onto silicon wafers from photo masks. Difficulties arise when a new generation of semiconductors needs to have more capacity. Increased capacity means more circuits need to be etched on wafers, which usually means the extremely thin circuit lines must be even thinner. Ten years ago, a 1M Dynamic Random Access Memory (DRAM)[8] chip had circuit lines 1.2 microns wide.[9] Today, it is down to 0.25 microns for a 256M DRAM chip. Successfully overcoming challenge can be very rewarding. A bare silicon wafer, costing about US$50, is worth about US$600 once fully processed.[10] This costly and risky high value-added and technology-intensive stage is an essential part of integrated semiconductor production.

Assembly is the downstream stage where wafers are cut into dies, attached to frames, wire-bonded and assembled on printed circuit board. The final stage is testing. Semiconductors have to go through visual inspection and different types of testing to ensure performance reliability. Only then can they be labelled and packaged for delivery to customers. Assembly and testing are the relatively low value-added and most labour-intensive stages of production.

These four distinct stages of production can be, and often are, separated from one another to reduce the costs of production. With cheaper air transportation costs and improvements in telecommunications, such a division of labour has become more economical. The most technology-intensive stages, i.e. R&D and wafer fabrication, tend to remain with the parent firms in the industrialized countries, while the last two stages, which require relatively more manual work, tend to be relocated to low-wage countries.

When relocation of assembly plants started in the early 1960s, the main host countries in Asia were the first-tier NIEs. Rows of unskilled, usually female, workers assembled semiconductors using microscopes. This was often said to involve exploitation of cheap workers by the MNCs. Soon, this was followed by setting up more advanced testing centres as assembly was slowly phased out and relocated to Malaysia, Thailand and Indonesia (see Siegel 1979). In the early 1980s, upstream integration progressed further in these first-tier NIEs, with the setting up of wafer fabrication plants, design houses and R&D institutes.

Unlike the first-tier NIEs, Malaysia has remained relatively stuck at the same downstream stages of production as 25 years ago, still doing assembly, testing and packaging for MNCs. Blank wafers produced in the country by two major silicon wafer producers – SEH[11] and MEMC – are exported to the industrialized countries for wafer fabrication, with some of these wafers sent back to Malaysia for assembly and testing. Currently, the missing link in the Malaysian semiconductor industry is wafer fabrication. Except for one wafer fabrication plant set up by Motorola in 1988 (which is said to be using out-dated technology to produce discrete devices), no other fabrication plant is in sight. In the past, quite a few announcements were made by MNCs about the establishment of wafer fabrication plants, but nothing has materialized.[12] While semiconductor firms in the USA, Japan, Europe and South Korea possess the technology necessary to produce the next generation of semiconductors, Malaysia can only undertake assembly and testing. Stuck at the tail-end stage of production, it is not surprising that value added per worker in 1994 was only US$14,601 in Malaysia (Department of Statistics 1994) compared to US$134,049 in South Korea (Korea 1995).

Though Malaysia has established a strong base for assembling semiconductors, it cannot indefinitely continue doing assembly work as increasing labour costs further erode its comparative advantage. Recognizing that it should not remain at this low value-added stage, but should instead move into upstream production, Semiconductor Technology Centre, a wafer fabrication plant, was set up by the government in 1995.[13] With access to government-backed fabrication, it is hoped that the indigenous firms will begin to invest in circuit design activities. Although a few MNCs have recently announced plans to set up wafer fabrication plants in Malaysia,[14] private Malaysian firms are conspicuous by their lack of interest.

Poor integration

The establishment of stronger linkages between MNCs and indigenous firms is important. Such linkages can provide strong support for the growth of the semiconductor industry, and more importantly, increase Malaysian value added in the semiconductors produced.

To supply an input needed for the production of semiconductors involves a backward linkage. As mentioned above, different inputs are required in each of the four stages of production. In the initial stage, photo masks are the major inputs. The second stage requires raw silicon wafers, various types of chemicals and gases. In assembly, wafers become the major input. Other inputs – such as lead frames (the metal "legs" that connect the semiconductors to the printed circuit boards), epoxy resins (the substance needed to attach semiconductors to the frames), gold and aluminium wires (which conduct electricity) and printed circuit boards (where the semiconductors are mounted) – are needed. Different chemicals are also required for cleaning and etching at this stage.

Since Malaysia only has assembly and testing stages of the semiconductor industry, the backward linkages that can be formed between the MNC-controlled industry and indigenous firms involve the supply of wafers, lead frames, epoxy resins, wires, printed circuit boards, chemicals and gases. Unfortunately, after more than twenty-five years of rapid growth of the industry in Malaysia, these linkages have still not been significantly developed. A survey conducted by the Malaysian Industrial Development Authority (MIDA) in 1981 reported that only 1 per cent of the inputs needed by semiconductor firms was supplied by indigenous firms (Rasiah 1988a:37), mostly simple-to-produce items such as low-grade wires.

Today, though inputs are still largely imported, some semiconductor firms buy lead frames locally. The establishment of lead frame manufacturers in Malaysia is important but unfortunately does not involve Malaysian firm participation at all. The lead frame manufacturers are either subsidiaries of MNCs or MNC suppliers from the industrialized countries which have relocated in Malaysia. (List 2 names the major lead frame manufacturers in Malaysia.) In fact, besides limited inputs produced by indigenous firms, such as low-grade wires and other items not directly related to production (packaging boxes, office furniture and stationery), more significant linkages between assemblers and indigenous parts suppliers have yet to be developed.

List 2 Malaysia: major lead frame manufacturers

Firm	*Ownership*
Dynacraft S. B.	USA
Kitsuda S. B.	Japan
Mitsui High-Tech S. B.	Japan
M-SMM Electronics S. B.	Japan
NCD Wearness S. B.	Singapore and Japan
Possehl Electronics S. B.	Germany
Shinko Electronics S. B.	Japan

The government introduced a local content requirement in 1990, hoping that indigenous supporting firms could be developed in the sector.[15] However, according to the survey by Mohd. Nazari (1995), semiconductor firms were willing to source inputs locally, not so much because of the requirement, but because, by doing so, considerable amounts of money as well as time could be saved (Mohd. Nazari 1995:140). Unfortunately, indigenous firms largely failed to supply these inputs, both in terms of quantity as well as quality. Therefore, the failure to develop backward linkages in the semiconductor industry seems to be primarily due to the lack of adequate technological capability among indigenous firms.

However, even if all the above-mentioned inputs, except wafers, were to be supplied locally, local value-added would only rise by about 10 per cent (O'Connor 1993:216). In order to significantly increase value added, wafer fabrication has to be carried out in the country. The lack of wafer fabrication plants at present remains a major setback for the development of the semiconductor industry in the country. With imports of wafers and other inputs, it is not surprising that the import content of semiconductors produced in Malaysia remains at about 90 per cent (*Business Times,* 29Jul. 1991).

Fortunately, there is some hope with the emergence of a few indigenous firms supplying tools and other equipment to semiconductor firms in the country as well as for export. In spite of the generally unimpressive development of the capital goods industry in Malaysia, the tools and other equipment produced by Eng Hardware as well as by Low Kim Teow (LKT) and its subsidiary (Semiconductor Equipment Manufacturer) have met the stringent requirements of customers such as Intel, National Semiconductor (NS), Hewlett-Packard (HP) and Advanced Micro Devices (AMD). Their successes have not come easily as both Eng Hardware and LKT started as small Chinese-owned foundries. Furthermore, they developed during the New Economic Policy (NEP) period, when industrial policy was not very favourable for them.

The growth of consumer electronics (colour television, audio and video pro ducts) and industrial electronics (such as computers and office equipment) industries in Malaysia during the last few years has created a large local market for semiconductors. One might then assume that the forward linkages of the semiconductor industry have been well established. Unfortunately, this is not so. Ironically, semiconductor users find that they have to import their requirements. This may seem strange, but, as mentioned above, the semiconductors produced in Malaysia are mainly for exports.[16] The other reason is that most MNCs set up their sales and marketing offices in Singapore rather than Malaysia, due to the proximity of the two countries and the superior facilities allegedly available in the island republic. As a result, the users import the semiconductors they need from Singapore. For these reasons, imports of semiconductors increased from RM2bn in 1981 to RM28bn in 1994 (see Table 6.1). In fact, semiconductor imports exceeded semiconductor exports in 1994, with a deficit of RM3.4bn, equal to a third of the current account deficit in that year. The share of semiconductor imports to total imports was 9 per cent in 1981 and increased to 13 per cent in 1990 and 19 per cent in 1994.

Besides semiconductors, other parts and components needed for the assembly

Table 6.1 Malaysia: semiconductor trade* (RM million)

Year	*Exports*	*Imports*	*Balance of trade*
1981	2,520	2,442	78
1988	8,716	7,067	1,649
1989	10,175	8,662	1,513
1990	11,685	10,308	1,377
1991	13,051	12,493	558
1992	14,357	13,680	677
1993	18,750	18,317	433
1994	24,881	28,285	−3,404

Source: Malaysia, *External Trade Statistics*, various issues.

Note

* SITC group: Thermionic valves, tubes, ICs and parts.

of electrical and electronic goods in Malaysia are also largely imported. In the early 1990s, the import content of the electrical and electronics industry was generally more than 70 per cent of all intermediate inputs used (see *Economic Report, 1993/94:* 177). Figure 6.3 shows the poorly integrated nature of the electrical and electronics industry. In 1992, out of the RM14bn worth of semiconductor exports, imported inputs accounted for RM11bn, with a substantial amount accounted for by wafers. Of the total export earnings of RM30bn by the electrical and electronics industry, about RM23bn went to imported parts and components, more than half of which were imported semiconductors.

This discussion indicates that Malaysia faces a dilemma. Malaysia promoted semiconductors as a high-tech, growth-oriented industry, yet the industry has failed to mature. Today, MNCs still dominate both semiconductor production and its supporting industries. Furthermore, this industry only involves the tail-end assembly stage of production, while value added in the global industry is ever more concentrated in upstream design, mask-making and wafer fabrication. The value-creating and advanced technology which is often associated with this industry is absent. Can Malaysia address these weaknesses without the foreign investment that has been unwilling to make such investments despite rapid growth?

Many would argue that there is no need for fundamental change in the direction of semiconductor industry development. They maintain that the weaknesses outlined above do not pose threats to the industry's long-term growth. After all, previous predictions that the industry would stagnate, or that MNCs would relocate out of Malaysia, have proved wrong. The industry continues to grow at a rapid rate. A second objection is that, notwithstanding the industry's weaknesses, there is little Malaysia can do to encourage a more structurally integrated industry with greater indigenous participation (O'Connor 1993). Any attempt to move in this direction will only drive away foreign investment and undermine growth. These two arguments are often invoked to recommend that Malaysia should continue to focus its efforts on supporting MNCs' continued presence with

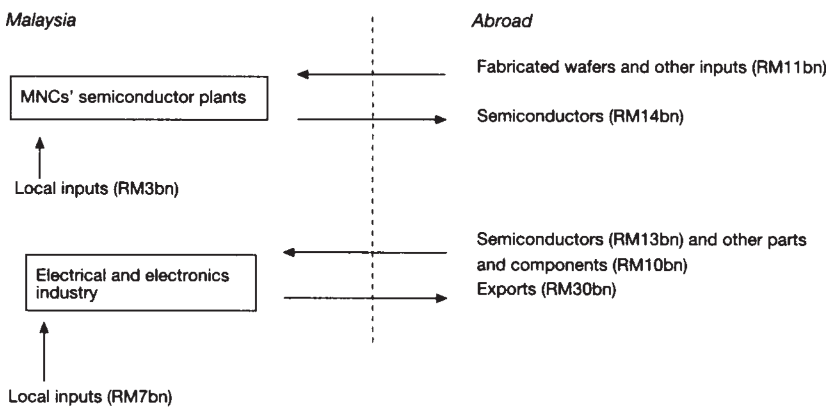

Figure 6.3 Malaysia: poor integration of the electrical and electronics industry, 1992

positive inducements. The first argument is difficult to refute, given the industry's high growth performance up to now and the difficulty of predicting future developments. However, the industry's persistently high import-intensity, and its low value added to output ratio, leave little doubt that the economy would enjoy much larger benefits from a more structurally integrated industry. Similarly, in terms of long-run growth, a more locally integrated industry with indigenous participation would guard against a relocation of value-added activity to other lower-cost industries. While many discount this prospect, Malaysia's rising costs and lagging productivity, combined with investments in skills and infrastructure in lower-wage countries, could easily combine to result in slowing growth and even stagnation. MNCs will ultimately have far less commitment to investing in productivity-enhancing technology and upstream integration than local firms. To illustrate these arguments, it is worthwhile to look at the success of the first-tier NIEs in fostering upstream integration and indigenous participation in semiconductors.

Development of the semiconductor industry in the first-tier NIEs

Upstream integration

In South Korea, until the early 1980s, when the Korean *chaebol* conglomerates entered the industry, there were many firms, mostly joint ventures, assembling semiconductors for MNCs. The entries of Samsung, Goldstar and Hyundai have since changed the picture. Today, Samsung is the world's top producer of DRAM chips, while Goldstar and Hyundai rank number six and seven respectively (*Asiaweek,* 9 June 1995:57). In 1986, South Korea produced 2.2 per cent of the world's semiconductors. By 1994, the percentage had increased to 7.5 per cent, for it to become the third largest producer of semiconductors in the world, after the USA and Japan (*Daiwa News,* 1 Nov. 1995:13).

When South Korea produced 64K DRAM chips[17] in 1984, its level of technological development was four years behind the industrial countries. Three years later, it produced 1M DRAM chips, with a technological gap of two years, and by 1992, South Korea was on par with the industrialized countries in the world to complete the prototype circuit design for the newest generation of DRAM chips, the 1Gb chip[18] with a circuit width of 0.6 microns (*Financial Times,* 12 Dec. 1995:6). In spite of being a latecomer, this breakthrough by the South Korea semiconductor firms threatened longer-standing American and Japanese firms.

Taiwan started in the assembly stage of the semiconductor industry about a decade before Malaysia. In the mid-1980s, design houses there started to design semiconductors, particularly Application Specified Integrated Circuits (ASICs).[19] The increase in the number of design houses led to the establishment of wafer fabrication plants, which helped commercialize the technological innovations of design houses. At present, there are about fifty design houses and fifteen wafer fabrication plants in Taiwan, the biggest of which is Taiwan Semiconductor Manufacturing Corporation (TSMC); others include United Microelectronics Corporation (UMC), Winbond, TI-Acer and Mosel-Vitelic. Furthermore, nineteen new fabrication plants, costing about US$17bn, are being planned (*The Economist,* 20 Jan. 1993:73). In 1985, Taiwan produced 0.1 per cent of the world's semiconductor output; by 1994, this had risen to 2.3 per cent, ranking Taiwan as the sixth largest semiconductor producer in the world (*Daiwa News,* 1 Nov. 1995:13).

In terms of level of technology in wafer fabrication, TSMC claimed to be only nine months behind Texas Instruments (TI) and Intel in 1988.[20] In the early 1990s, Taiwan started production of 1M and 2M DRAM chips as well as 256K Static Random Access Memory (SRAM) chips. In 1993, it had the capability to produce 4M DRAM chips. At the same time, it became one of the few countries successfully experimenting with the production of 0.5 microns 16M DRAM chips on an 8-inch wafer (Liao 1994:104).

The other two first-tier NIEs, Hong Kong and Singapore, have not had such outstanding achievements as South Korea and Taiwan, though upstream integration in the economies has still been better than Malaysia. Hong Kong was the first recipient of semiconductor investment in the region in 1962 when Fairchild set up a plant to assemble semiconductors (Henderson 1986:99). By the early 1970s, Hong Kong had become an important centre for final testing. Further developments saw the rise of wafer fabrication plants and design houses. Today, there are three wafer fabrication plants that produce ASICs: RCL Semiconductor, Elcap Electronics and Hua Ko Electronics (*Far Eastern Economic Review,* 18 Aug. 1988:86).

In the early 1970s, the Singaporean semiconductor industry had a lot in common with Malaysia's. Today, though MNC assembly plants are still operating, there has been substantial upstream integration. Singapore's first wafer fabrication plant was SGS-Thomson Microelectronics, a private joint venture set up in 1984 between Italian and French conglomerates. In 1988, Chartered Semiconductor Manufacturing was established, a joint venture between the state-owned Singapore Technology Corporation and two American firms: Sierra Semiconductors and NS. Currently, it has two wafer fabrication plants and two more will be set up before the turn of the century (*Malaysian Business,* 1 Dec. 1995:53). Tech Semiconductor, jointly-owned by TI, Canon, Hewlett-Packard and the government-controlled Economic Development Board (EDB), is more ambitious than the others in wafer fabrication. With new investment of US$6bn, it will have five fabrication plants by early next century (*Malaysian Business,* 1 Dec. 1995:53). Currently, there are eighteen assembly plants, four wafer fabrication plants and sixteen design houses in Singapore (*The Edge,* 24 Jul. 1995:6). The output from these firms produced 0.8 per cent of total world semiconductor output in 1994 (*Daiwa News,* 1 Nov. 1995:13).

Success factors

The success of the first-tier NIEs in upstream integration has been the result of a complex interplay of a number of factors. Two major factors – government support and human resource development – are discussed below.

Government support

The successful development of the semiconductor industry in most of the firsttier NIEs was due to strong support from the government, particularly in the early period of development (see Henderson 1986:107), with Hong Kong the exception.[21] As a capital- and technology-intensive industry, the uncertainties involved were too great to be borne by indigenous firms alone. Such uncertainties were reduced when the government stepped in to create a more favourable environment. Normally, support has been in the form of tax incentives, low interest loans, establishment of research institutes and industrial parks, human resource development, collaboration with MNCs to obtain needed technologies, and even direct involvement in production.

In South Korea, the electronics industry was selected as one of six industries to be promoted under the Heavy and Chemical Industry Plan of 1973. In 1974, the Eight-year Electronics Industry Development Plan contained three strategic features: first, to create mission-oriented research institutes; second, to expand advanced training capacity in electronics; and third, to encourage technology imports via licensing and consultants rather than through foreign direct investment (Wade 1990:313). In order to enhance technological capacity in upstream integration, the Korean Institute of Electronics Technology (KIET) was set up by the government in 1976. Its sole responsibility was to plan and co-ordinate semiconductor R&D. In 1978, this institute set up a liaison office in Silicon Valley, California, in order to obtain equipment and technology licences as well as to build contacts with American semiconductor firms. KIET also organized training programmes for semiconductor firms by sending engineers and scientists abroad.

Significant upstream integration took place in 1978 with the opening of South Korea's first pilot wafer fabrication plant, a joint venture between KIET and an American firm. At this time, however, semiconductor firms still remained at the assembly stage as the government encouraged indigenous firms, especially conglomerates, to move upstream (Yoon 1989:52). Coincidentally, conglomerates that had already invested in consumer electronics, such as Samsung and Goldstar, recognized the importance of producing semiconductors for their own use and were, therefore, keen to invest. With considerable government support in terms of low-interest loans and fiscal investment incentives, Samsung, Goldstar and Hyundai invested upstream (Wade 1990:314).[22]

In Taiwan, the Industrial Technology and Research Institute (ITRI) and its subsidiary, the Electronics Research and Service Organization (ERSO), were set up in the early 1970s, with the purpose of developing an indigenous semiconductor industry. ERSO became the main R&D institute, responsible for electronic technology research and training of local engineers and technical personnel. With the assistance of ERSO, UMC, a partnership between the private and public sectors, was set up in 1979 in order to commercialize the technological innovations contributed by ERSO. The UMC wafer fabrication plant started to produce ASICs in 1981. Further developments saw the mushrooming of design houses, mostly set up by American-trained Taiwanese engineers. In order to help these design houses in manufacturing semiconductors, the government assisted in the establishment of TSMC, which soon became a subcontracting manufacturer for about fifty design houses in this island.

In order to house these high-tech firms, Hsinchu Science-based Industrial Park was set up in 1980. It is perhaps the closest Asia has come to replicating California's Silicon Valley. Today, there are about 170 firms in the park which generated about US$5bn in sales during the first half of 1995, primarily in semiconductors, computers and peripherals (*Asian Wall Street Journal,* 9 Oct. 1995:11). Firms that set up their plants in the park are provided with financial incentives (such as five-year tax holidays), good infrastructure and easy access to established universities and research centres. Besides, subsidies from the Technology Development Special Project, a major R&D subsidized programme of the Ministry of Economic Affairs, have also been given out to encourage R&D (Liao 1994:142).

In the early 1990s, the Submicron Laboratory at the National Chiao Tung University was established in order to introduce DRAM production in Taiwan. With an investment of US$270m from the Ministry of Economic Affairs, it produced a prototype 16M DRAM chip in 1993. This technological breakthrough elevated Taiwan's position in world DRAM chips production.[23] It, therefore, can be concluded that the success of Taiwanese firms in producing semiconductors can be attributed to financial, technological, infrastructural and administrative support from the government.

The Singapore government started to attract foreign investment into R&D and wafer fabrication in the late 1970s. As discussed above, government involvement in wafer fabrication has been significant. The efforts to promote this front-end stage of production have recently been intensified with the allocation of 93 hectares of land area for this purpose alone (*Malaysian Business,* 1 Dec. 1995:53).

In terms of human resource development, Singapore has been given priority to the training of technical work force since the early 1970s. The EDB operates five technician training centres. The Vocational and Industrial Training Board has fifteen training centres (Begin 1995:note 9). Besides, the National Productivity Board and the Institute of System Science have been conducting regular training programmes as well. In 1979, the Skill Development Fund was established (with financial resources derived from levies on employers) for the purpose of supporting training courses undertaken by private firms. It cannot be denied that the availability of well-trained labour has facilitated the restructuring of the semiconductor industry towards more high value-added production.

Besides tax incentives, R&D has been encouraged by the Singapore government with the setting up of an R&D research fund of US$1.26bn (Khoo 1994). Currently, the Singapore Science Park is the base for about a hundred R&D firms, which include Motorola, NS and Hewlett-Packard (Naisbitt 1995:175). The Institute of System Science has also been actively searching for collaborative research projects with foreign electronics firms. In fact, the EDB supports about fifty Singaporean designers and process engineers in Silicon Valley in order to secure technology from the USA.

Financial assistance to semiconductor firms has included loans below market interest rates provided by the Development Bank of Singapore (Ariff and Hill 1985:20). Such measures are evidence of the serious efforts taken by the Singapore government to move towards upstream integration. However, this effort has largely succeeded in attracting foreign firms, as the indigenization of the semiconductor industry in Singapore is still at an embryonic stage.

Human resource development

Direct government support is important, but not sufficient to nurture the semiconductor industry. This high-tech industry requires a strong human resource base, particularly a labour force trained in science and engineering from technical colleges and higher institutions. Table 6.2 shows the technical enrolment at the secondary level for the period 1988–91: South Korea had 18.6 per cent of its secondary students enrolled in technical training while Hong Kong had 10 per cent. Furthermore, evidence has shown that people who have spearheaded the breakthroughs in semiconductor technology are scientists and engineers. It is, therefore, essential to emphazise tertiary education. The enrolment of students in tertiary education in the first-tier NIEs has been impressive. In 1995, the ratios of tertiary enrolment in these NIEs, except Hong Kong, were even higher than in industry. After gaining substantial experience by working, such overseas-trained scientists and engineers have returned to the region and helped to narrow the

Table 6.2 Technical enrolment as percentage of all secondary students, 1988–91

Japan	28.0
South Korea	18.6
Taiwan	n.a.
Singapore	5.6*
Hong Kong	10.0
Malaysia	2.2

Source: Human Development Report 1995: 174.

Note
n.a. = not available.
* Low and Toh 1991: 78.

Table 6.3 Percentage of 20–24-year-olds enrolled in tertiary education, 1995*

USA	76
Japan	31
South Korea	40
Taiwan	34
Singapore	38
Hong Kong	18
Malaysia	7

Source: Asian Wall Street Journal, 9 Oct. 1995, adapted from *World Competitiveness Report 1995*.

Note

* Tertiary education includes universities, teacher training colleges and higher professional colleges.

Table 6.4 Science graduates as percentage of all graduates, 1990

USA	15*
Japan	26*
South Korea	42
Taiwan	n.a.
Singapore	53
Hong Kong	39
Malaysia	30

Source: Human Development Report 1994: 138 and *Human Development Report 1995:* 174, 200.

Note

* For 1990–91; n.a. = not available.

Table 6.5 Engineering enrolment as percentage of population, 1995

South Korea	0.58
Taiwan	0.60
Malaysia	0.07

Source: World Bank (1995): 106.

Japan (see Table 6.3). More importantly, a significant number of these students were enrolled in science and engineering courses (see Tables 6.4 and 6.5).

Another important source of highly qualified labour in the first-tier NIEs has been overseas-educated professionals. As frontier semiconductor technology is mainly developed in the USA, students trained in the American universities have helped to acquire state-of-the-art technology for indigenous East Asian technological gap between the first-tier NIEs and the USA. In Taiwan, about 6,000 experienced managers and engineers returned from the USA over the past five years, many with doctorates (Naisbitt 1995:171). Such brain power has been a major force in the technological progress in the nation, e.g. they were largely responsible for the success of the Hsinchu Science-based Industrial Park.

It should be noted that the quality of the human resource base has little to do with the size of a country's labour force. What matters for a country's industrial competitiveness is the ability of its labour force to absorb new technologies, and, later, to adapt and apply these technologies for domestic use. The remarkable improvement in the first-tier NIEs' technological capabilities can be attributed to their consistent effort to enhance science and technology development. In 1997, of the forty-six economies surveyed in the *World Competitiveness Report,* Singapore ranked eighth in terms of science and technology, and was the best in Asia after Japan. Taiwan ranked tenth, while Hong Kong ranked eighteenth and South Korea twenty-second (*World Competitiveness Report 1997)*.

R&D also enhances a country's competitiveness. The importance of R&D for semiconductor production is reflected in the higher proportion of R&D as a percentage of sales compared with other high-tech industries such as aerospace, computers and telecommunication (see OECD 1985:40). As the evolution of the semiconductor industry is a continuous process, with each technological progress making the product life cycles ever shorter, in order to stay competitive in the market, R&D is essential.

The priority on R&D can be seen from the funds allocated. There has been a consistent increase in R&D expenditure in South Korea. The ratio of R&D expenditure to GDP was 0.39 in 1970, 0.58 in 1980 and 1.93 in 1987 (Taniura 1990:106). By 1995, the ratio had increased to 2.68 per cent, topping the ratios of other NIEs, and approaching those of the USA and Japan (Table 6.6). In 1995, Taiwan's R&D expenditure to GDP was 1.81 per cent, while Singapore spent 1.13 per cent of its GDP on R&D. Furthermore, in 1995, South Korea topped the other NIEs with 156,100 of person years of effort (Full Time Equivalent) on R&D (Table 6.7). Taiwan had 70,100.

Table 6.6 R&D expenditure as percentage of GDP, 1995

USA	2.47
Japan	2.84
South Korea	2.68
Taiwan	1.81
Singapore	1.13
Hong Kong	n.a.
Malaysia	0.32

Source: World Competitiveness Report 1997: 436.

Table 6.7 Nation-wide R&D personnel as full-time equivalent (FTE)*, 1995

	(*000)
USA	949.2
Japan	945.8
South Korea	156.1
Taiwan	70.1
Singapore	9.5
Hong Kong	n.a.
Malaysia	6.7

Source: World Competitiveness Report 1997: 437.

Note

* Full-Time Equivalent (FTE) is interpreted as total amount of work done (effort) on R&D by one person in a year.

Problems facing Malaysia in nurturing an integrated semiconductor industry

If the rewards of an integrated semiconductor industry with local participation have proved so large in the case of the first-tier NIEs, why has Malaysia not followed a similar course? The Malaysian government has demonstrated its interest in promoting rapid industrialization, and has explicitly declared, in its "Look East" policy, a desire to emulate the success of Japan and South Korea. Though the semiconductor industry began a decade later in Malaysia than in these first-tier NIEs, it is well past the age at which South Korea and Taiwan began aggressive moves to upgrade the industry. The limitations of semiconductor industry development in Malaysia thus pose a major puzzle. What has prevented the type of upstream integration and indigenous participation seen in other East Asian industrialization? In this chapter, two major factors that have constrained Malaysia's efforts to promote the semiconductor industry are discussed: ethnic constraints and a poor human resource base.

Ethnic constraints

In Malaysia, since the race riots in 1969, inter-ethnic economic redistribution through the NEP (1971–90) has been viewed as essential to ensure national unity. Though government intervention to expand ownership of business enterprises was very aggressive during this period,[24] the ownership of semiconductor firms by MNCs was left untouched. On the contrary, as mentioned above, the government has been very generous to encourage them to invest in the country, to generate jobs and earn foreign exchange. Furthermore, no indigenous entrepreneurs were interested in this industry during the 1970s and early 1980s as they lacked the necessary know-how, human resource, technology or market access.

Starting from the 1980s, however, the situation has changed. As discussed above, some ethnic Chinese became sub-contractors for MNCs through networks built during their employment with semiconductor firms, as well as related accumulated experience and skill. The ability to become a sub-contractor is an important first step achieved by these indigenous firms, but they have not demonstrated any ability to move further upstream. In the first-tier NIEs, government supports have played an important role in nurturing indigenous firms moving upstream. Unfortunately, little support has been given to this industry in Malaysia. According to Mohd. Nazari (1995), the lack of government support has been because of the low participation of ethnic Malays (Mohd. Nazari 1995:194). As also observed by Rasiah (1993), the federal government was reluctant to give support because the industry was dominated by ethnic Chinese (Rasiah 1993: 137). Since the implementation of the NEP, ethnic considerations have strongly influenced Malaysian industrial policy (Jesudason 1990: 1).

Despite the unfavourable environment under the NEP, Chinese-owned firms managed to survive. In fact, as mentioned above, a few firms grew from small foundries to become suppliers of tools and equipment for semiconductor firms. Apart from their manufacturing capabilities, ethnic Chinese networks between the Chinese managers of semiconductor firms and the Chinese owners of foundries may have been important in this development. With encouragement and technical assistance from the Chinese managers, the foundries managed to produce the equipment needed by the MNCs.

Though the semiconductor industry continues to be dominated by the MNCs today, there are some slowly growing signs of participation by indigenous firms. If the government is serious about nurturing an indigenous semiconductor industry, it is urgent to pay more attention to encouraging indigenous firms. In particular, it will be necessary for the provision of government support to be more performance-oriented rather than ethnic-oriented.

Poor human resource base

Malaysia has mounted strong efforts to increase students' enrolment since independence. Although primary educational enrolments are near universal among the relevant population, the same is not true for higher levels of education. As can be seen from Table 6.8, in 1994, the enrolment ratio was 97.3 per cent at the primary level, 55 per cent at the upper secondary level and only 22.1 per cent at the post-secondary level.[25] Compared with the figures for 1986, there has not been much improvement in the enrolment of students at the upper secondary and post-secondary levels. In 1994, 45 per cent of the 16–17 age cohort failed to continue their education to the upper secondary level, and about 78 per cent of the 17–18 age cohort did not pursue post-secondary education. These school leavers, who dominate the labour market, did not have skills appropriate to Malaysia's current industrial structure. As shown in Table 6.2, Malaysia had only 2.2 per cent of its secondary students enrolled in technical

Table 6.8 Student enrolment ratio at different levels of education (as percentage of the corresponding age cohort) (%)

Level	*1986*	*1994*
Primary	96.6	97.3
Lower secondary	84.9	82.8
Upper secondary	48.3	55.0
Post-secondary and college	16.7	22.1
University	2.3	3.6

Source: 1994 Malaysia Educational Statistics, 1994.

education in the late 1980s. It is not surprising that Malaysia lagged behind the first-tier NIEs in terms of the stock of skilled labour.

Compared with the first-tier NIEs, the enrolment ratio at the tertiary level in Malaysia was even smaller (see Table 6.3), partly because of the small population of students who complete post-secondary education. Furthermore, with limited places offered by the nine Malaysian universities, not many had a chance to pursue university education. Every year, almost two-thirds of eligible candidates are rejected by the local universities (*New Straits Times,* 20 Mar. 1995:12). It is, therefore, not surprising that of the relevant age cohort, only 3.6 per cent were enrolled in Malaysian universities in 1994 (Table 6.8).

Of the total university students, 58 per cent of these students majored in the arts and social sciences, while those majoring in science and engineering comprised 27 and 15 per cent, respectively (*Sixth Malaysia Plan,* 1991). Though efforts have been taken to increase the intake of students into the science and engineering faculties in Malaysian universities, there has been an increasing trend of upper secondary students to avoid science-based education. Only 21 per cent of the total secondary school population choose to study science-based education (*New Straits Times,* 7 Feb. 1996:12). If this trend continues, it will be difficult to reverse the 40:60 ratio of science to arts students, which has been official policy since 1967, reiterated in 1995. Hence, Malaysia will continue to face difficulties in climbing the technology ladder.

With limited opportunities for tertiary education in the country, there has been considerable demand for overseas education by Malaysians. In the early 1990s, the number of students studying overseas was about 70,000. Many students, mostly ethnic Malays, have been sent abroad under government sponsorship. For non-Malays, entrance into Malaysian universities has been limited under the NEP because of the ethnic quota imposed on the intake of students into local universities. As a result of limited places in local universities, an estimated 30,000 to 40,000 non-Malays are studying abroad. Many others who cannot afford to pay the expenses have consequently been denied a chance to receive a university education. The nature of university education in Malaysia has resulted in a severe educated labour force shortage. It has also caused huge currency outflows for overseas education, at about RM2.5bn a year (*Berita Harian,* 19 May 1994: 4).

The poor development of human resources has also jeopardized the supply of researchers, as shown in Table 6.7. Furthermore, only 0.32 per cent of the GDP was allocated for R&D purposes in 1995 (Table 6.6). This modest amount of funding has hardly been effective in enabling any significant technological development since 1 per cent of a country's GDP is generally considered to be the minimum needed (Anuwar 1992:113).

The lack of R&D in the semiconductor industry is to be expected as Malaysia only has assembly and testing operations. The Malaysian Institute of Microelectronics (MIMOS) set up in 1985 is the only relevant R&D institute with the objective of supporting Malaysia's microelectronic industrial technology. It, however, only had an annual budget of RM5m, fifteen engineers and thirty-five technical staff in 1995 (*Malaysian Industry,* October 1995: 18). Hence, it is not surprising that MIMOS could not play as effective a role as KIET in South Korea or ERSO in Taiwan.

From the above discussion, it is clear that by any indicator used Malaysia pales in comparison with the human resource development of the first-tier NIEs. Malaysia's poor human resource base has undoubtedly been a stumbling block in the technological development of the country.

For the last three decades, the government has been encouraging technology transfer from the industrialized countries, hoping that the labour force would absorb advanced technologies. Unfortunately, technological development remains at a low level. The willingness, ability and eagerness of workers to learn, absorb and adapt new technology are crucial but, unfortunately, still not widespread among Malaysians. The prime minister himself has been disappointed with the poor attitude shown by Malaysian engineers in adopting new technology (*The Straits Times,* 20 May 1995:10).[26]

Conclusion

The semiconductor industry has been a driving force in the growth of the manufacturing sector in Malaysia, creating jobs and increasing semiconductor exports. However, in Malaysia, it continues to be foreign-dominated, not very skill-demanding and poorly linked to the rest of the economy.

The semiconductor industry should be restructured to involve greater Malaysian participation in all four stages of production with strong supporting industries established by indigenous firms, to increase domestic value-added and competitiveness of the country.

The first-tier NIEs offer examples for Malaysia to emulate. These economies quickly moved into upstream integration as increases in labour costs eroded their comparative advantage in the more labour-intensive stages of production. Their ability to climb the technological ladder was supported by the government and a strong human resource base, particularly well-trained labour in the science and engineering disciplines. In Malaysia, however, the government has been reluctant to promote the indigenization of the industry because of ethnic considerations in industrial policy against the ethnic Chinese who have shown the most potential for developing the industry. A more formidable obstacle to upstream integration has been the severe dearth of adequate educated human resources. The educational system has obviously not been transformed to cater for high-tech industrialization, while culture does not foster the ability and eagerness to learn technology.

For industrialization to continue to serve as an engine of economic growth, it has to be accompanied by appropriate increases in technological capability. Although Malaysia has been producing semiconductors for the past quarter century, the accumulated indigenous technological capability remains modest. Without a strong scientific and engineering human resource base, the development of the semiconductor industry will continue to be an "ersatz" industry.

Notes

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1 In 1985, oversupply of semiconductors resulted in a price drop of about 50 per cent and nearly 64,000 workers were laid off world-wide (Forester 1993: 45).

2 In 1986, Japan caught up with Malaysia and became the biggest exporter of semiconductors to the USA. Since then, Malaysia has remained in second place (see *Electronic Market Data Book*, various issues).

3 Since about 70 per cent of the semiconductor devices produced in Malaysia are integrated circuits (ICs), the semiconductor firms discussed in this chapter are mainly IC manufacturers.

4 Rasiah (1988b: 97) described the growth of this industry as "accommodative growth".

5 Employment Act 1955 forbids the employment of women from 10pm to 5am daily.

6 For instance, in the first six months of Japanese fiscal year 1995, outward Japanese foreign direct investment increased by 25 per cent. Of this amount, the amount invested in Malaysia dropped by 27 per cent (*Financial Times*, 6 Jan. 1996: 10).

7 Carsem was set up in 1985. It is a subsidiary of a listed company, the Hong Leong Group. Unisem was set up in 1992. Globetronics was also set up in 1992, with 30 per cent equity held by Malaysian Technology Development Corporation (MTDC).

8 DRAM chips are one of the memory devices which require that the stored information be electrically refreshed periodically. They are largely used in the main memory of computer systems and account for about a third of the world semiconductor market.

9 A micron is one millionth of a metre.

10 Information obtained from a personnel manager of a MNC.

11 SEH or Shin Etsu Handotai of Japan is a major supplier of silicon wafers to American and Japanese semiconductor firms. It produces 4-, 5-, 6- and 8-inch wafers, and has 25 per cent of the world market share (*Semiconductor International*, February 1995).

12 In 1987, Intel and NS wanted to set up wafer fabrication plants in Malaysia. However, it was reported that due to the small user market in the region, both plans had been indefinitely postponed (*Far Eastern Economic Review*, 7 Sept. 1989: 99).

13 This fabrication plant, costing RM112m, is located in Malaysia Technology Park at Bukit Jalil, Selangor. It has successfully produced Malaysia's first prototype semiconductor in May 1997 (*The Star*, 8 May 1997).

14 The Hualon Corporation of Taiwan will invest RM2bn in wafer fabrication in Kulim High-Tech Park (*New Straits Times*, 13 Mar. 1996: 6).

15 Since 1990, foreign firms must have a minimum of 50 per cent of local material input after three years of operation in order to qualify for certain tax incentives.

16 As most semiconductor firms are located in free trade zones, they are required to export 80 to 100 per cent of their output. Domestic sales of their output are only allowed with the approval of the government and are treated as imports.

17 DRAM chips are typically distinguished according to the number of bits of information a chip can hold. A 64K DRAM chip can hold 64,000 bits of information, while a 1M DRAM chip can hold one million bits of information.

18 A gigabit chip can hold one billion bits of information.

19 In terms of design and manufacture, semiconductors can be divided into three categories: standard chips, custom chips and semi-custom chips. Standard chips are mainly designed and produced by large firms with high capital- and technology-intensive activities. ASICs are customized or semi-customized semiconductors which allow the users to specify design closely in order to add special features to the products. Since these chips are made-to-order, the quantity needed is normally small.

20 With the collaboration of the government, TSMC was set up in 1987 as a joint venture involving the government (49.0%), local entrepreneurs (23.5%) and Philips of Holland (27.5%). With access to Philip's state-of-the-art technology, it produced ten thousand wafers a month, with a line width down to 1.5 microns and a yield of 1.5 to 2.5 defects per square inch, compared to a Japanese average of 0.8 to 1.5 defects per square inch (Wade 1990: 105).

21 The Hong Kong government has been uninterested in supporting the upstream integration of the semiconductor industry (*South China Morning Post*, 17 June 1984).

22 Samsung was the biggest beneficiary of government assistance. In 1989, it produced 4M DRAM chips which then posed as a rival to Toshiba, the world leader. The colossal investment needed for this was reflected in its debt/equity ratio of 7:1. Since much of the debt was in the form of bank loans, and since the government still controlled the banking system, it is certain that the government was heavily involved in facilitating Samsung's 4M DRAM strategy (Wade 1990: 317).

23 Today, the Submicron Laboratory is a private consortium comprising ten partners, including TSMC, and renamed Vanguard International (*Far Eastern Economic Review*, 9 Feb. 1995:57).

24 The NEP targets were that, by 1990, ethnic Malay corporate ownership would be 30 per cent, non-Malays 40 per cent and foreign 30 per cent, in contrast to 1.9 per cent, 37.4 per cent and 60.7 per cent respectively in 1970.

25 The education system in Malaysia consists of six years of primary education, three years of lower secondary education and two years of upper secondary education. Before tertiary education, students have to go through another two years of post-secondary, pre-university education.

26 Citing the example of the Kuala Lumpur City Centre project, the prime minister said Malaysian engineers involved did not want to learn the latest concepts in high-rise steel and concrete building technology (*The Straits Times*, 20 May 1995: 10).

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7

FIRMS, POLITICS AND POLITICAL ECONOMY

Patterns of subsidiary–parent linkages and technological capability-building in electronics TNC subsidiaries in Malaysia*

Norlela Ariffin and Martin Bell

Firms established in developing countries through foreign direct investment (FDI) are frequently viewed as providing little or no support for significant technological development in the host economy (e.g. Lall 1992; Westphal *et al*. 1985), and this view has also been widely held in Malaysia (Anuwar Ali 1992, 1993; MIER and DRI/McGraw-Hill 1996).[1] More specifically, two general perspectives have been widely held. First, subsidiaries of foreign transnational corporations (TNCs) are thought to have little or no independent capabilities for technological innovation (Lall 1995; Ostry and Harianto 1995; Guyton 1994). Second, they are often criticized for generating few technological externalities or "spillovers" to local firms (Lim and Pang 1991:107–18; Lall 1994; Hamzah and Ismail 1993). This chapter addresses the first of these two generalizations by reporting on part of a study which aims at understanding the process by which TNC subsidiaries in Malaysia's electronics industry, an industry led by FDI, have built up (or failed to build up) their technological capability to innovate and improve products and processes.

The focus of the chapter is on the role of subsidiary–parent relationships or "linkages" in building TNC subsidiaries' innovative technological capabilities in a developing country. Most studies on inter-organizational links in the innovation process such as Lundvall (1988, 1992) on "user–producer" interaction, Raffa and Zollo (1994) on "in-firm/out-firm" relations, and Gupta and Govindarajan (1994) on parent–subsidiary knowledge flows presume the presence of intra-firm innovative capability as the basis for the interactions that occur. Consequently, while they are relevant to the context of developed countries, where those capabilities have already been substantially created in industry, they have less relevance in the context of developing countries like Malaysia where, as a major component of the process of late industrialization, significant innovative capabilities in industry still have to be built up.

This chapter investigates several questions. What roles (if any) were played by subsidiary–parent links in building up technological capabilities within electronics TNC subsidiaries in Malaysia? What kinds of relationships, or "linkages", between TNC parents and their Malaysian subsidiaries contributed to developing those technological capabilities? How have these linkages evolved over time, and what has been the impact on subsidiaries' technological capabilities? In addressing these questions, this chapter adds to the growing body of literature on firmlevel technological development in Malaysia (e.g. Hobday 1996; Bell *et al.* 1995; UNDP 1994; MASTIC 1994, 1996; Rasiah 1993, 1994).

The first section of this chapter reviews common arguments about technology development within foreign TNC subsidiaries in Malaysia. Based on in-depth interviews with twenty-five large TNC subsidiaries in the electronics industry in Malaysia, the next section presents evidence about different patterns of subsidiary-parent linkage and capability development in the subsidiaries. A detailed case study analysing the process of building these linkages and technological capabilities is presented in the following section. This also illustrates the point that learning links running from parent to subsidiary may be reversed, and variations on such reverse learning links are described in the penultimate section. Finally, the broad patterns of linkage and capability development are summarized in the final section, which draws general conclusions from the empirical analysis.

Common arguments about technological development of TNC subsidiaries in Malaysia

Over recent years, most of the growing body of studies of the technological development of TNC subsidiaries in Malaysia appears to have reinforced general perceptions that were already evident soon after the rapid acceleration of inward foreign investment in the 1970s. Three of these general perceptions are outlined below:

(1) *TNC parents control core technologies and higher value-added production stages, while their subsidiaries are involved only in labour-intensive operations for final assembly and build up little or no innovative capability.*

Many writings attribute Malaysia's strong economic and industrial growth to foreign direct investment (FDI) by TNC subsidiaries leading the growth of manufacturing exports (Hobday 1996; Okamoto 1994; Urata 1994; Kawai 1994; Natarajan and Tan 1992). However, an important debate has asked whether this development and growth can be sustained in the long run (Lall 1994, 1995; Anuwar Ali 1992; Jomo and Edwards 1993; O'Connor 1993). Long-run sustainability necessarily involves a significant technological dimension. This is typically seen as requiring continuing advance through progressively higher value-added products and production stages, together with the development of local innovative capabilities needed to provide a strategically independent basis for generating that advance.

In that context, industries established through FDI are generally viewed as operating mainly on the basis of TNC parent control over core technologies which restricts their subsidiaries' advance into higher-value types of production – frequently limiting them to labour-intensive operations for final assembly. Any advance that is made is seen as depending very largely on foreign capabilities with little local development of technology and even less contribution being made to the development of local innovative capabilities (MIER and DRI/McGraw-Hill 1996: 12, 15–19, 113; Lall 1995; Anuwar Ali 1992:79–80, 162). Detailed research supporting this view includes Guyton's (1994) study of forty Japanese consumer electronic subsidiaries in the Klang Valley and Johor. This found little technological development in the production process (in particular, low levels of automation), limited product complexity (mostly assembly operations) and little product design activity, since most product designs originated from TNC parents. Other authors report little "technological deepening" from basic production capabilities into product design and R&D (Danaraj and Chan 1993; Yamashita 1991; Lall 1995; MIER and DRI/McGraw-Hill 1996: 15–19, 114).

On the other hand, a slightly different picture has been suggested by a number of studies in the last two or three years. For example, in their case studies of twenty-six TNC subsidiaries in various industries, Anuwar and Wong (1993) reported that electronics TNC subsidiaries had significantly increased their levels of automation after around 1986, and that productivity had increased considerably. Similarly, a UNDP study of thirty-five electronics subsidiaries in Penang found a high level of technology in the production processes, particularly in US subsidiaries in the semiconductor sub-sector (UNDP 1994: 44–8, 174–9). Such studies have, however, indicated significant technological advance only in the products and processes of electronics subsidiaries, not in the development of their capabilities to generate the technology incorporated in those products and processes. For instance, the UNDP study of TNC subsidiaries in Penang explicitly suggests that their core product design and design engineering capabilities were low. Similarly, in his studies of sub-contracting and parent-subsidiary links in TNC subsidiaries and local tool and machinery firms in the late 1980s, Rasiah notes their positive role only in contributing to the development of production capability in local sub-contracting firms and their subsidiaries (Rasiah 1993, 1994).

More recently, fragmentary information about the development of innovative technological capabilities has become available. However, much of this relates to the very "visible" experience of only two firms (Intel and Motorola), which were often described as "exceptions" from which one should not derive generalizations about the technological role of TNC subsidiaries. Hobday (1996) provides a step towards such generalization by presenting evidence of significant production-related innovative activities and capabilities, while agreeing that TNC subsidiaries did not conduct core R&D activity such as basic research or primary design for new products. This may explain why survey data about innovation in industry indicate a higher level of activity than is suggested by data about their R&D.[2] However, it does not provide a clear and convincing picture that counters the general perception that TNCs typically develop only limited innovative capabilities in their Malaysian subsidiaries. His model of TNC subsidiary "technological positioning" should therefore be primarily seen as a useful guide for further analysis.

(2) *TNC parents from different home countries differ in the "depth" of know-how and technology they transfer to their subsidiaries. For instance, US TNCs are more likely than Japanese TNCs to deepen their technological investment and shift into higher technology products.*

Several studies have contributed to this comparative perspective. On the one hand, Japanese TNCs have been identified as making especially limited contributions to Malaysian technological development. For instance, Guyton (1994), Capannelli (1994) and Ostry and Harianto (1995) draw four conclusions about Japanese TNCs in Malaysia: (a) they have not broadened their technology sourcing (acquiring all technology from the parent firms); (b) they have not deepened the technological content of their process investment (e.g. low capital intensity and low automation levels); (c) they have not shifted into higher technology products (e.g. relocation of the production of only lower technology-intensive household and consumer electronics products); and (d) they have developed only very limited technological capabilities in their subsidiaries; and core technology remains in parent firms, with little R&D being undertaken by subsidiaries. Similarly, a survey of 144 Japanese firms by the Japanese Chamber of Trade and Industry of Malaysia (JACTIM) indicated that the highest ranked degree of technology transfer occurred in simple manufacturing technology, and the lowest degree in development technology (*Certified Management Digest,* October 1994: 30–1). US TNCs, on the other hand, have been viewed as contributing more positively to technological development within their Malaysian subsidiaries, and in sharing technology with their local suppliers/vendors (Palacios 1994; Rasiah 1994; Lai 1992, 1993; P. Lim 1992; Chan 1994).

Top Malaysian government officials and businessmen have also criticized Japanese TNCs for being reluctant to transfer technological capabilities to their off-shore subsidiaries and joint-venture partners. During the deputy prime minister's visit to Japan in 1994, he criticized "Japan's failure to transfer technology to Malaysian firms at a faster rate", and told Japanese top businessmen to draw up "greater and concrete steps for research and development" (*The Star*, 2 Sept. 1994). During the seventeenth annual joint conference of the Malaysia–Japan Economic Association (MAJECA) and Japan–Malaysia Economic Association (JAMECA) in 1994, senior Malaysian delegates criticized their Japanese counterparts on the issue of technology transfer. In response to the prime minister's expressed concern over the reluctance of Japanese corporations to impart technology know-how to Malaysians, e.g. in the automobile industry, JAMECA's president, Masami Iisi, replied that the Japanese firms' approach to technology transfer was different in that it was implemented in a step-by-step manner, and "slow but steady". Using the localization of management control as an indicator of technology transfer, MAJECA's vice-president, Azman Hashim, stated that Western firms transferred technology at a much quicker pace than Japanese firms – as indicated by the large number of Malaysians in top management in Western firms, which was not the case in Japanese firms. JACTIM replied that the assessment of technology transfer was dependent on how it was defined by different parties (*New Straits Times,* 28 July 1994). Anuwar and Wong's (1993) case studies of twenty-six foreign TNC subsidiaries also found that US and European subsidiaries had more Malaysians in next-in-line senior management positions while Japanese TNCs retained a higher proportion of expatriates at the senior level.

This comparative perspective has led to policy implications in, for example, the Second Industrial Master Plan (1996–2005), where a prescribed "MNC/FDI strategy" is for Malaysia to "direct its promotion efforts towards MNCs of those countries deemed relatively generous on technology transfer" (MIER and DRI/McGraw-Hill 1996: 114–15).

(3) *Government policy should aim to accelerate the pace at which TNC subsidiaries move from simple assembly/production activities into R&D.*

The Malaysian government's current industrial development strategy embraces encouraging technological development within TNC subsidiaries. Over recent years, it has prescribed policies to enhance what Hobday (1996) calls TNC subsidiaries' "technological positioning" within their parents' global networks by shifting from assembly/production operations to design and R&D functions. Thus, TNC subsidiaries have been encouraged – through government pressure and incentives – to move along this path as rapidly as possible, e.g. by establishing R&D centres, regardless of length of operation in Malaysia, the products they manufacture, and their national origin (MITI 1994). For the Second Industrial Master Plan (1996–2005), there has been a move to encourage TNC subsidiaries to take on a more comprehensive role to include R&D, distribution, purchasing and marketing functions by establishing operational or regional/world headquarters (OHQs) or integrated manufacturing facilities. Currently, OHQ incentives include provisions for a concessionary tax rate of 10 per cent for five years, with a possible extension of five years. As a result, ten OHQs have now been established (MIER and DRI/McGraw-Hill 1996).

While these three types of argument are persuasive and widely held, there are several problems with the underlying empirical evidence. In particular, most studies of the technological behaviour of TNC subsidiaries in Malaysia – as elsewhere – have been constrained in four important ways.

First, with few exceptions (e.g. Hobday 1996; Bell *et al.* 1995), they have focused on the characteristics and behaviour of firms at particular points in time. They have drawn general conclusions about the dynamics of industrial and technological development from such cross-sectional observations despite the fact that this approach may fail to capture the significance of change over time in both the technological behaviour of subsidiaries and the strategies of parent firms.

Second, most surveys draw conclusions about technologically innovative activities in firms using a highly simplified conceptual framework which merely distinguishes between (i) routine production, that is often described as "simple assembly", and (ii) innovative activity, which is usually defined as "R&D" – which is frequently measured by expenditure on, or employment in, R&D. This approach may fail to capture the considerable significance of a much wider range of innovative activities that would not normally be described as "R&D".

Third, technological "development" or "progress" in an industry is typically seen as involving movement along this single dimension from "simple assembly" to "R&D". This conflates two significantly different forms of "progress". One involves change in what is produced and/or how it is produced – e.g. from low to higher value-added products, or from simple to more complex assembly processes. The other involves change in the "depth" of technological activities undertaken – e.g. from (i) producing products (whether simple or complex) to (ii) designing them, and to (iii) developing (perhaps via R&D) the underlying technology.

Fourth, few, if any, studies have been designed in ways that permit identification of the relative importance of the wide range of different variables likely to influence the technological behaviour of TNC subsidiaries. This is partly a matter of the size of the samples examined, which have usually been too small to permit analysis of the significance of such variables as ownership or localization of management, while holding other key factors, such as product and process technology or the age of the subsidiary, reasonably constant. However, it is also partly an issue of the underlying analytical frameworks that often see TNCs as monolithic organizations with invariant global strategies that are simply imposed on subsidiaries, rather than as complex organizational systems with differing and changing strategies within which individual subsidiaries may have significant influence over the roles they come to play (Ghoshal and Bartlett 1993).

The study reported in this chapter attempted to overcome some of these problems. Perhaps the most important aspect of the approach taken here is the explicit concern with dynamics. The research sought to trace the paths of technological development in TNC subsidiaries over as long a period as possible, usually over the entire period since establishment.

Second, the study also uses a relatively fine disaggregation of different types of technological capability. Bell and Pavitt (1993, 1995) have adapted Lall's (1992) framework to first distinguish between routine production capabilities and innovative technological capabilities (see Table 7.1). Routine production capability is the capability to produce goods at given levels of efficiency and with given input requirements which may also be described as technology-using skills,

Table 7.1 Industrial technological capabilities: an illustrative framework

Levels of capability	*Investment activities*		*Capital goods supply*	*Production activities*		*Linkage activities*
	Facility user's decision-making and control	*Project preparation and implementation*		*Process and production organization*	*Product-centred*	
Routine production capabilities: capabilities to use and operate existing technology						
Basic operating capabilities	Engaging prime contractor. Securing and disbursing finance. Officiating at opening ceremony.	Preparation of initial project outline. Construction of basic civil works. Simple plant erection.	Replication of unchanging items of plant and machinery.	Routine operation and basic maintenance of 'given' facilities. Efficiency improvement from experience in existing tasks.	Replication of fixed specifications and designs. Routine QC to maintain existing standards and specifications.	Procurement of available inputs from existing suppliers. Sale of 'given' products to existing and new customers.
Innovative technological capabilities: capabilities to generate and manage technical change						
Basic innovative capabilities	Active monitoring and control of: feasibility studies, technology choice and sourcing, project scheduling.	Feasibility studies. Outline planning. Standard equipment procurement. Simple ancillaries engineering.	Copying new types of plant and machinery. Simple adaptation of existing designs and specifications.	Commissioning and de-bugging. Improved layout, scheduling, and maintenance. Minor adaptation.	Minor adaptation to market needs, and incremental improvement in product quality.	Searching and absorbing new information from suppliers, customers and local institutions.
Intermediate innovative capabilities	Search, evaluation and selection of technology/sources. Tenders/negotiation. Overall project management	Detailed engineering. Plant procurement. Environment assessment. Project scheduling and management. Commissioning. Training/recruitment.	Incrementally innovative reverse engineering and original design of plant and machinery.	Process improvement and 'stretching'. Licensing new technology. Introducing organizational changes (JIT, etc.).	Licensing new product technology and/or reverse engineering. Incremental new product design.	Technology transfer to suppliers and customers to raise efficiency, quality and local sourcing.
Advanced innovative capabilities	Developing new production systems and components.	Basic process design and related R&D.	R&D for specifications and designs of new plant and machinery.	Process innovation and related R&D. Radical innovation in organization.	Product innovation and related R&D.	Collaboration in technology development.

Source: Adapted from Lall (1992).

knowledge and organizational arrangements. Innovative technological capability, on the other hand, is defined as the capability to create, change or improve products and processes; it may be described as change-generating capability, consisting of technology-changing skills, knowledge, experience and organizational arrangements. Then, as indicated in the lower part of Table 7.1, innovative technological capability is further disaggregated into different levels or "depths" – summarized as basic, intermediate and advanced, with only the latter likely to involve the kinds of activity usually described as "R&D".

This framework provides a basis for describing one of the two trajectories of technological development noted above: progress from routine production capabilities to successively greater "depths" of creative and innovative technological capability, running from fairly "basic" levels (e.g. for minor adaptation and incremental quality improvement) through "intermediate" levels (e.g. for various types of product and process design and engineering) to more "advanced" levels (e.g. for developing the knowledge base for new product and process designs). This trajectory should be distinguished from the other involving progress through increasingly complex and higher-value products and processes.

TNC subsidiary–parent linkages and technological capability building

Method and sample

In this section, patterns of subsidiary–parent linkages will be related to technological capabilities of TNC subsidiaries in Malaysia's electronics industry. A sample of twenty-five large TNC subsidiaries mainly located in Penang and the Klang Valley, areas with the greatest concentration of electronics firms in Malaysia, were selected from a 1994 UNDP database of electronics and supporting firms in the Klang Valley (compiled from MIDA and JETRO directories) and the Penang Development Corporation directory (PDC 1994). Primary data were gathered through face-to-face interviews with top management (managing director/ production manager) and product development/R&D/design/engineering department managers, site visits to actual production and innovation processes, and observations of products and product innovations in these firms. In-depth interviews and plant visits were held between September 1994 and February 1996 in collaboration with UNDP Kuala Lumpur, the World Bank and the Ministry of Science, Technology and the Environment, Malaysia (MOSTE). The interview guide approach was used where topics and issues to be covered were specified in advance (Patton 1990: 288); a questionnaire was also sent before or after the interview.[3] Firm publications (reports, brochures, books) and video presentations obtained during these visits provided valuable archival information about these firms. Information about parent home country and location of the sample is shown in Table 7.2 below,[4] and further details about the firms are provided in Appendix 7.1.

Typology of TNC subsidiary–parent linkages

As the existing literature assumes a single unitary model of relations between TNC subsidiaries and parent firms, it does not capture the range of relationships identified in this research. In particular, most models focus exclusively on the production roles played by subsidiaries and parents, and ignore the technological dimensions of their interaction. We therefore provide a new typology for understanding technology-related links between firms, particularly in the context of late industrialization. Our approach involves two important distinctions.

First, links which are primarily concerned with market transactions for goods and services are distinguished from links centred on inter-firm collaboration in innovation. In much of the innovation-related analysis of user-producer links in industrialized countries, and in the associated analysis of technology-centred interactions running along supply chains in those economies, these two kinds of relationship may overlap, but may also be quite independent. On the one hand, for instance, innovation-centred strategic alliances may be developed between firms that are not involved in significant supplier–customer relationships. On the other hand, an enormous number of inter-firm relationships involve market transactions in goods and services with no associated collaboration in innovation.

The second distinction is between (i) links primarily based on the use of existing capabilities which firms already possess, and (ii) links which contribute significantly to creating such capabilities. The first may occur between parent firm and subsidiary, for instance, when market transactions for goods and services involve little or no associated skill and knowledge transfer that enhance the pre-existing technological capabilities in subsidiaries. On the other hand, links with TNC parents may involve substantial flows of knowledge and skills to help create new

Table 7.2 Sample of TNC subsidiaries

Malaysian location	*Number of TNC subsidiaries by TNC parent home country*		
	US/Europe	*Japan/Taiwan*	*Total*
Klang Valley	n = 3[a]	n = 11[b]	n = 14
Penang	n = 8	n = 3[c]	n = 11
Total	n = 11	n = 14	n = 25

Notes

a Philips-JVC Video Malaysia, a subsidiary of Philips and JVC, has been classified in this category since the production operations were under the responsibility of Philips, and the acting MD was from Philips.

b Two Sony plants are included in this group,

c Another two Sony plants are in this group.

capabilities in subsidiaries – either new production capabilities (as in many licensing agreements) or new innovative technological capabilities.

As indicated in Table 7.3, these two sets of distinctions can be combined to yield four types of parent–subsidiary link. This typology of subsidiary–parent linkages, summarized in Table 7.3, provides the framework for examining the experience of the sampled twenty-five TNC subsidiaries in Malaysia in the next section.

The fact that these different kinds of relationship frequently overlap has been suggested in a growing body of literature. In particular, as explored in detail by Hobday (1995) in the case of the electronics industry in East Asia, inter-firm links that are primarily concerned with market transactions and the use of existing production capabilities in latecomer firms (MP-Links in Table 7.3) may also involve significant knowledge flows that help to create new technological capabilities. However, much of the evidence about such learning components of market links is about arm's-length subcontracting and OEM-type relationships, rather than TNC subsidiary–parent links. Also, it is not clear whether such learning links only contribute to building up new production capabilities in latecomer

Table 7.3 Typology of TNC subsidiary–parent linkage

	Links centred on market transactions in goods and services	*Innovation-centred linkages*
	MP-Links	I-Links
Capability-*using* Links	In these *marketing/production* links, interactions between firms is a purely marketing relationship involving the sale of goods and services derived from the use of existing production capabilities, and involving no significant elements designed to create or enhance these capabilities.	In these *innovation* links, interaction is the source of innovation. Here, firms already have innovative technological capabilities, and they collaborate in using these to innovate, usually involving collaborative research, development and design for new products and processes.
	LP-Links	LI-Links
Capability-*building* Links (Learning Links)	These *learning-for-production* links are used by firms to create or enhance basic production capabilities. Usually, one of the firms draws on the other to build up a basic capability to produce particular products, to use particular processes, and/or to master specific managerial and organizational practices.	Through these *learning-for-innovation* links, firms build up new basic and intermediate level innovative capabilities. This may involve training and formalized experience acquisition, together with less formally organized learning through reverse engineering and incremental improvement.

firms (LP-Links in Table 7.3), or whether they also enhance those firms' innovative technological capabilities (LI-Links in Table 7.3). The first of the generalizations outlined earlier suggests that the latter is unlikely, but the evidence in the next section suggests a rather different conclusion.

Diversity in the patterns of subsidiary–parent linkages

This section describes different patterns of linkages between the sampled subsidiaries and their TNC parents. It gives particular emphasis to the dynamic processes by which these linkages have developed over time.

Pattern 1: Pure marketing/production links

The generalization that subsidiaries are only involved in final assembly/production often conjures the picture that TNCs' subsidiary–parent relations are wholly centred on the production and sale of goods from the subsidiary to the parent (MP-links). This assumes that TNC subsidiaries would assemble production capabilities already available in the host location, add little further knowledge or skill to those capabilities, and just use them to meet parent firms' market objectives.

None of the subsidiaries examined in this study fell into this category, which is not surprising. In an industrializing country like Malaysia, a TNC subsidiary usually starts operations without internal basic production capability adequate for international competitiveness, and this capability needs to be built up before stable production for export is achieved. Thus, in most TNC subsidiaries in Malaysia, the relationship with the parent is initially centred on learning-for-production involving significant LP-links.

Pattern 2: Learning-for-production links

Among the cases examined in this study, the LP linkage between parent and subsidiary never consisted of a single, one-off transfer of technology to initiate production. In all the cases, this type of link continued repetitively after the subsidiary had begun initial volume production. The main objective of these successive LP-links was to build up a subsidiary's production capabilities, so enabling it to produce a wider variety of products, or more complex products, or to use progressively more advanced technology in its production processes.

The building of production capability through LP-links was observed in all TNC subsidiaries regardless of location or national origin. During initial operations, engineers were sent to the parent facilities to be trained (usually returning to train others in the Malaysian subsidiary) and/or engineers from the parent were sent to Malaysia to train local personnel. The focus of the interaction was to assist subsidiaries in learning technical aspects of particular items of equipment, broader aspects of production processes and their organization and/or product characteristics and requirements. The objective was to ensure that the subsidiary acquired the necessary operational knowledge and skill.

But even after the subsidiary had established a stable production and market relationship (an MP-link), with large volumes produced and shipped out from the subsidiary, the learning/training link was repeated every time a new product (fully developed by the parent) or a new item of more advanced equipment was introduced in the subsidiary. Through these repeated cycles of learning/training and production interactions, many subsidiaries have been able to build substantial production capabilities. The type of production capability which subsidiaries learnt varied with each firm's production strategy. There were at least two quite clear variations on this general pattern.

In principle, the first variation involves a subsidiary successively expanding into a wider range of products. But the technological complexity of these products does not advance significantly with such progressive diversification. This pattern (illustrated in Figure 7.1) conforms quite closely to the argument noted earlier about foreign TNC subsidiaries typically contributing little to the introduction of increasingly "advanced" product and process technology. In practice, however, only one of the twenty-five firms in the sample could be classified in this category – Sharp-Roxy Appliances. This firm operated one of the four Sharp (Japan) plants in Malaysia, and assembled an increasing variety of products ranging from television and audio/video products to household electrical and electronic products like refrigerators, washing machines, vacuum cleaners and gas cookers, primarily for the domestic market. However, the experience of this particular Sharp plant in diversifying across a range of products with "similar" levels of technical complexity was not representative of the experience of the Sharp group in Malaysia

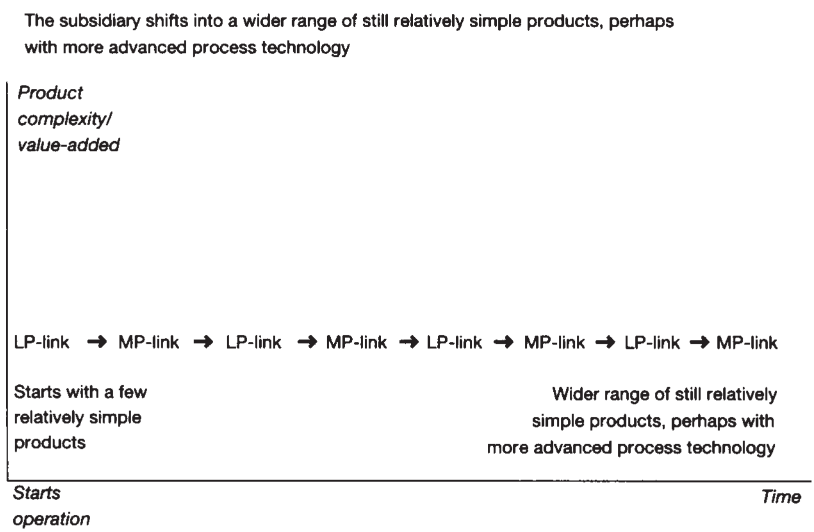

Figure 7.1 Pattern 2: learning-for-production – variation (a)

as a whole. Since the first Sharp plant was established in 1974, the product base of the whole Sharp group has not only broadened but also increased in complexity and value-added, moving, for example, from the assembly of transistor radios and cassette recorders to the production of audio mini-discs and compact-disc pickups.

Also, although the product base of Sharp-Roxy itself has not increased in complexity, as compared to other sister plants, the firm has acquired strong capability in local parts sourcing and overseeing local vendor development for the whole Sharp group in Malaysia. This capability led, in 1995, to the establishment of a technology centre for international parts procurement and for parts servicing. This example partly points to the importance of distinguishing between the two different trajectories described in the previous section.

In the second variation on this pattern, subsidiaries expanded into more complex, higher value-added products. However, they did so by drawing the necessary technology from their parent firms, rather than from their own innovative capabilities. Thus, the pattern (illustrated in Figure 7.2) still conformed quite closely to the argument about subsidiaries relying almost entirely on TNC parents for their new technology, with the parent doing little to build up local innovative capabilities to supply such technology. Nevertheless, the cumulative advance in product and process complexity can be very significant.

Many subsidiaries started from the assembly of parts to full assembly of complete products, and from full assembly of simple products to full assembly of more complex, higher value-added products: for example, from simple telephones to facsimile machines in Centronix, from radios to hi-fis in Grundig, and from simple semiconductor assembly to more complex electronic automation

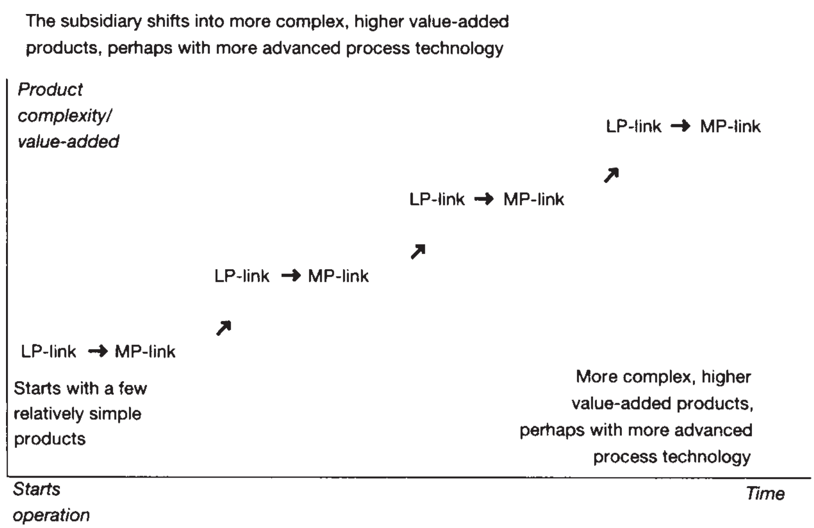

Figure 7.2 Pattern 2: learning-for-production – variation (b)

transponders and custom manufacturing services in Texas Instruments. In many cases, such advances in product technology were part of broader patterns of production relocation undertaken by TNC parents. In many cases, Malaysian production was being technologically upgraded as simpler and more labour-intensive products were being relocated from Malaysia to lower-labour-cost countries such as China. Some TNC subsidiaries have also been relocating the assembly operations of simpler products or parts like printed circuit boards (PCBs) to local firms. For example, Intel transferred its lower-end integrated circuits (ICs), like ceramic dual in-line packages, to Globetronics while Motorola transferred the assembly of its radio accessory products and PCBs to Bakti-Comintel. This strategy reduces MP-links with the parent in individual products and transfers them to local firms.

This progressive upgrading of product complexity has been striking in the more recent relocation of some of the world's largest disk-drive assemblers and hard disk manufacturers like Conner, Seagate, and Quantum in disk-drive assembly, Read Rite in heads manufacturing and head stack assembly for disk drives, and Komag in thin-film magnetic (hard) disk manufacturing. These firms have shifted from simple to complex production and assembly activities using advanced robotic production processes and rigid "clean room" specifications. Consequently, although the sampled subsidiaries in this sector were all following a "learning-for-production" strategy, they usually employed very high levels of operating skills. For example, Komag had no operators, and more than 90 per cent of its staff were technicians and engineers, with high computer and engineering skills who run production, conduct statistical process control and maintain large complex equipment. Around 70 per cent of its production processes were automated, with some 400 robots and large automated equipment. As an illustration of the high level of value-added in production, Komag (Penang) transformed a piece of aluminium costing US$ 1.40 into a product which it sells for about US$10. The relocation of the disk-drive industry has also encouraged other existing TNC subsidiaries, like Western Digital, to shift their product base into disk-drive assembly and to transfer semiconductor (IC) assembly and testing to a local subcontractor (*New Straits Times*, 11 Oct. 1994), and has encouraged its customers, e.g. personal computer makers like Dell Computers and Packard Bell, to establish production in Malaysia (*New Straits Times*, 2 Nov. 1995).

In several cases, the patterns of change were more complex, suggesting that considerable care is needed in interpreting observations of single steps, some of which might even appear to be moving "backwards". For example, Sony expanded its capital investment from one to five production plants producing audio/television products and components, where the latest facility assembles floppy disk drives. However, among the different Sony plants, there were considerable differences in firm behaviour in terms of changes in the production processes used. Some plants shifted towards increased automation while others enhanced manual assembly depending on the products' characteristics. For instance, two plants used surface mount technology to mount chips in CD-ROM and VCR products, and have the largest number of auto-insertion machines (100–256) for PCB assembly. The plant assembling floppy disk drives had the most advanced automation in the group. Interestingly, the plant producing colour televisions (CTVs) has shifted from mechanical conveyor lines and automated insertion to skilled and flexible one-person manual assembly as it began to produce large CTVs (34 inch) which, though involving higher value-added, have large and irregularly-sized parts. Interviews with process design engineers revealed that this move was not a regression in production technology, but rather, a deliberate move away from fixed automation to improve process efficiency in small-lot batch production. The shift to multi-skill manual assembly was an attempt to develop a more flexible response to the rapid introduction of new models by the parent.[5]

The complexity and long-term dynamism of these learning paths are indicated by the fact that many of the subsidiaries moved beyond the point of depending totally on LP-links with their parent firms for the technology incorporated in their products and processes. For instance, drawing on "learning-for-innovation" links, the Sony CTV plant in Klang Valley was designated the Asia CTV Design Centre in 1991; and the Sony Electronics (audio) plant in Penang established a successful R&D Centre in 1990 through which it collaborates in new product development with parent and sister firms in Japan and Singapore. Thus, although these plants assemble lower-range products (televisions and audio products) compared to the other sister plants producing CD-ROM and floppy disk drives, they have added basic/intermediate innovative capability in product design and development to their basic production capabilities.

To sum up, twenty-four of the twenty-five subsidiaries followed a strategy of drawing on their parents' technology through LP-links to introduce increasingly advanced product and process technology. Thus, contrary to the generalization noted earlier about foreign TNC subsidiaries, almost all subsidiaries in the sample studied have shifted into more complex, higher value-added products and processes. Among these twenty-four subsidiaries, seventeen had progressed beyond this "learning-for-production" pattern by the time of the interview. Like the Sony subsidiaries noted above, they had moved into the development of links concerned with learning-for-innovation and with collaboration in actually undertaking innovation. Consequently, only seven of the twenty-five subsidiaries fell exclusively into the "learning-for-production" category at the time of the interview.[6] There were no significant differences between them in terms of the nationality of the parents or location in Malaysia: four had parents in Japan/Taiwan and three in US/Europe, with three subsidiaries located in Penang and four in the Klang Valley. All these cases involved relatively young subsidiaries, with all seven starting operations after 1988. In terms of products, three were in the disk drive sub-sector, two in consumer electronics and one in semiconductors.

Pattern 3: Learning-for-innovation links

As noted above, seventeen of the subsidiaries in the sample (68 per cent) had added an innovation dimension to their learning-for-production and production/marketing relations with TNC parents. They had drawn on learning links with their TNC parents that had been explicitly concerned with strengthening their innovative technological capabilities. This involved deliberate efforts to acquire innovative capabilities through training at parent R&D facilities (usually three months to a year), and through learning, with parent development/R&D staff being seconded to their own newly established design or R&D centres to assist in undertaking a series of smaller and short-term product development, process or equipment innovation projects.

In all cases, these learning-for innovation links have not been one-off arrangements. They have been repeated in patterns that have taken subsidiaries through cumulative steps of incremental learning. In these patterns, repeated cycles of learning-for-innovation involved interactions aimed at developing capabilities to innovate in capital equipment, processes and production organization, and/or products in the subsidiary. For example, in product innovation activities, these cumulative learning paths have moved from projects starting with mechanical, electrical, PCB, and cosmetic design to more complicated product technology (e.g. software development); from parts design to full product design; or from development of simple product models to more complicated models.

However, firms diverge in terms of whether they began building innovation capability in capital equipment, process and production organization, or product design and development, or a combination of these activities. Not all TNC subsidiaries follow (or plan to follow) the technological positioning path towards product innovation and R&D, just as some simply continue along Pattern 2 to build new production capabilities, or to build other capabilities such as procurement, as in the case of Sharp-Roxy. These evolutionary patterns reflect a subsidiary's focus on building different niche capabilities as part of an intra-TNC strategy, shaped by a variety of factors including the type of product manufactured, type of production activities, parent corporate strategy or subsidiary leadership initiatives.

Some trajectories focused on building niche capabilities to innovate in capital equipment for example, Intel Penang, SEH, Dynacraft and Copal Precision. Others like Motorola Penang, Inventec, Sony TV, Sony Electronics, and recently, Matsushita, JVC, Hitachi and Grundig have focused more on developing product innovation capabilities. For both trajectories, the learning relationship usually involved LI-links with TNC parents in training/learning through a series of graduated innovation projects at parents' R&D facilities and establishing their own R&D centres. For example, Sony CTV's Asia Design Centre carried out product innovation projects in mechanical design, electrical circuit design, and design for manufacturing (cosmetic drawing and basic chassis design were done by the parent) for the different market and customer needs in Asia; while Sony Electronics' R&D Centre in Penang completed the design of the "Discman" product (ASIC design by the parent), with production in China. After achieving basic/intermediate capability in the initial niche activity, depending on the factors mentioned, some subsidiaries then start forming LI-links in other activities, thus building innovative capability in a wider range of activities.

Although the learning links with TNC parents were very important in all these trajectories of innovative capability development, they were never the sole source or mechanism of learning. Initiatives to strengthen innovative capabilities were also implemented independently at the level of the subsidiary, and these played major roles in overall capability development. Indeed, in some cases, independent initiatives provided the origin and impetus for developing innovative capabilities, and LI-links with the parent followed as mechanisms for further strengthening or diversifying the initial, independently developed innovative capability. In other cases, LI-links with parent firms were the initial mechanism for developing innovative capabilities, with independent initiatives then building on the initial impetus to further strengthen and/or diversify capabilities. Regardless of these different origins of innovative learning trajectories, all cases involved some combination of LI-links and independent learning initiatives as the basis for sustaining and diversifying the subsidiaries' innovative activities. Some of the subsidiaries had moved beyond this phase of learning to innovate and had entered into patterns of collaboration in innovation with their parent firms – Pattern 4 reviewed below.

Nine subsidiaries (36 per cent) fell exclusively in this "learning-for-innovation" category (Pattern 3), and had not gone beyond this "learning mode" stage to collaboration in innovation (Pattern 4) at the time of the interview. Of these nine subsidiaries, seven were Japanese/Taiwanese and two were US/European. Four were in consumer products, two in telecommunications, and one in precision parts manufacture. Six were located in Penang and three in the Klang Valley. In terms of length of operation, most (seven) of the subsidiaries had started operations in or after 1988.

Pattern 4: Innovation links

Under this pattern, subsidiaries have progressed beyond Pattern 3, and have acquired intermediate innovative technological capabilities in particular product areas or niche activities, usually demonstrated by their capability to complete larger, more complex or longer-term (2–5 years) projects. At this stage, their design, product development or R&D centres have usually been upgraded into regional or world centres for particular products, or the subsidiaries have been given "world product mandates" in individual product areas. The interactions with TNC parents include not just learning and production activities, but the actual execution of innovation, sometimes resulting in patents,[7] and sometimes, collaborative development and design for new products or processes (I-links).

However, LI-links still continued to build innovative capabilities in new (or different) product areas, new niche activities or new research/technology areas.

Eight subsidiaries (32 per cent) had achieved this stage, of which six were from the US/Europe and two Japanese. In terms of length of operation, all had been operating in Malaysia since the early 1970s (about twenty-four years of operation). In terms of products, four were in semiconductors and components, two in wafer manufacture, one in telecommunication products and one in consumer electronics. Six were located in Penang and two in Klang Valley.

Among these eight subsidiaries, there was considerable diversity in the learning paths by which they built up their innovative capability and in the particular ways in which they then used that capability independently and in collaboration with parent firms. The path followed by one subsidiary, Siemens Penang, is illustrated in Figure 7.3. This German subsidiary manufactures specialized optocouplers and other optosemiconductors for industrial equipment makers. The firm started building LI-links in product-centred activities through the establishment of a product design group in 1986. It soon progressed to undertake medium-term projects (three to five years) developing more complex models; conducting basic design, electrical and mechanical design, equipment design, chemical processes and design for manufacturing, while basic research on compounds and chip design was done by the parent. The beginnings of I-links through joint product development projects with the parent started in 1987, and in 1991 this subsidiary was chosen as Siemen's worldwide Optosemiconductor Centre.

Recently, the firm reorganized its R&D/product development activities within Business Units, rather than in a central R&D department. The motivation for this reorganization was to beat competitors in bringing products to the market in the shortest time. It currently subcontracts assembly/production activities for some products to local firms so that it can concentrate on new product development. Along with building product design capabilities on its own initiative, the firm in 1991/92 began to build innovation capabilities in process technology niches, including production organization and total quality management. It quickly acquired direct material purchasing capabilities and process engineering/ process design capabilities. Interestingly, this has resulted in reverse learning links with engineers from parent and affiliate facilities coming to Siemens Penang to learn about production organization.

Case Study: Motorola Penang[8]

The experience of Motorola Penang since its establishment in 1974 is summarized here to illustrate the complexity of the various interactions in the evolution of technological development through the three patterns outlined above. The firm has cumulatively developed production excellence through LP-links and by accumulating experience. Beyond that, partly through LI-links, it has developed capabilities for product and equipment innovation, and has built up marketing and customer service capabilities to support key areas of product innovation. The

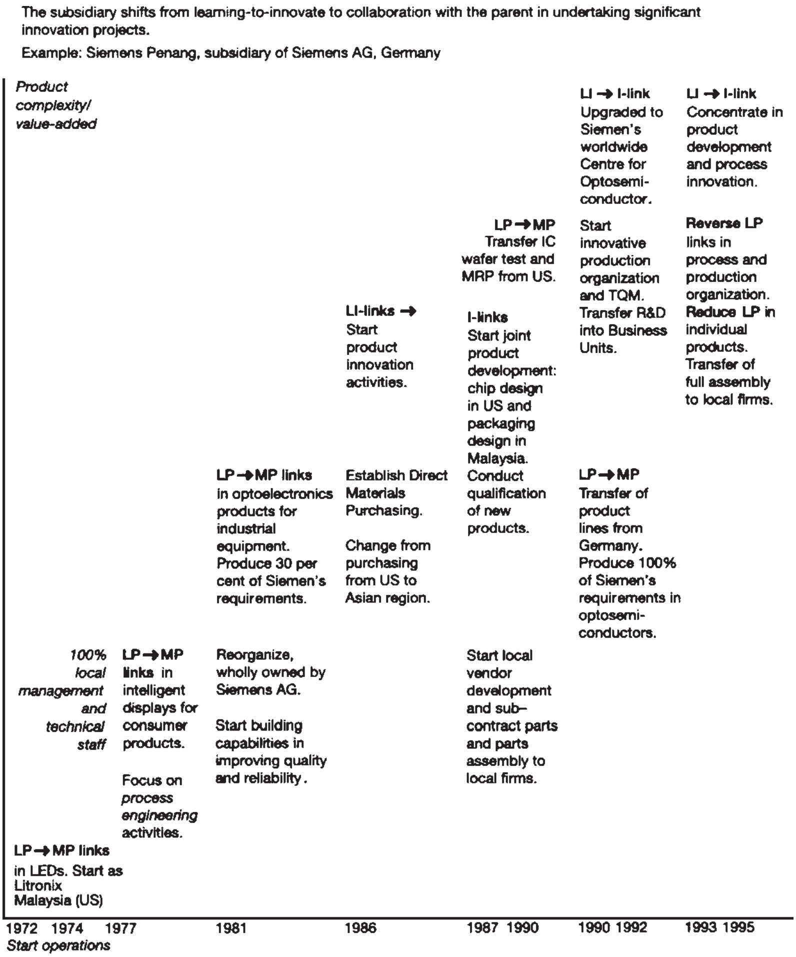

Figure 7.3 Pattern 4: the development of I-links
Source: Derived from the research.

main steps in this sequence and in the evolution of its relationship with its parent are outlined next and summarized in Figure 7.4, while the main sources and mechanisms of learning are briefly reviewed after that.

Main stages in the learning process

Building learning-for-production (LP-links) and production-centred (MP-links) linkages

This TNC subsidiary started operations in Malaysia in 1974 with limited production capability and ten production operators manually assembling hybrid circuits.

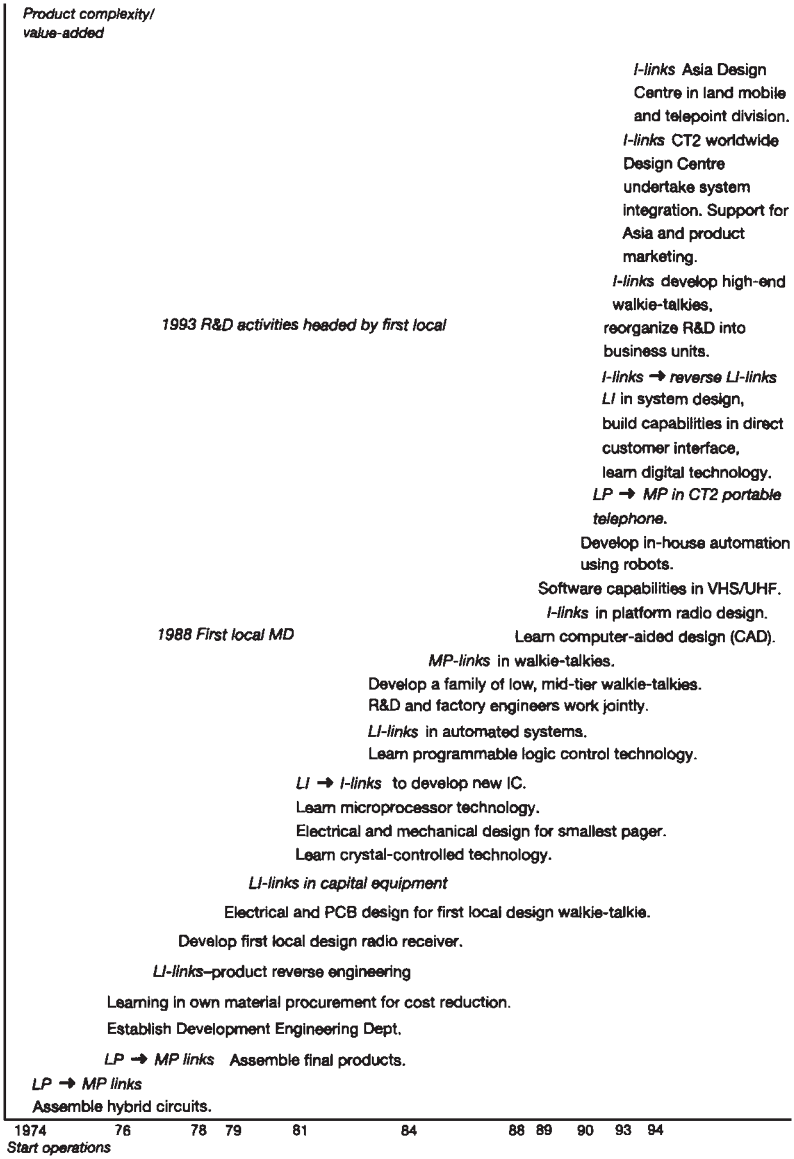

Figure 7.4 Motorola Penang: links and long-run capability development
Source: Derived from the research.

Initially, as in Pattern 2, the subsidiary learnt to manage its production facilities with initial training by managers and engineers posted from the parent firm. The assembly of hybrid circuits progressed into wire bonding and, within a year, manual testing, analysis and repair of the circuits were done locally. Two local engineers were then sent to the parent firm to receive initial training on how to operate computer-controlled testing equipment. Upon their return, the engineers trained others, and with the successful introduction of testing equipment, the subsidiary was able to achieve higher yields and more accurate results. During this initial one-year period, the relationship with the parent firm was centred on learning-for-production (LP-link).

Only after a year, when it had acquired adequate basic production capability, the subsidiary moved from the manufacture of hybrid circuits to include assembly of final products. After the parent firm approved the export of large volumes of its products, the subsidiary established a production/marketing relationship (MP-link) with its parent. The LP-link, however, recurred every time a new product, technology or more complicated equipment was introduced. By 1976, the range of products being manufactured ranged from modules to chip carriers, frame kit sub-assemblies, speakers, microphones, controller boards and complete products (pagers and radios). The main objective was to build the subsidiary's production capabilities as it advanced manufacturing from component production to full assembly. The LP- and MP-links continued through the whole period. For instance, the first portable telephone produced by the subsidiary (the CT2) in 1990 was based on initial designs acquired from the parent. By 1995, products ranged from two-way radios to pagers, battery flexes, portable telephones and systems, and telephone controller terminals.

Building learning-for-innovation-centred links (LI-link)

A learning-for-innovation dimension was added in stages to the evolving process of learning-for-production outlined above. In 1978, the parent firm changed the subsidiary's production-only operation into an organization which would be "world-class" (Chan 1994:89–90) and sent a new managing director (MD) to implement the change. Using intense pressure and by questioning all aspects of the operations, the new MD challenged engineers and workers to come up with original ideas for improvements. Subsidiary engineers and workers were trained to innovate, and not just replicate both process and product-centred activities. Driven by this external initiative, Motorola Penang formed LI-links with the parent, and began to build innovative technological capabilities distinct from production capabilities. The quest to be "world-class" was continued by the other MDs (including the first local MD appointed in 1988) – all of whom had developed under the first MD's tutelage – instilling a culture of "adopt, adapt and improve", teamwork, and learning through sharing with parent and sister firms. One local MD commented, "We cannot often be first with a new technology, but we are persistent in learning from pioneers."

The product-centred dimension of this training and learning process involved a series of challenging design and development projects, of short-term (six months) to medium-term (three years) duration. The development of capabilities to improve the production process was enhanced by setting a series of challenging quality goals which the subsidiary's engineers had to meet by using their own devices. In particular, because importing equipment from US suppliers was too costly and took too long, they had to optimize their existing capital equipment through innovations designed to suit the products being manufactured, and otherwise to increase efficiency as well as reduce lead time and costs. In each new product design and process innovation project, there was incremental learning of new technology.

In the case of Motorola, the innovation-centred learning trajectory was concentrated most heavily on product design and innovation, at least initially. The trajectory then evolved into a phase of collaboration with the parent in product-centred innovation. Process and equipment innovation initially received less emphasis, only becoming more significant for learning after the phase of product-centred learning. These three differing emphases in the learning process are outlined separately below.

Building LI-links in product-centred activities

In 1976, two years after the start of operations, a Development Engineering (now R&D) Department was started with five engineers to "concentrate on developing new products, independently from the parent, for world markets" (Chan 1994: 74). Headed by a Director of Engineering from the parent firm, it initially worked on cost reduction of products developed by the parent. This activity centred on learning to source parts from Asia, and continues presently, as sourcing engineers are also involved in product design. This team first learnt product design through the classic reverse engineering route (by taking apart products developed by the parent and copying selected design features) and undertook its first design project in its second project for 1976. Through further reverse engineering of products developed by the parent (a mobile radio and a pager charger), the firm completed its first Malaysian-designed product in 1978 – a weather alert radio receiver for the US Department of the Environment.

For its third project in 1979, the R&D team did 70 per cent of the electrical design (including PCB design) for its first walkie-talkie, while mechanical design involving thin film technology was done by the parent. In this project, the team was introduced to crystal-controlled technology, and took two years to develop basic models. This learning-for-innovation relationship with the parent (LI-link) during the early years is described by R&D engineers as involving hard work with a lot to be learnt from parent firm counterparts and exacerbated by lagging behind in equipment and technology.

For a fourth project, the team was assigned to do the electrical and mechanical design for the smallest pager world-wide, using microprocessor technology for the first time. Motorola Penang was assigned the project due to its proximity to Japan, from where parts would be sourced, and to shorten lead time to production (development was achieved within a record six months). The chip was developed by the parent IC design team, with input from the subsidiary's R&D team and packaged by the sister facility in the Klang Valley. This was the first experience of the subsidiary R&D team working concurrently with the parent IC Development Centre to develop a new IC. Here, some form of collaboration in innovation with the parent (an I-link) was beginning to develop.

For a fifth project (1984), the R&D team, which had grown by then to forty engineers, undertook a major three-year project to develop a family of low- and mid-tier microprocessor-based synthesized walkie-talkies, with the parent R&D counterpart developing the high-tier products. This project included electrical and mechanical design, as well as using microprocessors and ICs with electronic reprogrammable memories. This project marked the first time when the R&D team worked jointly with factory engineers to design, develop and manufacture a full product for the European market. Prior to this project, no development of the manufacturing and testing processes was required (only some debugging of production processes of mature products transferred from the parent). In this project, however, the subsidiary's engineers had to write the test programmes for testing modules, chip carriers and finished products. Auto-test systems had to be developed in order to manufacture in large volumes. Clearly, by this stage, the subsidiary had acquired basic and some intermediate level technological capability to innovate in product-centred activities (in terms of Table 7.1). It had also started learning-for-innovation in capital equipment. By 1988, the shipment of such products grew to 5,300 units per week, with a 22 per cent reduction in defects per unit and a 22 per cent reduction in labour costs.

Building innovation-centred links (I-links) in product-centred activities

The success of this project and the use of computer-aided design from 1988 spurred other more complex projects, including joint development projects with parent and sister facilities in other regions (I-links). By 1989, through a joint project with the parent to develop a platform radio design that would enable future models to be developed quickly, the subsidiary developed closed architecture software capabilities in their VHS and UHF design. The products developed by this project were manufactured at the parent facility.

Much more than technical design, the underlying strength of these joint projects was the ability to communicate and work effectively with various groups in parent and sister firms in different regions. The building of this communication and networking capability led to the development of a fully integrated design-to-factory system linking the firm's R&D and factory engineers. Through a joint project with their parts suppliers and a local university, this was then extended to include vendors in an on-line network system.

Programme managers who worked on these projects went on to lead and work with other teams at the parent firm and sister facilities in the US, Singapore and Copenhagen. Compared to other facilities, the Malaysian subsidiary achieved lowest-cost product designs and actual production in minimum time. The R&D team was also reorganized into business units for different product groups. In

1993, the R&D team was headed, for the first time, by a Malaysian engineering manager. At this time, the team undertook a project to design a high-end range of walkie-talkies for the US market to compete with Japanese products. This eight-month project involved execution of the whole process from concept to detailed product design. The product was then manufactured at the parent facility in the US to save shipment costs. By 1995, R&D activity, which had employed five engineers in 1976, had grown to employ 130.

Building learning-for-innovation links for capital equipment

Mechanization of the front-end assembly process started in 1980 (six years after the start of operations) with a pick-and-place machine. The parent firm sent a pick-and-place expert to train engineers at the subsidiary, who thus first attempted to understand the components of capital equipment technology. Thus, mechanization started a learning-for-innovation link (LI-link) focused on improvement of capital equipment. The subsidiary's engineers' improvements led to the development of the first locally designed auto-test handler. So successful was the handler that only two years after the introduction of mechanization, two units were sent to the parent to be used by other facilities there, demonstrating that the subsidiary had acquired basic technological capability to innovate on capital equipment. However, the learning process continued beyond that point, with LI-links continuing to play an important role into the early 1980s. This involved, for instance, the learning of programmable logic control technology, and led to other innovative mechanization projects including auto marking machines, auto powder application machines and auto lead straightening machines.

Automation, using robots, started with the introduction of a major automated PCB assembly line in 1984. Engineering modifications and improvements on these automated systems were constantly made, and greatly encouraged by management. By 1989, the subsidiary had acquired an intermediate level innovative technological capability in capital equipment with the development of in-house automation using robots with vision capability for the assembly process. The learning and building of this capability was not the result of importing ready-made technology and the latest equipment (according to factory engineers and workers as reported in Chan 1994), but depended on learning the technology embedded in equipment and optimizing whatever equipment was at hand.

Building marketing and customer support capabilities

With the introduction of the CT2 portable telephone using digital technology in 1990, the R&D team ventured into complete system design, which led the firm into building capabilities for direct customer interface and customer support and a more active marketing role with product diversification. In order to take advantage of the rapidly expanding telecommunications market in Asia, the parent firm relocated – from a sister plant in Europe – the production of a mature "vintage" product very different from the Penang subsidiary's existing products, a telephone controller terminal. Drawing on similar learning experiences from previous LP- and LI-links with the parent, the team progressed to undertake system integration support for Asia and product marketing.

The R&D department was upgraded into (1) an Asia Design Centre for the land mobile products sector and the telepoint division in December 1993; and (2) the worldwide CT2 portable smart telephone Design Centre in early 1994. By 1995, the Asia Design Centre alone had grown to 105 software, mechanical, electrical and electronics engineers and PCB designers.

Sources and mechanisms of learning: the role of formal training programmes

In reviewing the main stages and components of the subsidiary's learning trajectory, we have concentrated so far on illustrating the roles played by three mechanisms: (i) learning links with the parent firm, (ii) various types of reverse engineering undertaken, more or less independently, in the subsidiary, and (iii) the accumulation of innovation-related knowledge, skill and experience through "learning-by-doing": not by doing routine operational activities but by undertaking a variety of increasingly complex improvement, design and development activities. The cumulative interaction of these mechanisms is probably the key part of the story. For instance, learning did not remain dependent on LI-links with the parent, but moved from there to the experience-generating practice of innovation. Similarly, limits to learning-by-doing innovative activities within the bounds of the existing stock of knowledge were relaxed by access to new elements of knowledge through the other two mechanisms. By the late stage of the process, the learning mechanisms were often so interconnected in collaborative innovation projects that it was difficult to distinguish between them.

All this, however, leaves out the formal training activities which the firm also used to build its technological capabilities. Although significant training efforts were made from the start of operations, these were intensified in the mid-1980s in at least three ways.

First, a major contribution to developing Motorola Penang's innovative technological capabilities was made through its weekend-university programme. Held on the firm's premises, this involves collaboration with a local university for post-graduate (Master's) study in mechanical engineering and electrical engineering for factory and R&D engineers. The programme started in 1986, and a year later, the firm was recognized as an academic campus by the university (University of Malaya) to conduct advanced degree courses. Bachelor degree programmes were also run for manufacturing supervisors. Second, a junior apprenticeship scheme was established for operators to attend classes three days per week at the Penang Skills Development Centre. Scholarships were provided for engineers and workers to undertake these studies. Third, a rigorous training strategy was implemented involving training-of-trainers, for the 2,000 engineers and workers in the firm, with production lines shut down for training purposes. In 1994, this firm earned the Asian Regional Training and Development Organization (ARTDO) Human Resource Development award for the firm's initiatives in human resource development.

Linkage maturity, diversification and reversal

Foreign investment in the electronics industry in Malaysia has been significant since the early 1970s. For many TNC subsidiaries which have been in existence for most of this time, the technological relationships with parent firms have shifted away from the main patterns outlined earlier, particularly the widespread dependence on one-way flows of technology that characterized the early years of all subsidiaries. Part of that shift is reflected in the I-link patterns already reviewed, involving two-way collaboration with TNC parents in innovation. In several other cases, the change has taken different forms.

In some cases, subsidiaries which have achieved a certain threshold of production and innovation capability began to operate more autonomously, reducing their learning and innovation linkages to TNC parents. Such firms evolve towards the structure of more fully integrated business units by building other capabilities, such as purchasing (e.g. Intel Penang), marketing/distribution or customer services (e.g. Motorola Penang), or by becoming a regional headquarters for the TNC parent. Some of them change ownership structures by reducing the holding of the original parent (e.g. Pernec of NEC and Sharp-Roxy), and/or become more independent in running the firm while sustaining MP-links with the parent (e.g. MEMC, Komag, Conner, Dynacraft and Siemens).

Other subsidiaries began to diversify their technological relationships by building LI-links with other firms and organizations (e.g. SEH). Some continued building LP-, LI- and MP-links with TNC parents, but also built links with other firms/organizations through joint ventures/partnerships. For example, after achieving intermediate/advanced product design and development capability in calculators, the Taiwanese firm Inventec built a new LI-link with the Japanese firm Toshiba, through a successful joint venture, in order to learn chip component design for its calculator and facsimile products. Meanwhile, it continued to pursue learning linkages with its parent, an LI-link in telephone design and an LP-link for the production of notebook computers.

Perhaps, the most striking recent change in the pattern of subsidiary–parent technological interaction has been the evolution of links involving reversed flows of technology, as illustrated above in the cases of Siemens and Motorola. These have involved the subsidiary transferring knowledge (e.g. through training or the transfer of capital-embodied technology) to assist parent firms or sister subsidiaries elsewhere build up their own production or innovative capabilities. These reverse links have, so far, fallen into three main categories:

- reverse LP-links focused on *process and production organization,*
- reverse LP-links centred on the transfer of *capital equipment,*
- reverse LI-links concerned with *product innovation.*

Reverse LP-links in process and production organization

Many TNC subsidiaries, particularly those that have been in operation since the 1970s, have become major production sites within the TNC's global network; Malaysia is now the third largest producer of semiconductors in the world and the largest producer of air conditioners. Substantial production capabilities have therefore been accumulated. In particular, with world-wide testing being conducted in Malaysia by many TNCs, much of the global base of knowledge and skill in production/testing operations is now held within these subsidiaries. As a result, reverse flows of learning from Malaysian subsidiaries to parent and sister plants have developed in production-related activities such as production organization, assembly and testing. Six subsidiaries in the sample (four US/European and two Japanese/Taiwanese) had developed significant reverse LP-links of this type.

In addition to the case of Siemens Penang outlined earlier, this kind of reverse LP-link is illustrated by the case of MEMC (Figure 7.5), a German manufacturer of silicon wafers. Set up in the early 1970s, MEMC built up innovative capabilities in process and production organization and developed production systems that were significantly different from the parent, so much so that by 1994 it had become the model for the establishment of new sister plants or for the upgrading of existing facilities within its parent's global network. Alongside this reverse flow of technology, MEMC recently built LI-links and I-links for capital equipment innovation in order to improve product performance and reduce costs. However, the learning and innovation strategy of this firm remains process/production centred, and it has no plans to venture into product innovation.

Reverse LP-links in capital equipment

Some subsidiaries that have built niche innovative capabilities in capital equipment have formed reverse LP-links with parents and sister firms, through which technology, in the form of capital equipment developed, designed and built by subsidiaries in Malaysia, has been sold to affiliate plants abroad. In most cases, these flows of machinery and associated know-how to set up or improve production capabilities in other plants have involved equipment for production and testing processes. Intel Penang, SEH and Motorola Penang exemplify this reverse linkage.

This pattern is illustrated (Figure 7.6) by SEH, a Japanese manufacturer of silicon wafers which started operations in 1973. The firm began learning process engineering through day-to-day process problem-solving to improve production performance, and then through renovating and overhauling the slicing process, the first of the four main processes in wafer manufacture. A formal process engineering department was established in 1977. The first Japanese MD determined

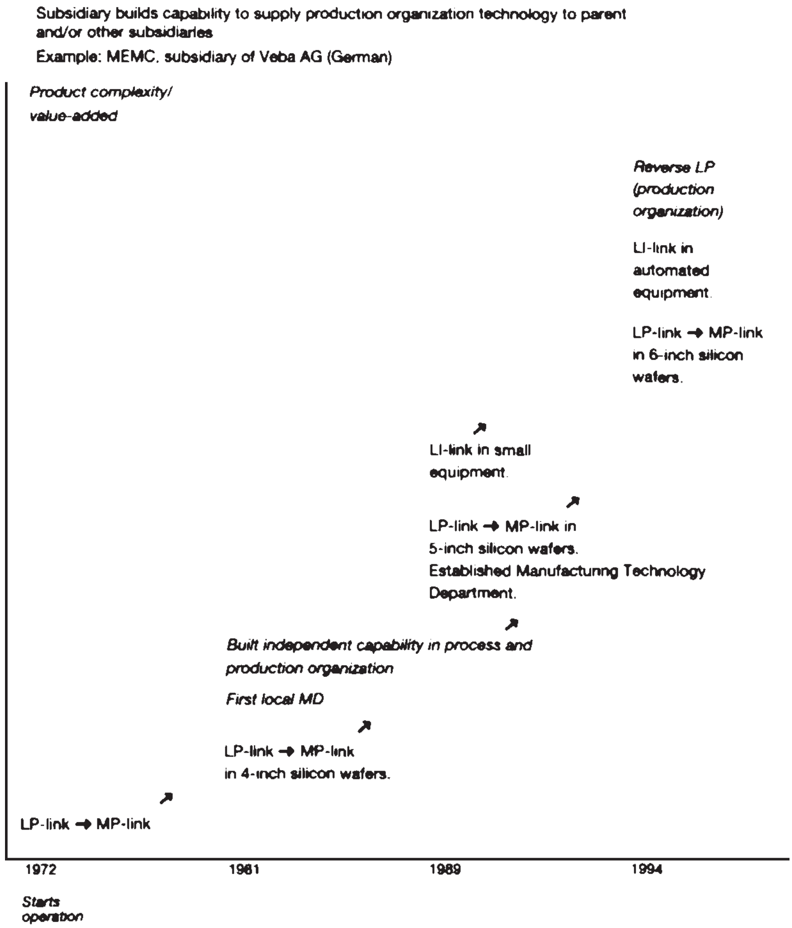

Figure 7.5 Reverse LP-links – process/production organization
Source: Derived from the research.

that this subsidiary would achieve technological self-reliance, and under his tutelage the local staff learnt to retool machines to automate previously manual processes, and soon acquired intermediate design capability in smaller equipment. Units of locally designed and built automated slicing and etching machines were sold to other sister plants abroad. With these successful innovations, the process engineering department was upgraded into an R&D department in 1981, by which time it was headed by a local manager. In late 1985, the R&D department was successful in developing and introducing, to the factory floor, a new, patented wafer housing template using wax-free polishing technology for the first time anywhere in the world. By 1994, the team had produced more than a dozen new innovative process technologies, and had designed and built equipment for all

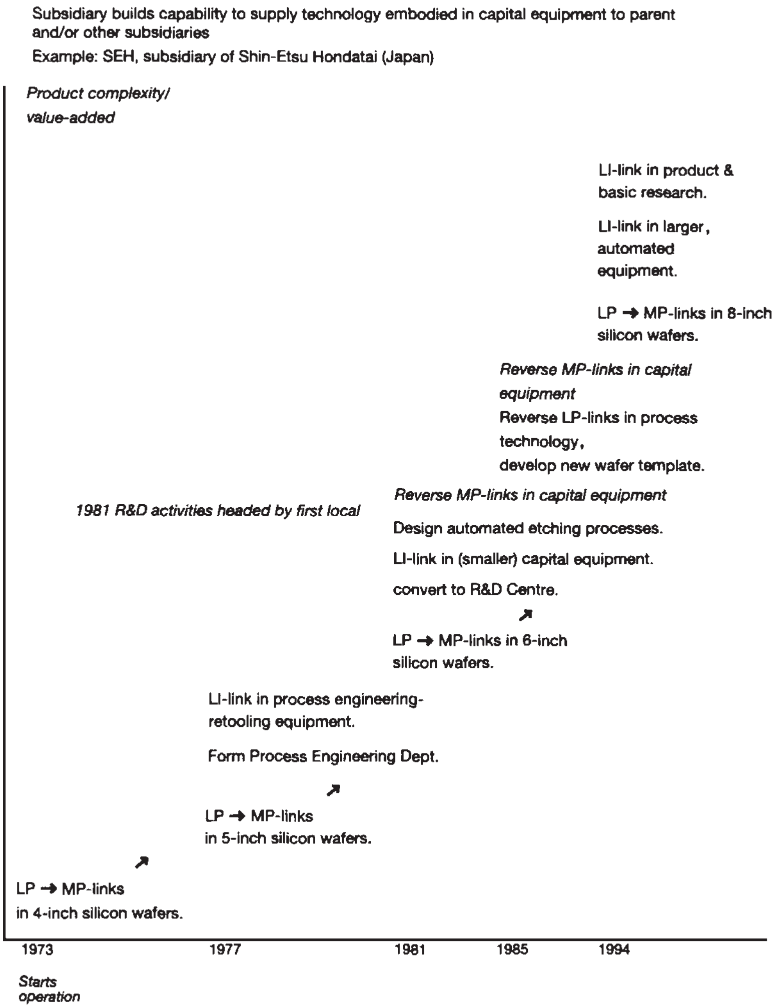

Figure 7.6 Reverse LP-links for capital equipment
Source: Derived from the research.

four main processes in wafer manufacture which have been adopted as the standard in all SEH associated plants.

After successfully building these niche innovative capabilities in capital equipment and process technology, the subsidiary used new LI-links to deepen and diversify its innovative capability. Via a one-year training programme and regular researchers' meetings at parent R&D facilities in Japan and the US, the R&D department acquired new capabilities in basic research in furnace processes and also in more product-centred activities, such as materials characterization for direct customer interface. Meanwhile, process engineering staff deepened their capital equipment design activity by designing larger, programmable machines and by working jointly with local equipment vendors.

Reverse LI-links for product innovation

Several subsidiaries have built niche capabilities in product innovations and, in particular, have accumulated advanced/intermediate technological capabilities in PCB, electrical, mechanical design, design for manufacture, or even complete design of individual products. In many cases, very large parts of the design and engineering components of product development projects have been concentrated in Malaysian subsidiaries because R&D staff at parent facilities have focused on chip design and more basic research on materials. As a result, for new product developments, local staff have been sent to parent and sister facilities to train in these design and engineering activities, or to head projects in individual product areas where the subsidiary in Malaysia has the world mandate. This type of reverse flow to strengthen the innovative capability of parents and other affiliates was evident in fragmentary ways in several subsidiaries. It was, however, more substantial and evident in Siemens Penang and Motorola Penang.

Conclusion and implications for policy

FDI and the technological development of TNC subsidiaries

A summary of the linkage patterns observed in TNC subsidiairies in this study is presented in Table 7.4. It is evident from this that the first of the generalizations outlined at the start of this chapter is misplaced. Far from remaining static for long periods, the production capability of most TNC subsidiaries in Malaysia has been steadily upgraded from simple assembly operations to advanced, complex production and testing processes; and products have been correspondingly upgraded to more complex, higher value-added items.

Beyond that, the technological relationships between TNC parents and subsidiaries have not merely been concerned with transferring technologies developed by parents (LP-links) to subsidiaries, but have also acted as significant channels for enhancing the subsidiaries' innovative capability (LI-links). Indeed, this process of learning to innovate has proceeded to the point where several of the subsidiaries have collaborated as partners with their parents and sister affiliates in significant innovation projects (I-links). Overall, two-thirds of the sample firms have moved into innovative activities, drawing heavily, but not exclusively, on learning links with their parents. Of these, almost half (one-third of the whole sample) have entered into collaborative innovation projects with their parent or sister firms.

However, this is only part of the story. The process of technological learning, achieved partly through relationships with parent TNCs, has proceeded to the point where previous links from parent to subsidiary have now been reversed.

Table 7.4 TNC subsidiary–parent linkage patterns in twenty-five sampled electronics subsidiaries

	Market transactions in goods and services		*Innovation-centred relationship*	
	Japan/Taiwan	*US/Europe*	*Japan/Taiwan*	*US/Europe*
Capability-using Links	*MP-Links:* *Marketing/Production* links		*I-Links* *Innovation* links	
	0	0 = 0	2	6 = 8
Capability-building Links (Learning Links)	*LP-Link* *Learning-for-Production* links		*LI-Link* *Learning-for-Innovation* links	
	5	3 = 8	7	2 = 9
n = 25	5	3 = 8	9	8 = 17
Reverse Linkages				
Capability-building Links	*Reverse LP-Link* *Reverse Learning-for-Production* links		*Reverse LI-Link* *Reverse Learning-for-Innovation* links	
	(a) Process and Production Organization		Product-centred	
(Reverse Learning Links)	2	4 = 6	0	2 = 2
	(b) Capital equipment			
	1	2 = 3		
	3	6 = 9	0	2 = 2

The innovative capabilities of some subsidiaries have enabled them to build up leading positions within their corporate groups in particular areas of product and process technology, especially the latter. On that basis, they now play an important role in strengthening production capabilities in other sister firms in the corporate group (reverse LP-links). Beyond that, some subsidiaries, drawing on their own capabilities, have developed production and testing equipment which they sell to parents or sister firms (reverse LP-links). Some have also developed reverse learning interactions to support the innovative activities of parents or other affiliates – transferring to them knowledge and skills in PCB, electrical, mechanical and packaging design, and especially in "design for manufacture" for new product development (reverse LI-links).

This picture of technological learning and development is striking. However, the research presented here argues against simple mechanistic models of TNCs' technological roles in developing countries, whether optimistic or pessimistic. TNC subsidiaries in the Malaysian electronics industry neither remain technologically stagnant nor progress universally towards innovative capabilities. The evolutionary patterns drawn from the twenty-five sampled subsidiaries show that the progression from LP- and MP-linkages to LI-links, the accumulation of innovative capabilities, the development of collaborative I-links and the further development of reverse links is not automatic. Also, even when they do progress along this trajectory, they do not do so at the same pace.

Moreover, it is misleading to suggest that there is a single trajectory. The firms follow learning paths in different directions. First, some subsidiaries progress towards producing more and more complex products, and focus on building production capabilities, using higher production technology (e.g. the disk drive subsector). Second, some produce relatively simple products, but progress towards product innovation capabilities (e.g. television, audio/video and telecommunication products sub-sectors). Third, some subsidiaries manufacture complex products, and focus on building niche innovative capabilities in process, equipment or production organization (e.g. wafer manufacture and advanced chip manufacture subsectors). Fourth, although the general pattern is that subsidiaries which build innovative capabilities do so initially in specific niches and then progress towards a wider range of capabilities, the pace at which different subsidiaries do so varies, and some may not advance into building particular innovative capabilities.

This diversity is not consistent with a monolithic model of homogeneous TNC technology strategy. The relationships with their subsidiaries, and the technological evolution of these subsidiaries, is shaped by a variety of factors, including: (i) subsidiary leadership initiative, (ii) subsidiary strategy, (iii) parent corporate strategy, and (iv) type of product manufactured.

National differences in TNC behaviour

Cutting across the diversity outlined above, this study calls into doubt arguments focusing on national differences in TNC behaviour, especially those suggesting that Japanese TNCs in particular make very limited contributions to the technological development of their subsidiaries. Table 7.4 indicates that as many Japan/Taiwan TNC subsidiaries (nine) as US/Europe subsidiaries (eight) have progressed from LP- and MP-links to innovative activity involving LI- and I-links. While more US/Europe than Japan/Taiwan subsidiaries have progressed into I-links (six vs. two), there are more Japan/Taiwan than US/Europe subsidiaries in the preceding learning-for-innovation (LI-links) category (seven vs. two). A key issue here is time. The subsidiaries that have progressed to Pattern 4 (innovation) links have been in operation in Malaysia since the early 1970s, and also happen to be mainly US/European subsidiaries. In contrast, those that are still involved in Pattern 3 (learning-for-innovation) links have mostly only been in operation since the late 1980s, and happen to be mainly Japanese/Taiwanese subsidiaries.

Thus, it may be the case that Japanese/Taiwanese subsidiaries are progressing, though maybe not at the same pace, towards building innovative capabilities in much the same way as US/European subsidiaries have already done. Whether or not this is what is happening, the analysis highlights the importance of time as an influence on the technological behaviour of subsidiaries. As outlined above, the length of time that a subsidiary has been in operation should be added to the other factors which contribute to the diversity of technological behaviour observable in the Malaysian electronics industry at any particular moment.

Policy implications

The research reported here has not focused directly on policy measures and their effectiveness, but does throw light on some of the perspectives which, as suggested earlier, seem to underlie common approaches to policy.

First, it is important to distinguish between two fundamentally different dimensions of technological development: movement through increasingly "advanced" and complex products and processes on the one hand and movement through increasingly creative roles in connection with those product/process technologies on the other – e.g. from their basic operation and use through various kinds of design and engineering to differing "depths" of R&D. Progress along these two dimensions involves the creation of very different kinds of resources and the use of different learning mechanisms. So, while governments may have interests in accelerating both types of progress, different measures will be required in each case.

Second, the study indicates that progress to the development and use of innovative technological capabilities is an evolutionary and cumulative learning process. In particular, it highlights the considerable range of technologically creative roles that lie between technology "use and operation" on the one hand and technological "R&D" on the other. It also suggests that subsidiaries necessarily take considerable time to build up the various engineering and design capabilities to play these roles, besides taking a diversity of routes through that dimension of technological development. Although it may well be possible to accelerate the development of these capabilities and activities, that phase of technological learning cannot simply be bypassed. So, focusing policy exclusively on R&D (e.g. by pressuring TNC subsidiaries to establish R&D centres and by transferring R&D activities to their Malaysian subsidiaries) may be irrelevant for much of the development trajectories of many firms.

Third, the study suggests that there is no clear evidence about how, or even whether, subsidiaries' technological behaviour is associated with the nationality of their parent TNCs, rather than with the length of time they have been operating in Malaysia. Consequently, approaches to policy which aim to favour FDI from particular source countries, as a means of accelerating technological development, may prove to be misplaced.

Research methods, limitations and future directions

On the other hand, the study indicates the value of three aspects of research design and method in examining the technological role of TNCs.

First, the focus on different types of TNC subsidiary–parent linkages, and the simple taxonomy of MP-, LP-, LI- and I-links (Table 7.3), are useful in analysing and clarifying the different technology-related interactions between subsidiaries in developing countries and their TNC parents. This taxonomy captures a broad range of relationships, including not just market/production unilateral interactions, but also learning and collaborative innovative interactions. This taxonomy, which focuses on the technological dimensions of subsidiary–parent interactions, builds on existing literature on TNC inter-organizational relationships (e.g. Ghoshal and Bartlett 1993; Doz and Prahalad 1993). In particular, almost all the literature on TNC parent–subsidiary relationships examines the relationship from the parents' viewpoint. This work, on the other hand, examines the relationship from the viewpoint of subsidiaries, particularly subsidiaries in developing countries which start without any significant innovative capacity already available.

In this context, there is a need to understand whether and how parent–subsidiary interactions contribute to building initial innovative capabilities. The taxonomy provides a framework to explore this issue which is more appropriate than those used to examine technological relationships between parents and subsidiaries in more industrialized countries: for example, subsidiaries in Korea and other NICs, in Europe (e.g. Sweden, Italy, Germany, Switzerland), the US and Japan (Dunning 1994; Ghoshal and Bartlett 1993; Gupta and Govindarajan 1994; Raffa and Zollo 1994). In such studies, the linkages examined are between parents and subsidiaries in countries with existing innovatory infrastructures and innovative activities already established within industrial firms. In less industrialized countries, these capabilities have to be built. The taxonomy used here enables one to explore whether and how parent–subsidiary interactions contribute to that.

Second, our approach is explicitly concerned with time and the dynamics of the learning process. This enables research to highlight the technological evolution of firms, which is not captured in cross-sectional studies. This approach therefore enables one to explore key issues about timing, phases and sequences of technological learning in the process of industrial development – a set of issues that has remained surprisingly poorly understood. Moreover, it helps to untangle causes and effects that are sometimes confused: for instance, in the case of the apparently misleading view that TNC parent nationality, rather than the age of the subsidiary, influences technological behaviour.

Third, the use of a framework that explicitly identifies different types and levels of industrial technological capability (Table 7.1) is useful in drawing attention to the extremely important set of technological capabilities, activities and learning processes that is concerned with neither routine production nor "R&D". As noted above, this study suggests that a very large part of the process of technological development in the Malaysian electronics industry over the last quarter century has been concerned with building and using these commonly neglected capabilities. Moreover, that long and important phase of technological learning is evidently a precondition for entry into R&D-based innovation.

However, the study has three limitations.

(1) It includes no evaluative component. Consequently, for instance, its conclusions cannot be used to imply that what has been observed in Malaysia represent "best practice". Under different conditions, TNC-related learning may occur more (or less) effectively than described here.
(2) It includes no component comparing these strongly TNC-linked learning patterns with others that are less dependent on parent–subsidiary technological links (for example, involving locally owned firms in the industry). Consequently, one can conclude nothing about the relative merits of such alternative development routes.
(3) The study covers only a limited period in the development of the Malaysian electronics industry (i.e. from the early 1970s until 1995). The conclusion that significant TNC-linked technological learning has occurred during this period does not imply that this process will continue through subsequent phases of the industry's development. It may happen, but there may be limits to the learning role played by TNCs, and other types of firms and other types of learning mechanisms will have to play key roles in the future.

These limitations of the study point to key questions for future research. Is the kind of TNC-linked learning process described here relatively efficient? Is it more effective than other paths that are less dependent on TNC parent– subsidiary technological links? Will variations around the kind of TNC-linked learning process described here continue to support the further development of technological capabilities in this industry, and what factors are likely to affect that?

Notes

* This chapter is based on part of Norlela Ariffin's on-going D.Phil, research on "Technological Capability Building and Inter-organizational Links: Electronics and Supporting Firms in Malaysia" (1993–98) at SPRU. In-depth field research was made possible by UNDP Kuala Lumpur, the World Bank, and the Ministry of Science, Technology and the Environment, Malaysia (MOSTE). The authors would like to thank Dr Mike Hobday (SPRU), Mr Misrun (MOSTE), Dr Fikret Ackura (UNDP) and Greg Felker (Princeton University) for their assistance and guidance during the field research. The authors are especially grateful to the participating electronics firms in Malaysia for their invaluable contribution to this research.

1 A contrasting, more optimistic, viewpoint is found in Hobday (1996); Bell *et al.* (1995); Rasiah (1994); and O'Connor (1993).

2 This contrast is evident from comparison of the 1994 National Survey of Innovation in Industry (MASTIC 1996), and the 1992 National Survey of R&D (MASTIC 1994).

3 To ease interviews with Japanese managers and to get as much information as possible, Japanese Programme Officers from the UNDP assisted during some of the interviews.

4 The combined sales output of the sampled subsidiaries was about US$8.2 billion, close to 40 per cent of manufactured electrical machinery and electronics products exports in 1993 (MITI 1994: 58). Also, the eleven sampled US/European subsidiaries

represent 44 per cent of the estimated total of large US/European electronics TNCs operating in the Klang Valley and Penang (the Malaysian-American Electronics Industries (MAEI) has fourteen TNC members, according to *Corporate World*, November 1994:17). The fourteen sampled Japan/Taiwan subsidiaries represented 37 per cent of an estimate of the total number of large Japanese/Taiwanese electronics TNCs operating in the Klang Valley and Penang.

5 The advanced floppy-disk drive plant also deliberately shifted to manual operation to increase flexibility and reduce lead time.

6 It should be noted that this category has been quite broadly defined here. Although the "learning for production" links are primarily centred on learning for routine production of products or processes fully developed by the parent, the seven subsidiaries in this category, especially those in consumer electronics (including Sharp-Roxy), have had to do minor adaptations to the products to meet different market needs or to meet manufacturability needs – demonstrating at least some basic product-centred innovative technological capabilities. It is also important to note that the firms are classified in terms of their learning patterns at the time of the interview. So, for instance, this category includes one firm manufacturing hard disks which had only started operations in 1992 and planned to venture into product development activities within the next two years.

7 Patents were sometimes applied for by the parent firm, and not by the individual researchers in the subsidiary.

8 This case study is based on in-depth interviews with top management and R&D representatives, the firm's publications, archival data and interviews by Chan (1994) with parent corporate managers, subsidiary managers, engineers and workers.

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Appendix 7.1 A summary of TNC subsidiaries studied in this research, showing their location of operation, ownership, main activities, sales, employment and first year of operation in Malaysia

TNC subsidiary and location	*Ownership and parent*	*Main TNC subsidiary activities (manufacture for 90–100% export)*	*Sales/employment (1994, US$ million)*	*First year*
Motorola, Penang	US, Motorola Inc.	Design and manufacture two-way radios, smart portable telephones and system production, telephone controller terminals.	1994/95 US$154m/2,300 Malaysia (4 plants): US$2.5billion	1974
Intel, Penang	US, Intel Inc.	Testing, development of ceramic packaging, packaging of microchips (Pentium).	n.a./3,000	1972
Northern Telecoms, Penang	Canada, Northern Telecoms	Manufacture magnetic, power and wireless products; supplies 90% of NT requirements.	US$111.4m/3,300 Malaysia (4 plants): 1992: US$124.6m/3,974	1990
Texas Instrument, Klang Valley	US, Texas Instrument	Manufacture semiconductors, material and control products, and custom manufacturing services.	n.a.	
Conner-Seagate, Penang	US, Conner-Seagate	Assembly of low-end and high-end disk drives.	n.a.	1989
Komag, Penang	US, Komag Inc.	Manufacture thin-film hard disks; produced 30% for Komag worldwide (1994) and by 1996, planned to produce 60%.	(1995) US$138m /570	1992
Dynacraft, Penang	US, National Semiconductor	Manufacture precision stamped lead frames for ICs, transistors LED; connectors and components.	US$150m/1,370	1974
Grundig, Penang	German, Grundig AG	Design (for local production) and full assembly of radios, stereo pocket products, compact centre, clock radio and hi-fi/CD players using digital technology.	US$90m/900	1988
Siemens, Penang	German, Siemens AG	Opto-electronic component design and manufacture.	US$128m/1,560	1972
MEMC, Klang Valley	German, Veba AG	Manufacture silicon wafers (4″ and 6″).	US$86.8m/640	1972
SEH, Klang Valley	Japan, Shin-Etsu	Manufacture silicon wafers (8″).	US$196m/1,350	1973

Fujitsu, Klang Valley	Japan, Fujitsu	Manufacture SMT devices and ICs from silicon wafers; transistors and resistors.	n.a./338	1988
Copal Precision, Klang Valley	Japan, Copal	Moulding and production of precision parts for cameras, disk drives.	US$9.5m/259	1990
Inventec, Penang	Taiwan, Inventec	Manufacture and design ODM calculators, telephones, answering machines, pocket organizers.	US$240m/3,000	1987
Centronix, Klang Valley	Taiwan, Centronix	Assembly of ODM telephones, answering machines, facsimiles and portable printers.	US$29.5m/700	1988
Sony Electronic, Penang	Japan, Sony Japan	CD player, radio, hi-fi production.	US$1.059billion/8,000	1987
Sony TV, Klang Valley		Manufacture and circuit design of colour television.	US$705.9m/3,163	1988
Sony Video, Klang Valley		CD-ROM and video player production.	US$592.2m/2,116	1989
Sony Mechatronic, Penang		Floppy disk-drives assembly.	US$830m/2,900	1989
Hitachi Electronics, Klang Valley	Japan, Hitachi Ltd	Full assembly and some design of colour television (CTV) sets.	US$196m/1,700	1989
JVC, Klang Valley	Japan, JVC	Full assembly and some design of audio products.	1993 US$222m/2,283 (1994)	1988
Philips-JVC Video, Malaysia, Klang Valley	Dutch–Japan, Philips 50%, JVC 50%	Manufacture and some design of VCR, TV, audio electrical appliances.	US$400m/3,190	1988
Matsushita, Klang Valley	Japan, Matsushita	Manufacture and design of air conditioners, components, motors and compressors; manufacture of consumer electrical appliances and components: washers, fridges, vacuum cleaners, compressors, etc.; electronic components and devices (capacitors and resistors); transformers, magnetic heads for computers and printer parts; office automation and audio/tv electronic motors, component parts and products; precision die and mould designs.	US$2.5billion/25,470 Malaysia: 16 manufacturing plants.	1972

[*continued on p. 190*]

Appendix 7.1 A summary of TNC subsidiaries studied in this research, showing their location of operation, ownership, main activities, sales, employment and first year of operation in Malaysia (continued)

TNC subsidiary and location	*Ownership and parent*	*Main TNC subsidiary activities (manufacture for 90–100% export)*	*Sales/employment (1994, US$ million)*	*First year*
Sharp-Roxy Appliance, Klang Valley	Japan–Hong Kong–Malaysia, Sharp 25.5%, Roxy 25.5%, Tongkah 49%	Assembly of television and VCR products, and consumer electrical appliances: washers, fridges, vacuum cleaners, cooking stoves; domestic market oriented (95%).	1993 US$67m/n.a.	1962 Under Sharp: 1985
PERNEC, Klang Valley	Japan–Malaysia, NEC 30%, PNB 60%	Telecommunication transmission and switching production, and system integration; domestic market oriented.	US$117m/230	1973

8

TECHNOLOGY TRANSFER FROM JAPANESE CONSUMER ELECTRONIC FIRMS VIA BUYER–SUPPLIER RELATIONS*

Giovanni Capannelli

The process of industry relocation and framework for analysis

Increase of trade and investment interdependence in East Asia

During the last decade, a massive outflow of foreign direct investment (FDI), especially in industries like transport equipment and electronics, has fostered the integration of Japan with other economies in the East Asian region. The continuous appreciation of the yen and increased production costs in Japan have altered the country's comparative advantage and pressured manufacturers to shift labour-intensive operations to lower-cost locations in Asia. Beyond simple factor–cost motives, however, several other reasons have caused major Japanese multinational corporations (MNCs) to adopt a strategy of production internationalization: (i) to interact more closely with customers in international markets; (ii) to build strategic advantages in oligopolistic global competition; and (iii) to respond to political pressure to reduce Japan's huge trade surplus.

The surge of Japanese manufacturing investment in East Asia has boosted trade within the region, in turn creating incentives for further investment, with positive effects for regional economic growth (MOF 1993, Petri 1995, Yamashita 1995). The interdependence between trade and investment stems from the specific nature of the industrial relocation process and the increasing specialization of production encouraged by trade liberalization and facilitation policies, as well as by various development co-operation programmes within the APEC initiative. The positive circularity of trade and investment results in increased dynamism within the host economies, and generates two distinct effects. The first is the direct impact on employment, income and export growth, while the second consists of more indirect, but long-lasting, benefits arising from the potential transfer of technology.

Recent economic literature has stressed technology transfer through FDI as one of the best ways to introduce new information into developing countries and to foster the development of local technological capacities (Romer 1993, Ruffin 1993). This new field of research is providing many interesting results, with various empirical studies stressing the importance of both knowledge creation and transfer via non-market mechanisms (Wong 1991, Yamashita 1991 and 1995, Palacios 1995).

However, economic analysis of inter-firm technology transfer has mainly focused on the behaviour of the technology sources, i.e. MNCs, and the costs and management practices which influence their willingness to transfer the technology to the local economy. The role of technology recipients, i.e. local firms, has generally been taken as given, namely to absorb whatever knowledge is made available by technology sources. By contrast, recent work on technology transfer indicates that technology is only partly transferable in the form of codified information, and that technology recipients must make non-trivial investments to absorb it. This explains, for example, the dual role played by R&D investment in generating new knowledge as well as in absorbing technology from external sources. It also suggests that successful technology transfer requires that technology suppliers benefit sufficiently to compensate for the costs of transfer, and that the gains to the recipients cover the investments in raising their absorptive capacity. Another remarkable characteristic of technology transfer is the fact that successful implementation often cannot be achieved through a simple arm's-length market transaction, but also requires a certain amount of transaction-specific investment and interactive effort from both the technology sourcing and receiving agents. In other words, an analysis of the success of technology transfer should consider variables and conditions related to both sides of the process.

The following pages provide some theoretical and empirical insights on the link between the potential for technology transfer created by the relocation of consumer electronics production from Japan to Malaysia, and the absorptive capacity of the local supporting industries. Based on field work carried out in 1995, the discussion focuses on the buyer–supplier relations between Japanese assemblers and their locally based makers of parts and components. After a brief review of the relocation process from Japan to Malaysia, the rest of this section will introduce the framework used to analyse the problem of buyer–supplier relations and technology transfer. The next section presents the findings of a survey of forty-three firms in Malaysia. The final section analyses the question of Japanese assembly firms' procurement sourcing activities and the transfer of technology to the local supporting industry.

The process of industry relocation

The electronics industry accounts for the largest share of Japanese FDI outflow during the last decade, and Malaysia is, by far, the preferred offshore location for such investment. According to the figures provided by the Electronics Industry Association of Japan (EIAJ), as of March 1994 Japanese-affiliated electronic firms in Malaysia amounted to 135 projects, or 22.7 per cent of the 596 in Asia, and 14.1 per cent of the world-wide total of 958 (Table 8.1).

The relocation process has been most apparent in consumer electronics like radios, colour television sets (CTV) and video-tape recorders (VTR). The trend in Japanese CTV firms' domestic and overseas production during the period 1980–92 is shown in Figure 8.1. Interestingly, rapid growth in overseas production (from 5.7 to 23.2 million units) entirely accounts for the doubling of total production from 17 to 35 million units. As a consequence, the share of domestic production has declined from two-thirds of the total in 1980 to one-third (12 million units) in 1992. As Figure 8.1 shows, Malaysia's share of total production has increased dramatically from 0.28 per cent in 1980 (50,000 units) to almost 22 per cent of Japanese firms' global CTV production in 1992 (7,760,000 units).

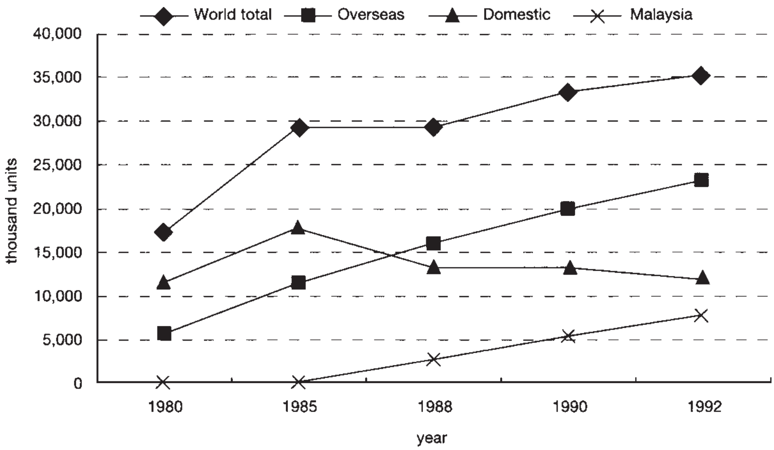
Japanese electronics industry investments in Malaysia have evolved through three distinct phases. The investment flow began in the mid-1960s, when a few large producers of household electrical equipment goods relocated some final assembly stages to capture Malaysia's domestic market. This investment was prompted by Malaysia's imposition of import tariffs as part of an import-substitution industrialization strategy. The second stage began during the mid-1970s, when Malaysia offered low-cost labour and generous tax incentives for export-oriented foreign investment projects. The new export-oriented strategy succeeded in attracting many projects for the low-end assembly of electronic parts, especially "active components" like integrated circuits, transistors and semiconductors, which were almost entirely destined for export to more advanced countries. In the second half of the 1980s, the yen appreciation following the Plaza Accord of 1985 caused Japanese firms to enter a third stage of production

Table 8.1 Foreign affiliates of Japanese electronics firms, 1994

	Malaysia	*Asia*	*Total*
Total electronics industry	135	596	958
Parts and components	93	385	563
Industrial goods	17	93	193
Consumer goods	39	169	285
Televisions	9	42	85
VTRs	8	23	47

Source: EIAJ 1994 Kaigai Houjin Risuto.

Note
These figures only include the EIAJ's members.



Year	*Domestic*	*(%)*	*Overseas*	*(%)*	*World total*	*(%)*	*(Malaysia)*
1980	11,611	66.9	5,744	33.1	17,355	100.0	50
1985	17,897	61.2	11,365	38.8	29,262	100.0	200
1988	13,219	43.3	15,931	54.7	29,150	100.0	2,736
1990	13,243	39.9	19,937	60.1	33,180	100.0	5,376
1992	12,024	34.1	23,243	65.9	35,267	100.0	7,760

Figure 8.1 World-wide production of CTV by Japanese firms
Source: EIAJ, 1993.

relocation. While the first two phases mainly involved large MNCs and low-technology assembly operations, a major characteristic of this third stage has been its greater complexity and depth. In particular, the decision to invest abroad has not only been taken for single-product categories, or by various firms independently, but now clearly involves a much wider range of activities throughout the industry, so that it can be described in more general terms as a process of industry-wide relocation (for a more detailed analysis, see Capannelli 1993 and 1994).

In this new phase, Japanese firms have begun to transfer more technology-intensive operations for several industrial electronic products, such as telecommunications equipment and computer peripherals, and have pursued a deeper degree of backward integration beyond final-stage assembly. Furthermore, the relocation process is no longer limited to big MNCs, but also involves a large number of small and medium-sized firms which produce intermediate parts and components. Such firms are motivated not only by rising production costs in Japan, but also by the need to remain located close to their major customers.

For Malaysia, the dramatic inflow of FDI during recent years has been a major source of capital for industrialization. The electronics sector has played the leading role, both as the largest single industry, and by creating linkages with other sectors. Tables 8.2 and 8.3 show the growth of manufacturing and electronics projects respectively in the first half of the 1990s. It is interesting to observe that 51 per cent of cumulative manufacturing investment from 1990 to 1994 was by foreign capital, whose share of electronics industry investment was an even higher 80 per cent.

Table 8.2 Approved manufacturing projects in Malaysia, 1990–4 (number of cases and million ringgit)

	1990	*1991*	*1992*	*1993*	*1994*	*1990–4*
Number of cases	906	973	874	686	870	4,309
100% Malaysian	197	209	232	179	226	1,043
100% foreign	339	363	270	200	277	1,449
Joint ventures	370	401	372	307	367	1,817
Capital investment	28,168.1	30,818.4	27,775.1	13,752.7	22,951.3	123,465.6
Local capital	10,539.0	13,763.1	10,003.0	7,465.5	11,612.2	53,382.8
Foreign capital	17,629.1	17,055.3	17,772.1	6,287.2	11,339.1	70,082.8
Foreign share (%)	62.6	55.3	64.0	45.7	49.5	51.0

Source: MIDA, 1995.

Table 8.3 Approved projects in Malaysian electronics industry, 1990–4 (number of cases and million ringgit)

	1990	*1991*	*1992*	*1993*	*1994*	*1990–4*
Number of cases						
Manufacturing	906	973	874	686	870	4,309
Electronics total	213	258	211	200	268	1,150
Electronics' share of manufacturing (%)	23.5	26.5	24.1	29.2	30.8	26.7
Electronics with foreign participants	198	238	181	167	237	1,021
Foreign share (%)	93.0	92.2	85.8	83.5	88.4	88.8
Capital investment						
Manufacturing	28,168.1	30,818.4	27,775.1	13,752.7	22,951.3	123,465.6
Electronics	4,211.8	3,132.4	1,579.5	2,304.8	6,339.5	17,568.1
Electronics' share of manufacturing (%)	15.0	10.2	5.7	16.8	27.6	14.2
Electronics with foreign participants	3,773.2	2,716.1	957.5	1,830.5	4,825.4	14,102.6
Foreign share (%)	89.6	86.7	60.0	79.4	76.1	80.3

Source: MIDA, 1995.

These figures show that Malaysia is a strategic location for Japanese electronic firms, and also that the Malaysian electronics industry greatly relies on foreign-induced capital formation. The role of Japanese firms is especially important in this regard, as their share of cumulative total capital investment during the period 1988–94 accounts for 38 per cent of the entire Malaysian electronics industry, reaching 80 per cent in the case of consumer products, like CTVs and VTRs. Japanese firms' industrial relocation has thus had a tremendous impact on the increase of industrial production and exports, as well as on employment creation. On the other hand, from the point of view of newly industrializing economies like Malaysia, an even more important aspect of FDI has been the process of technology transfer,[1] and in particular, the fact that local supporting industries' technological capacities can be upgraded through the channel of buyer–supplier relations. However, as the use of such channel has received little attention in the literature, there is still not much evidence of its effectiveness. Accordingly, before discussing some empirical results, an analytical framework for studying technology transfer via buyer–supplier relations will be briefly introduced.

I will refer to this framework in assessing the importance for Malaysian firms of investing in their own technology absorption capacity. I believe that this is one of the most important actions to be urgently undertaken in order gradually to upgrade the locally owned supporting industries and to better benefit from the presence of foreign multinationals. In fact, a major conclusion of the present study is that the greater the capacity to absorb external technologies, the higher the incentives for technology transfer; the actual low level of Japanese firms' procurement of inputs from Malaysian suppliers reflects the lack of such absorptive capacity rather than discriminatory practices against non-Japanese firms, as is often presumed. Of course, this is not to say that Japanese MNCs do not have such practices, but I want to stress that technological upgrading of suppliers may significantly affect the input procurement strategy of assembly firms.

Buyer–supplier relations as a means for technology transfer

Of the various channels for international technology transfer, economic analysis has focused particularly on two types: (i) the arm's-length trade in technology between different countries, and (ii) the intra-firm flow of technology within MNCs through FDI. The former channel includes all kinds of technology contracts involving the payment of royalties to the source, while the latter refers to internalized forms of technology transfer due to the foreign relocation of production activities by firms. In particular, this refers to the relationships between the parent company and the foreign-located affiliated firm, involving both the transfer of physical capital as well as skills to local personnel (for some recent literature, see, Basant and Fikkert 1993, Basant 1993, Braga and Willmore 1991, Chen 1994, Horstmann and Markusen 1987, Montalvo and Yafeh 1994, Palacios 1995, Suzuki 1993, Wakasugi 1995, Yamashita 1991 and 1995).

However, FDI also offers significant potential for technology transfer through the localization of parts and materials procurement, which can stimulate industrial and technological activities among local suppliers and other supporting industries.[2] The impact of the buyer–supplier interaction can be greater than any other mode of technology transfer, especially when FDI creates significant backward and forward linkages. As a matter of fact, many developing countries' governments in the East Asian region have given increasing priority to the development of local ancillary production for the MNCs. This is seen as an important step towards upgrading domestic technological capacities and catching-up with more industrialized countries (MOF 1993, Chia 1995). In this regard, several lessons can be learned from the Japanese manufacturing system, whose strength has been widely recognized as grounded in the elaborate procurement network existing between large assembly firms and different tiers of input producers (Aoki 1988, Asanuma 1988, Helper 1990, Nishiguchi 1994).

The industry-wide relocation of Japanese electronics has been expected to create the basis for such systems to be replicated in Malaysia as well. However, realizing this opportunity implies introducing appropriate changes to take account of the different economic environments, past experience, and strategies for future industrial development.

Apart from the microelectronics sector in Penang, the Malaysian electronics industry a decade ago was still quite under-developed and far behind international competitive standards, with few locally-based manufacturers of intermediate goods. Today, by contrast, the electronics industry makes the largest contribution to the manufacturing sector in terms both of production and exports, and the role of supporting industries has expanded in significance. However, the main agents of this rapid development have been especially Japanese, Taiwanese and South Korean foreign firms, while the presence of Malaysian companies is still relatively scarce. In particular, although the supporting industries for consumer electronics include a very large set of intermediate goods whose manufacture requires various degrees of technological sophistication, Malaysian-owned firms are still concentrated in lower-end operations, like packaging materials, metal stamping and plastic injection.

Nevertheless, the rapid expansion of manufacturing production induced by industry-wide relocation from Japan has had a multiplier impact on supporting industries, providing opportunities for more local firms to enter. In particular, the formation of joint ventures with foreign partners, and the development of buyer-supplier relations, appear to be very effective ways for upgrading the domestic technology, to the extent that local firms undertake adequate investments in order to enlarge their capacity for technology absorption.

The production and technology flows generated by means of buyer–supplier relations are illustrated in Figure 8.2. Here, the underlying assumption is that the buyer of the intermediate good is an MNC, which is assumed to be more technologically advanced than its small or medium supplier. Accordingly, while the input flows from the supplier to the buyer, the technology is likely to be

Type of firm	MNC (assembly firm)		SME (part maker)
Input flow	*Buyer*	← ←	*Supplier*
Technology flow	*Source*	→ →	*Recipient*

Figure 8.2 Product and technology flows via buyer–supplier relations

transferred from the buyer to the supplier in the form of knowledge specific to or "embodied" in the business relationship. In other contexts, where the supplier is technologically superior to the buyer, the knowledge flows may be reversed and hence move in the same direction as the product. In fact, several Japanese producers of electronic parts and components serve as sources of technology for the assembly firms which purchase their products. However, as the focus here is on the effect of Japanese FDI on the technological upgrading of Malaysian suppliers, it is implicitly assumed that the relationship is as depicted in Figure 8.2.[3]

The interviews carried out with electronics firms in Malaysia in 1995 suggest that a technology transfer process through buyer–supplier relations consists of four stages (Figure 8.3).[4] First, both firms search for the most appropriate partner. In particular, the buyer searches for the best suppliers according to its own production specifications and standards. Second, the parties stipulate a business contract for inputs procurement, which includes an agreement on price, the length of the commitment, quality standards, and so on. In particular, input procurement will be determined by the structure of the intermediate and final markets, and by the technological capacity of the supplier. Third, the process is effectively implemented through production co-operation between the two agents, which is determined by how the buyer (technology source) transfers technology to the supplier (technology recipient). Fourth, the supplier internalizes the acquired technology and expands its technological capability.

My field work in Malaysia was also concerned with the actual forms and effects of technology transfer emerging from production co-operation between buyers and suppliers. Though quite difficult to clearly distinguish in practice, the analytical framework identifies and distinguishes two types of technology transfer which occur in the course of production-based co-operation. The first category refers to those activities intentionally transferred by the technology source (buyer)

1. Identification of the partner

2. Stipulation of the contract

3. Product co-operation activity

4. Internalization of the technology

Figure 8.3 Stages of technology transfer via buyer–supplier relations usually involving specific transfer costs. Such activities, which have some direct effects on the recipient's production operations, include: (i) provision of updated specifications for product and process technologies, (ii) solution of specific technical problems, (iii) training of the suppliers' personnel, and (iv) counselling to improve plant organization and use of equipment.[5] The second category of activities consists of positive spillovers for the technology recipient (supplier) which do not require any additional effort from the source and do not increase the cost of transfer. Such indirect effects for the technology recipient include: (i) improvement of input quality and cost performance, (ii) exposure to the buyer's management and technology, (iii) inflow of new ideas and information, and (iv) reduction of the perceived risk of technology investment due to the anticipated stable source of income provided by the contracted supplier relationship (future supply and production commitment). The internalization of these spillovers depends on the strategy of the technology recipient (Figure 8.4).[6]

A necessary condition for technology transfer via buyer–supplier relations is the existence of procurements sourced from external companies. In fact, if the assembly firm decides to internalize the production of all intermediate goods, this channel of technology transfer will be irrelevant. However, in industries like transportation equipment or electronics, where numerous components and materials of varying degrees of technological sophistication are used, assembly firms may procure a large number of inputs externally and only produce a fraction of them "in-house".

In addition, work on the suppliers' network of Japanese assembly firms shows that the buyer's procurement strategy is affected by both the costs of intermediate goods and available product quality. It is argued that the total rents captured by oligopolistic buyers such as assemblers will be increased by some relationship-specific rents generated by combining their technological expertise with that of

Intentional transfer (*direct effects*)

(i) New product and process technologies
(ii) Solution of specific technical problems
(iii) Technical training of personnel
(iv) Better plant and equipment organization

Spillovers (*indirect effects*)

(i) Improvement of quality and cost performance
(ii) Exposure to the buyer's management and technology
(iii) Inflow of new ideas and information
(iv) Reduction of the perceived risk of technology investment

Figure 8.4 Forms and effects of technology transfer via buyer–supplier relations more highly specialized suppliers in “quasi-exclusive” relations. In other words, long-term commitment and close co-operation with external suppliers, who have specialized in the manufacture of intermediate products, will lead to improvements in product quality for which consumers are expected to pay more.[7]

Consequently, when inputs are sourced from technologically inferior suppliers, as in the case discussed in Figure 8.2, the buyer will have an incentive to transfer the technology to its suppliers in order to increase product quality (and hence, the relationship-specific rents). In such cases, the transfer of technology will impose added costs on the buyer, but this can be regarded as an investment to raise the quality of the final product, and thus gain higher income from rents.[8]

The “two faces” of technology transfer

Economic modelling and empirical research on FDI and international technology transfer have been guided by a range of authors testing different hypotheses. However, most such analyses focus on the relationships between the parent firm and the subsidiaries in the host country, and thus fail to consider technology transfer through the channel of buyer–supplier relations between locally based MNC subsidiaries and domestic firms in the host country (Teece 1977, Davidson and McFetridge 1985, Horstmann and Markusen 1987, Wang and Blostrom 1992, Ramachandran 1993, Suzuki 1993, Montalvo and Yafeh 1994, Wakasugi 1995). It has been argued that the transfer of technology from a profit-maximising parent firm to its subsidiaries abroad is related to several factors affecting the behaviour of both the technology source and the recipient, and that the incentives for sustaining the technology transfer are determined by the profits that the source is able to gain by appropriating a certain share of the rents generated by the technology recipient firms (part-suppliers) in their use of the technology (Teece 1977, Ramachandran 1993, Wakasugi 1995).

However, effective technology transfer occurring at the inter-firm level, as in the case of buyer–supplier relations, requires the technology recipient to have the ability to absorb and make effective use of the technology. As yet, there is no formal model available adequately to consider the recipient’s investment decision to enhance its technology absorptive capacity and the interaction between the two sides of the technology transfer process. Further research on this issue should yield interesting results. One of the most relevant contributions from which such a model could be built is by Cohen and Levinthal (1989) on the “two faces” of R&D. The authors suggest that, from the point of view of the firm, R&D investment has a dual nature as it not only generates new knowledge, but also expands the firm’s ability to absorb existing information available from the environment.[9] This approach, which stresses the importance of the firm’s absorptive capacity, suggests that the presence of those “two faces” of the R&D activity is also reflected in the existence of “two faces” in the technology transfer process. Effective implementation depends not only on the conditions concerning the cost of technology transfer, but also on the absorptive capacity of the technology recipient.

Accordingly, a framework for analysing technology transfer via buyer–supplier relations should also consider the investment decisions of the firm that receives the technology. For simplicity, we can restrict the analysis to the case of a technology transfer between a buyer (assembler), who is the technology source, and a supplier of an intermediate product, who is the technology recipient.[10] Following from the above discussion, the incentive for the buyer to transfer part of its technology to the supplier is created by the possibility of gaining some relationship-specific rent in the final product market, even if the technology transfer entails some cost. We can also think of such a cost as a kind of technological investment by the buyer which, besides the direct R&D effort, contributes to the firm's stock of knowledge.[11]

In fact, according to the Cohen and Levinthal argument, the firm's new knowledge increase is the sum of its own R&D efforts and the technological spillovers from R&D efforts of other firms, being the amount of the latter dependent on the firm's absorptive capacity. However, when a process of technology transfer is considered, the relevant activities for the source's increase in new knowledge will also include some specific R&D efforts for the effective implementation of the transfer process. The capacity to absorb external knowledge (relevant for the technology recipient) will determine the actual gain from both the direct effects due to the intentional transfer and the indirect effects from spillovers, as discussed in Figure 8.4. Consequently, the gains from the technology transfer process will be enhanced by the recipient's higher absorptive capacity.

The buyer–supplier technology transfer process can decrease the input's production cost and therefore correspondingly increase the relationship-specific rent, some part of which can be captured by the technology source (buyer) through its bargaining power. Accordingly, this suggests that the technology source will only invest in technology transfer if the increase in its total rents will exceed the transfer cost. The relationship between the "two faces" of technology transfer is now evident. In fact, the higher the recipient's absorptive capacity, the greater the incentive for the technology source to invest resources in the transfer, given a certain level of indirect spillover effect and the source's bargaining power.[12] As a consequence, we can say that the more the recipient firm invests in R&D to effectively absorb externally generated technologies, the higher the likelihood that it will benefit from significant technical assistance provided by the technology source.[13]

Japanese consumer electronic firms' operations in Malaysia

Outline of the field work and company profiles

The extent of technology transfer via buyer–supplier relations and the problems related to the development of a locally-based supporting industry for electronics in Malaysia were investigated through factory visits and interviews with forty-three firms, by the author in mid-1995. The idea was to interview a few Japanese producers of consumer electronic goods and some locally based makers of parts and components belonging to their networks of suppliers, using an "*ad hoc* questionnaire" to analyse the various factors affecting both sides of the technology transfer process, i.e. the cost of transfer for the technology source, and the absorptive capacity of the technology recipient.

The first step was to select two representative consumer electronic goods for which production was relocated from Japan to Malaysia, as described above. Accordingly, CTVs and VTRs were chosen. The original plan was to interview a total of forty-five firms, including nine assembly firms (buyers) and thirty-six parts makers (suppliers), by asking each buyer to introduce four of its suppliers, including both Japanese and Malaysian firms. However, this was only possible for eight of the buyers, while one other was only able to provide contact with two suppliers. Consequently, a total of forty-three interviews were carried out with firms: nine buyers and thirty-four suppliers. Two locations were selected for the interviews. One was Kuala Lumpur and its surroundings, including the Kelang Valley in the state of Selangor, and the other was an industrial area close to the city of Johor Bahru. The choice of these two locations was motivated by the relatively high concentration of consumer electronics and by the presence of supporting industries (Table 8.4).[14]

Some indicators of the nine interviewed Japanese assembly firms, with respect to their products and location, are presented in Table 8.5.[15] The CTV producers selected were four firms (three in Kuala Lumpur and one in Johor) while the VTR producers included five firms (two in Kuala Lumpur and three in Johor). The average production experience of these nine assemblers was about eight years, but the firms located in Johor were much younger (four years and five months) compared to those based in Kuala Lumpur (almost eleven years). The average paid-up capital was about 57 million ringgit, the average number of employees around two thousand, and the average total sales in 1994 more than 2 billion ringgit.

A classification of the suppliers, by production category, capital ownership, and location, is provided in Table 8.6, while some selected indicators are presented in Table 8.7. Of the total of thirty-four, twenty were classified as Japanese, and

Table 8.4 Presence of Japanese companies in Malaysia (as at March 1995)

	*K.L.**	*Johor*	*Penang*	*Total*
All sectors	675	102	127	1,070
Manufacturing sector	266	97	102	596
Electronics industry	109	49	34	244

Source: JETRO Kuala Lumpur, 1995.
Note
* K.L. includes the Federal Territory of Kuala Lumpur and the state of Selangor.

Table 8.5 Selected indicators of interviewed Japanese assembly firms

Location, product	*No. of firms*	*Production experience*[1]	*Paid-up capital*[2]	*Employment*[3]	*Total sales*[4]
Kuala Lumpur					
CTV	3	162.7	84.8	1,966.7	2,933.3
VTR	2	83.0	45.0	2,391.0	2,280.0
Total	5	130.8	68.9	2,136.4	2,672.0
Johor					
CTV	1	42.0	12.0	800.0	650.0
VTR	3	57.0	52.0	2,181.7	1,776.7
Total	4	53.3	42.0	1,836.3	1,495.0
Total					
CTV	4	132.5	66.6	1,675.0	2,362.5
VTR	5	67.4	49.2	2,265.4	1,978.0
Total	9	96.3	56.9	2,003.0	2,148.9

Notes

1 Average number of months since the start of production to September 1995.

2 Average paid-up capital in million ringgit.

3 Average number of staff.

4 Average 1994 sales in million ringgit.

Table 8.6 Classification of the interviewed parts and components suppliers

Location	*Kuala Lumpur*		*Johor*		
Category/Capital ownership	*Malaysian*	*Japanese*	*Malaysian*	*Japanese*	*Total*
Packaging materials	2	1	2	–	5
Metal stamping	2	–	1	–	3
Wires and cables	–	1	–	5	6
Plastic injection	6	2	–	1	9
Sub-assembly (rem. con.)	–	1	–	–	1
Coils, filters, defl. yokes	–	1	–	1	2
Printed circuit boards	–	1	1	1	3
Connectors	–	1	–	–	1
Relays	–	1	–	–	1
Speakers	–	1	–	–	1
Tuners and capacitors	–	2	–	–	2
Total	10	12	4	8	34

Note

Japanese firms include those whose Japanese equity share is >50%. Malaysian firms include all the other cases (100% Malaysian capital and joint ventures).

fourteen as Malaysian. The former were firms whose Japanese capital share was more than 50 per cent, while the latter were all other firms, including those with full Malaysian ownership as well as joint ventures with third-country firms. There were twenty-two firms located in Kuala Lumpur, and twelve located in Johor.

Table 8.7 Selected indicators of the interviewed locally-based suppliers

Location, Capital ownership	*No. of firms*	*Production experience*[1]	*Paid-up capital*[2]	*Employment*[3]	*Total sales*[4]
Kuala Lumpur					
Japanese	12	98.8	23.4	1196.1	54.7
Malaysian	10	120.4	11.6	369.4	17.1
Total	22	107.4	19.1	874.6	40.2
Johor					
Japanese	8	73.6	9.3	413.9	45.9
Malaysian	4	102.2	17.5	323.5	45.0
Total	12	83.2	12.3	381.0	45.6
Total					
Japanese	20	88.7	18.2	891.9	50.9
Malaysian	14	114.3	13.8	352.7	27.6
Total	34	98.3	16.6	687.4	42.4

Notes

1 Average number of months since the start of production to September 1995.
2 Average paid-up capital in million ringgit.
3 Average number of total staff.
4 Average total sales 1994 in million ringgit.

The Malaysian firms were concentrated in lower-end technology sectors, like packaging materials, metal stamping and plastic injection, while the manufacture of more technologically sophisticated products was mainly by Japanese firms.

The production experience of the Malaysian parts makers was nine years on average, not much longer than the average for the Japanese firms in Malaysia (seven years). The Japanese firms were generally bigger than their Malaysian counterparts. Table 8.7 shows how this was true in forms of the average paid-up capital (RM18.2 million for Japanese firms in comparison to RM13.8 million for Malaysian firms), employment (almost 900 people in the Japanese firms in comparison to 350 people in the Malaysian firms), and also total sales (RM50.9 million in 1994 for the Japanese firms in comparison to RM27.6 million for the Malaysian firms).

The thirty-four supplying firms were chosen so as to obtain a sample consistent with the final product's cost break down attributable to the different parts and components. For this reason, two standard products were chosen (21-inch CTVs, and 4-head VTRs), while all the parts used for the final production of these goods were classified into three groups according to their technological content (low, medium, high), calculated as a share of the total cost of the final good (Figure 8.5). Accordingly, the assembly firms were asked to select their suppliers from a list of makers of eleven different categories of parts and components covering all three groups. This list was prepared on the basis of the production facilities' classifications and location directory for electronics firms, provided by the Malaysian Industrial Development Authority (MIDA). One major purpose of the field work was to assess the extent of technology transfer through buyer-supplier relations, following the analytical framework introduced above, so the makers of low- and medium-technology content parts were preferred. The firms producing more technologically sophisticated inputs were assumed to have reached a stage where technology transfers were less intense, and so, were given relatively less weight (see Figure 8.5).

Japanese firms' relocation of production

All the Japanese firms, including both final assemblers and parts makers, were asked to list the major determinants of their decision to relocate production in Malaysia, specifying those factors which pushed the move out of Japan, and those which pulled them to locate in Malaysia. Interestingly, relationships between buyers and suppliers appeared to play a central role in the choice of relocating production in Malaysia. In fact, the assembly firms listed "presence of supporting industries" as the major factor attracting them to Malaysia, while parts makers indicated that "customers' production relocation" and "regional concentration of electronics" were major factors in the transfer of their production to Malaysia (Figures 8.6 and 8.7).

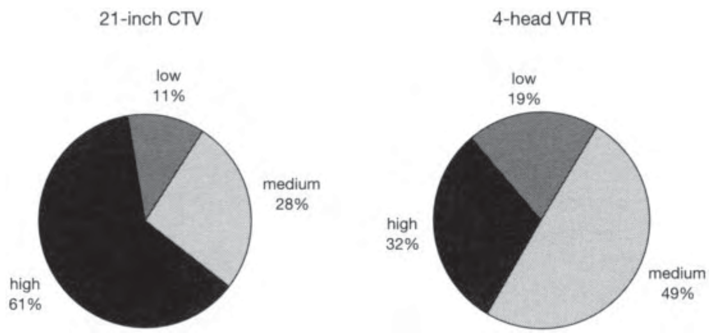


Figure 8.5 Share of different parts in the total cost of a representative product, according to degree of technological sophistication

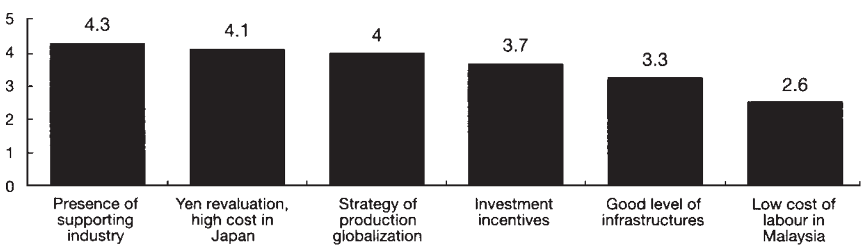


Figure 8.6 Major determinants of production relocation for Japanese assembly firms (average answers based on a 1 to 5 range)

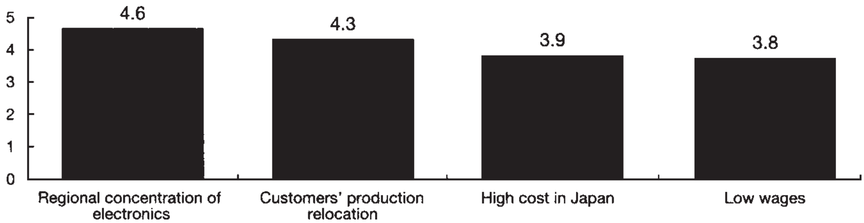


Figure 8.7 Major determinants of production relocation for the Japanese suppliers (average answers based on a 1 to 5 range)

Assembly firms also listed the presence of "investment incentives" as a second pull factor, and the "relatively good level of infrastructure" as a third. This suggests that the host government policy to attract foreign investment and the availability of good infrastructure played important roles in the location decisions, and that these might be more important than the availability of low labour costs, as so often suggested. This implies that the comparative advantage of Malaysia in electronics has changed to favour a higher level of technological sophistication.

All assembly firms reported a rapid increase in total sales, due to both the expansion of their market shares and the progressive relocation of more production lines from Japan. Moreover, according to the Japanese managers, domestic market share accounted for only about one-fourth of the total sales increase, with the rest due to the latter reason. This suggests that the process of industrial relocation is proceeding at a much faster speed than captured by actual government figures on the investment outflows from Japan. In fact, while Japanese FDI data show a relative decline in 1993–5, this only refers to new projects, and does not include the expansion of existing operations due to the further relocation of production lines from Japan (Figure 8.8).

Employment, income and export creation were considered to be the principal direct effects of production relocation from Japan, while technology transfer, the development of supporting industries, and the creation of linkages within the local manufacturing sector were listed by the Japanese firms as the major indirect effects on the Malaysian economy. At the same time, the major benefit for Japanese firms was perceived as "increasing market share" for assembly firms, and

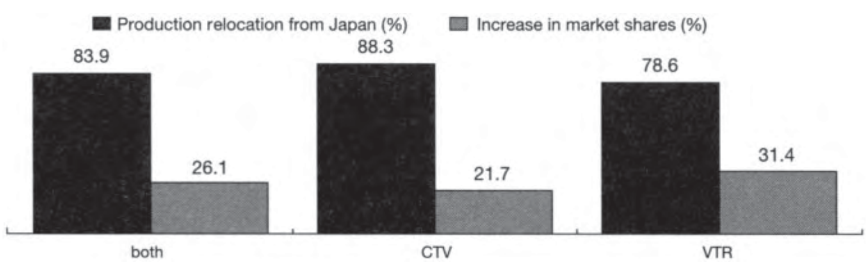


Figure 8.8 Determinants of production activity expansion for Japanese assembly firms

"decrease in production cost" for parts makers.[16] By far, the "lack of skilled labour" was considered to be the principal problem companies faced, by both assembly firms and parts makers (Figure 8.9).

The very high turnover of the work force (due to job hopping) and lack of skilled labour seem to be the major shortcomings adversely affecting technology transfer, increasing the cost of transfers to the Japanese firms, and lowering local absorptive capacity. The structure of the educational system, limited years of schooling and limited number of engineers and technicians in the labour force are problems that will certainly take much to solve. The Malaysian government seems to have undervalued the importance of such education in the past, and the lack of skilled labour is negatively affecting economic development today.

Sales markets and pricing policy of assembly firms

Eight of the nine assembly firms exported almost 100 per cent of their total production to foreign markets. The main reason for this is the generous investment incentives (particularly tax exemptions) for 100 per cent export projects in targeted activities. In some cases, even production destined for the local market was first exported, and then re-imported in Malaysia. In this regard, Singapore plays an important role as an intermediary to trade location, where many of the exported products are frequently first sent before being allocated to their final markets. Moreover, several of the firms in Johor reported having their sales offices in Singapore, while all the firms suggested that the role of Japan as a consumer of products manufactured in Malaysia through "reverse imports" was increasing at a very fast speed.

The Malaysian affiliates usually do not depend on their mother companies in Japan for determining their price strategies. In general, the calculation of prices was said to be based on market prices, while the mark-up on cost strategy was not used much, as assembly firms have considerable discretion in fixing the prices of their procurements. At the same time, while the practice of transfer pricing seems to be widely used, techniques change from firm to firm, and it was quite difficult to obtain such sensitive information. In any case, one could argue that, as a general rule, due to tax exemptions, it may be convenient for the firms to show higher profits in Malaysia than in Japan and consequently apply higher prices for

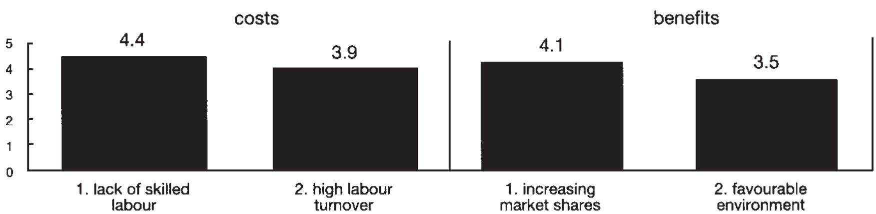


Figure 8.9 Costs and benefits for assembly firms producing in Malaysia (average answers based on a 1 to 5 range)

Malaysian exports or lower prices for imports from Japan in transactions between the mother company and the local affiliate. However, the recent downturn of the Japanese economy has squeezed the mother companies' profits, inducing several firms to shift the burden of some common costs, e.g. the delivering of personnel from the mother company to foreign affiliates. Consequently, changing economic conditions seem to have affected the practices of transfer pricing with foreign affiliates.

Inter-firm technology transfer and local R&D activity

Although industry relocation is proceeding quickly, the technology adopted by Japanese electronics subsidiaries in Malaysia is generally still inferior to that used by their parent companies in Japan. This is due to the costs of technology transfer and to the different economic environments, in particular, level of employees' technical skills and experience, and the availability of specialized economic infrastructures. Management of plant and equipment – which requires considerable knowledge, information-processing ability and experience – particularly seems to fall behind Japanese standards.

The responses to the questionnaire clearly show that the technologies used for maintenance, inventory control, and testing and inspection operations in Malaysia are often inferior to those adopted in Japan. However, the product technology adopted for more standardized products by assembly firms is, in some cases, superior to that used by the mother companies in Japan. While this might be related to the use of more advanced machines, one can also argue that the new international division of labour adopted by Japanese electronics MNCs is increasing local specialization, and the importance of Malaysia is growing (Figures 8.10 and 8.11).

Production co-operation between Japanese assembly firms and their suppliers often involves several forms of technical assistance, aimed at enhancing product characteristics and gaining higher rents from the final product market.[17] The interviews revealed that such assistance provided to suppliers is usually more intense for manufacturing activity, but less so when direct financial support is

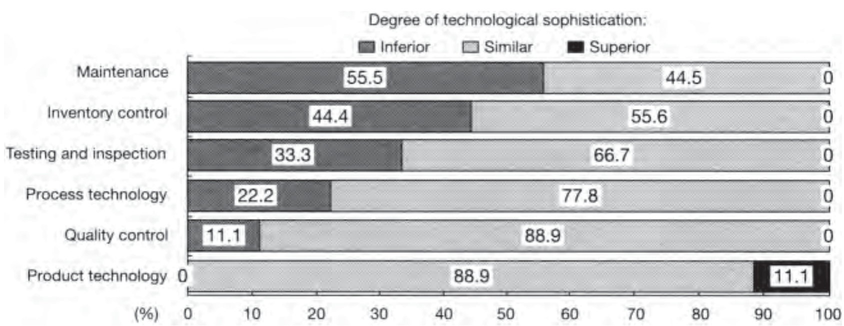


Figure 8.10 Assembly firms' technology adopted in Malaysia compared to Japan

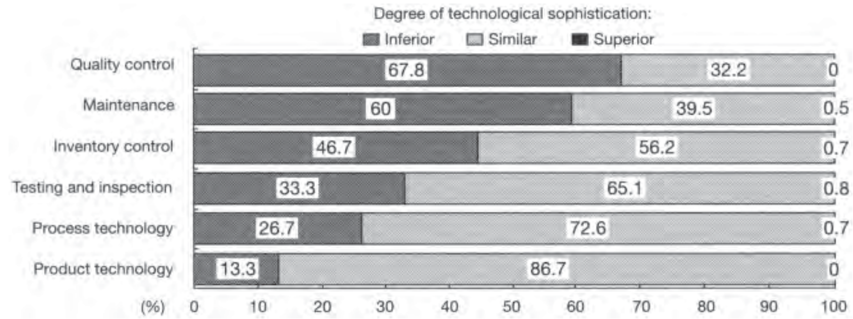


Figure 8.11 Japanese suppliers' technology adopted in Malaysia compared to Japan

required. In particular, the buyers' preferred forms of production co-operation involved: (i) product design specifications, and (ii) advice on equipment use in production operations (Figure 8.12).

The responses to the questionnaire confirmed that Malaysian suppliers' major means of technology acquisition was via their relationship with Japanese buyers. Figure 8.13 shows that the Malaysian suppliers listed "inter-firm relations with buyers" as the most important channel among various ones. This was followed by "joint-venture partners", "purchase of capital goods" and "spillovers from other firms", while "technology licensing" did not seem to be particularly relevant for

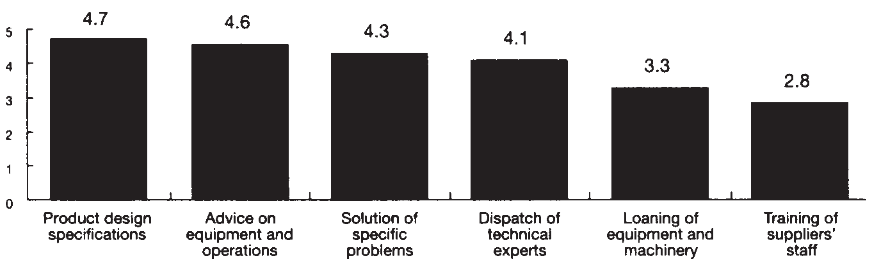


Figure 8.12 Forms of technical assistance to suppliers (average answers based on a 1 to 5 range)

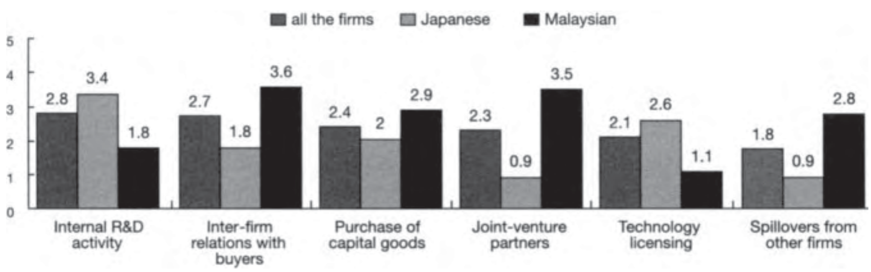


Figure 8.13 Channels of technology acquisition for suppliers (average answers based on a 1 to 5 range)

them. On the other hand, Japanese suppliers emphasized “internal R&D activity” and “technology licensing”, and much less on joint ventures and spillovers.

These findings reveal that Malaysian suppliers rely greatly on their Japanese buyers as sources of technology, and that their average technological level is inferior with respect to that of their Japanese competitors in supplier industries. For instance, their failure to make more use of technology licensing is probably due to their comparatively low degree of absorptive capacity and basic technological knowledge. Accordingly, as the theoretical framework introduced earlier suggests, Malaysian suppliers should devote more resources to increasing their own R&D efforts and to enhancing their ability to make use of externally generated technologies. However, Malaysian firms, compared to their Japanese counterparts, were reportedly less active in visiting their buyers, which provides an indirect measure of Malaysian firms’ weaker efforts to enhance absorptive capacity (Figure 8.14).

Direct forms of technology transfer from buyers mainly involved the introduction of new product and process technologies and solving specific technical problems, while the technical training of personnel, involving more explicit costs for buyers, appears to be less important. These results, which confirm those obtained from interviews with buyers (Figure 8.12), were similar for both Japanese and Malaysian suppliers, but more intense for the latter (Figure 8.15).[18]

The overall improvement of quality and cost performance, induced by the need to fulfil the strict requirements of the Japanese buyers, was the most relevant indirect effect for both Malaysian and Japanese suppliers. However, while the

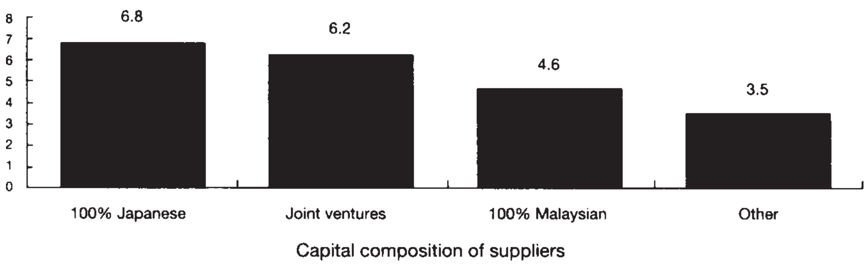


Figure 8.14 Average number of monthly visits from suppliers to buyers

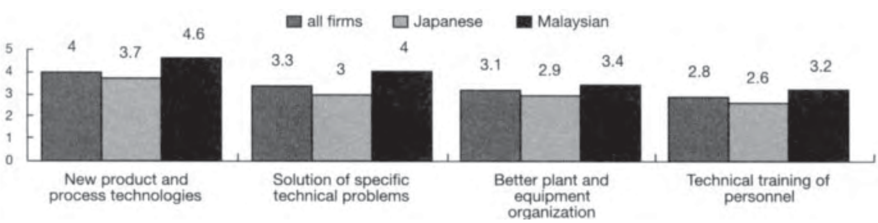


Figure 8.15 Direct effects for locally based suppliers of business transactions with Japanese buyers (average answers based on a 1 to 5 range)

second most important effect for Malaysian firms was exposure to the management style and technology of the buyer, Japanese suppliers listed the exchange of ideas and information in second place, and the reduction of the perceived risk of technology investment, with the provision of a stable source of income from buyers, in third place (Figure 8.16).

The discussion introduced earlier stressed that technology transfer through buyer–supplier relations depends on the buyer's decision to bear related costs and on the supplier's R&D effort to enhance absorptive capacity. However, several factors may constrain the transfer process and may consequently need positive actions for their removal. The suppliers' primary criticism of Japanese assembly firms was related to excessively strict standard requirements and unilateral imposition of prices,[19] which suggest that supplier firms have little bargaining power. On the other hand, Japanese buyers responded that lack of experience and poor technology absorptive capacity were the two major constraints to production co-operation with their Malaysian suppliers, while the main problem with Japanese suppliers was (surprisingly) the difference in their corporate style.[20]

Finally, not one of the thirty-four suppliers, both Malaysian and Japanese, reported "R&D expenses" in their budgets. However, their activities included technological development and knowledge expansion, which were more concentrated on process than on product technologies, and on adaptive more than on innovative efforts. Furthermore, the major constraints to more intense R&D activity were due to the lack of qualified staff, know-how, and internal financial resources, in the case of Malaysian suppliers. The Japanese assembly firms' R&D activities were limited, and focused on the adaptation of product and process technologies originally developed by their mother companies in Japan. However, three large Japanese firms were rapidly expanding their local R&D staff and expenses, both for testing and inspection of the parts and components used in the assembly process and for the development of new products whose basic designs were provided by their mother companies in Japan.

Assembly firms' motivations for undertaking R&D are summed up in Figure 8.17. High marks were assigned to the improvement of the manufacturing process, the quality control and the standards of existing products. In contrast, basic

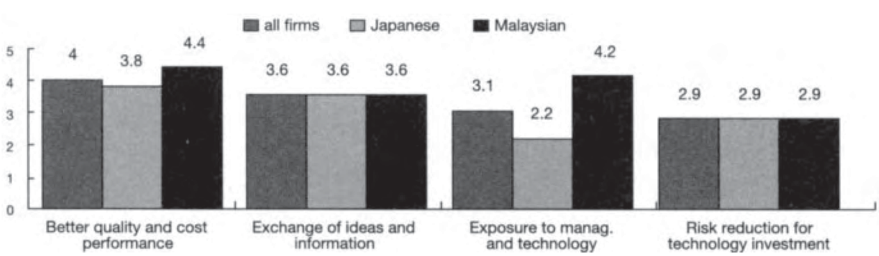


Figure 8.16 Indirect effects for locally based suppliers of business transactions with Japanese buyers (average answers based on a 1 to 5 range)

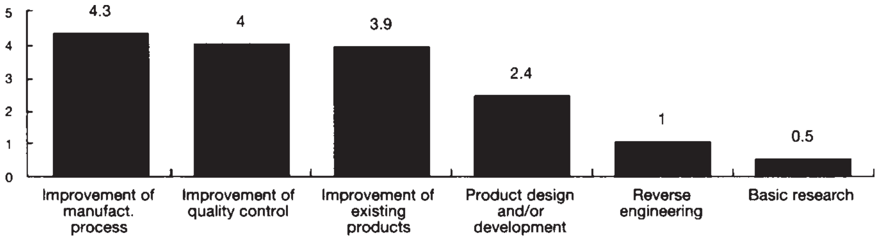


Figure 8.17 Priorities for assembly firms' R&D activity (average answers based on a 1 to 5 range)

research and reverse engineering were reportedly not relevant, while the development and/or design of new products was only important in some cases, i.e. for the three firms mentioned above, whose group corporate strategies had selected Malaysia as their major production centre in Asia.

These results suggest that production relocation of consumer electronics is more rapid than intra-firm technology transfer from the parent company in Japan to the local subsidiary in Malaysia. Although more production experience and further shifts in Japan's comparative advantages will lead to greater increases in Malaysian-based R&D activities, the basic knowledge and core technologies are still maintained in Japan. Our findings indirectly confirm the "technological black box" hypothesis proposed by Yamashita (1991), according to which participation of local staff in final product assembly and of local firms in the provision of parts and components is still limited to relatively simple technological tasks. In fact, as our theoretical framework suggests, the cost of transfer for the technology source is still too high, usually because the recipient's absorptive capacity is not sufficiently developed, in the case of parts suppliers as well as local affiliate staff's technological skills.

Procurement activity and technology transfer

Procurement sourcing of assembly firms

An assembly firm's local input procurement ratio, or "local content ratio", is one of the principal indicators for evaluating technology transfers due to buyer–supplier relations. In fact, the more inputs are sourced locally, the greater the possibility for Malaysian-based parts makers to increase their technical knowledge using the specific channels of production co-operation with their buyers. However, this applies only when the buyers are an important source of technology. Accordingly, the interviews with the assembly firms sought to investigate the determinants of their procurement strategies, and to obtain detailed information about the total procurement shares sourced from different suppliers, by ownership and location.

The nine Japanese assemblers' supplier networks were made up of different types of firms, many of which were Japanese themselves, located in Malaysia, Japan or a third country. All the assemblers belonged to large *keiretsu*, and procurements were, to a certain extent, sourced from parts makers of the same group. Although the strategy of intra-group sourcing varied among the assemblers, as a general rule, the parts involving core technologies were often procured from sister companies of the same group. In contrast, the lower-end technology parts were mainly supplied by "Malaysian" firms.[21] In several cases, these input makers (classified for simplicity as "Malaysian") were joint ventures with third country firms, mainly from Singapore and Taiwan, which had gained previous experience as suppliers to Japanese assemblers in their own country. Finally, another category of suppliers consisted of firms whose capital ownership was entirely non-Malaysian and/or non-Japanese, and located either in Malaysia or in a third country. Such firms included American, European, South Korean and Taiwanese input suppliers.

According to the interviews, the nine assemblers had supplier networks with an average of about 160 firms. However, the average number of suppliers was higher for VTR makers located in Johor (207 firms), than for CTV makers located in Kuala Lumpur (123 firms), the difference due to both technical specifications as well as location characteristics. In fact, the total number of parts required for manufacturing VTRs is larger than for producing CTVs, while the firms located in Johor had easier access to a wide market for electronics parts and components in neighbouring Singapore (Figure 8.18).

The procurement offices of the nine Japanese buyers were asked to provide information about the composition of their supplier networks, by categorizing firms according to their capital ownership (same group, other Japanese, Malaysian, other firms), and location (Malaysia, Singapore, Japan, other countries). Figures 8.19 and 8.20 summarize these results for both the total number of suppliers and total procurements. Figure 8.19 shows that while approximately 60 per cent of all suppliers consisted of Japanese firms – i.e. sister companies belonging to the same group (5.5 per cent) and other independent firms (54.4 per cent) – almost one-fourth of the suppliers (23.6 per cent) were Malaysian firms, and the rest (16.5 per cent) consisted of third country makers. Moreover, about half the

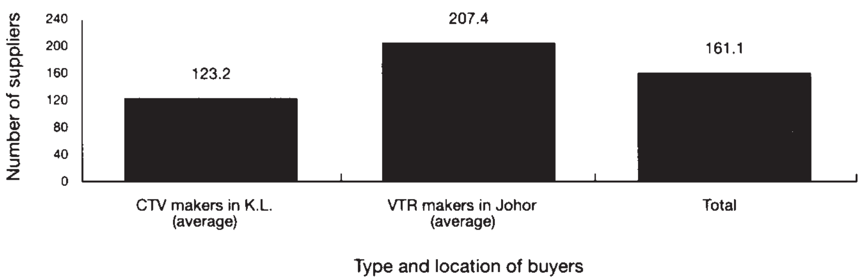
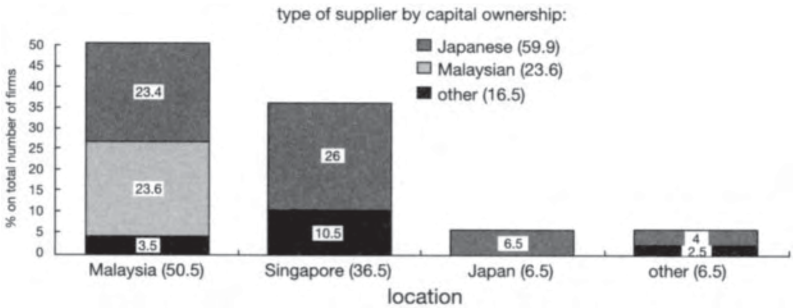
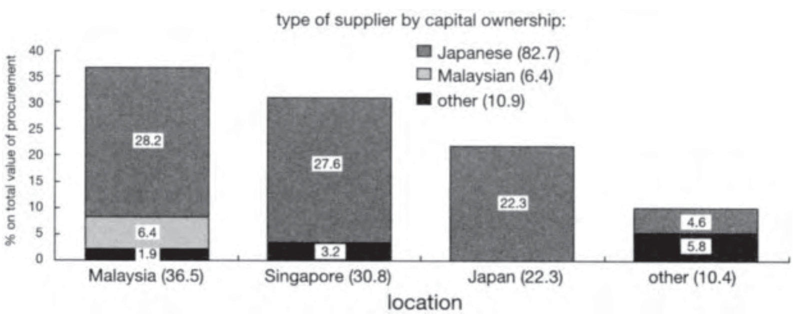


Figure 8.18 Average number of suppliers



Capital ownership/Location	*Malaysia*	*Singapore*	*Japan*	*Other*	*Total*
Same group	1.1	2.7	1.0	0.7	5.5
Other Japanese	22.3	23.3	5.5	3.3	54.4
Malaysian	23.6	0	0	0	23.6
Other firms	3.5	10.5	0	2.5	16.5
Total	50.5	36.5	6.5	6.5	100.0

Figure 8.19 Procurements sourcing by assembly firms (no. of firms) (average share of total number of procurements by sourcing firms)



Capital ownership/Location	*Malaysia*	*Singapore*	*Japan*	*Other*	*Total*
Same group	15.9	8.6	8.5	1.2	34.2
Other Japanese	12.3	19.0	13.8	3.4	48.5
Malaysian	6.4	–	–	–	6.4
Other firms	1.9	3.2	–	5.8	10.9
Total	36.5	30.8	22.3	10.4	100.0

Figure 8.20 Procurements sourcing by assembly firms (total value) (average share of total value of procurements)

total number of suppliers were located in Malaysia, a third in Singapore, 6.5 per cent in Japan and the rest in other countries, especially in East Asia,

However, this picture of the assembly firms' supply networks drastically changes if one considers the actual shares on total procurements. Figure 8.20 shows that the share of Japanese firms in the total cost of inputs was 82.7 per cent. In particular, sister companies had 34.2 per cent of the total. In contrast, the share of Malaysian firms decreased to 6.4 per cent, while that of third country firms was 10.9 per cent. Moreover, with regard to the location of the firms, the share of total procurements sourced in Malaysia decreased to 36.5 per cent, and in Singapore to 30.8 per cent, while that in Japan increased to 22.3 per cent.

These data suggest that Japanese assemblers of consumer electronics mainly procured expensive, technology-intensive inputs from a few suppliers belonging to the same group of companies. Other Japanese makers – representing almost half the total number of firms as well as half the total cost of procurements – principally supplied intermediate technology products. Cheap and less technology-intensive parts were more likely to be sourced from locally based "Malaysian" firms, whose number was much greater than their share of total procurements.

Hence, the share of parts and components procured by the nine Japanese CTV and VTR makers from suppliers located in Malaysia was, on average, less than 40 per cent of the total: the share of Malaysian companies, in particular, was only 6.4 per cent. This means that being "made in Malaysia" refers mainly to the location of the assembly factory, and does not imply being "made by Malaysian firms". In fact, inputs are, by far, sourced primarily from foreign companies, especially Japanese ones, with most technologically sophisticated parts imported from abroad.

Determinants of local procurement strategies

In recent years, increasing local content has become a major issue for Malaysian industrial and technology policy. However, any successful policy to overcome the problem of low procurement ratios from Malaysian companies in the field of consumer electronics must be based on an understanding of what shapes Japanese assemblers' procurement strategies. The results of an econometric exercise on the determinants of the local procurement strategy of Japanese electronics affiliates in Malaysia provide some insights on the likely roles of the potential sources of technology for upgrading the local supporting industry within the framework of technology transfer via buyer–supplier relations.

From the point of view of a Japanese assembly firm located in Malaysia, deciding how much to source locally is affected by two groups of variables: (i) firm-specific variables, which characterize the firm itself (either the subsidiary, the parent in Japan, or both); and (ii) country-related variables, which define the procurement environment in Malaysia.

With regard to firm-specific variables, the length of production experience of Malaysian affiliates is probably positively related to increased local sourcing. In fact, the shift from old to new suppliers, adaptation to the new economic environment, the stimulation effect on the local supporting industry created by the presence of assembly MNCs, and a number of other related factors, require some time to become significant. Consequently, a lower proportion of local parts and components can be expected during the early period of production operations.

Second, equity ownership affects local sourcing; the presence of local capital and management encourages the use of local parts. The ratio of local procurement should therefore increase in the case of joint ventures with Malaysian firms or when investment occurs through acquisition of or capital participation in the equity of an already established local company. In other words, procurement of local inputs probably decreases in wholly owned Japanese subsidiaries and with greenfield investments.

Third, procurement strategy will change with the degree of final product sophistication, as the technological requirements of inputs vary accordingly. For instance, by using the destination of sales as a proxy for product quality, and by assuming that the quality of locally sold final products is, on average, lower than that required for exports, one can expect the procurement of lower technology-intensive parts from Malaysian firms to increase with the share of local sales.

Fourth, the size of the subsidiary may be another relevant factor affecting procurement decisions. It is, however, quite difficult to predict *a priori* whether the relationship between the two variables will be positive or negative. In fact, as the large Japanese electronics MNCs are usually affiliated to vertical *keiretsu*, they may enjoy economies of both scale and scope within the group, and consequently be induced to maintain high intra-group procurement ratios. In turn, this will lower local sourcing to the extent that sister companies – following a strategy of regional production specialization – are not located in Malaysia. On the other hand, one can also argue that large firms will be under greater pressure from national authorities to increase local content, and therefore expect a larger share of parts and components to be procured in Malaysia by such firms.

Fifth, another important factor affecting MNCs' procurement or sourcing strategies is the parent firm's technological innovation effort. A high R&D/sales ratio of the mother company in Japan is probably associated with a higher share of "in-house", or "intra-group", input sourcing by local affiliates, and hence a lower share of local input procurement. In fact, the technology gap between Malaysia and Japan is still large and parent R&D activities will tend to be carried out in Japan or in other more advanced countries.

The input procurement strategy of Japanese subsidiaries is also affected by country-related variables. First, the concentration ratio of supporting industries for consumer electronics in Malaysia, and their standards (quality, cost, delivery), will be positively related to increases in the local procurement ratios of parts and components. In fact, the greater the availability of input producing firms, the higher the ratio of local procurement; conversely, the scarcity of suppliers implies a lower local procurement ratio.

Second, the existence of strict policy requirements for increasing the local content of "made in Malaysia" electronic goods should induce the growth of the locally procured share of parts and components. Sometimes, however, such regulations may also have the perverse effect of discouraging this, also limiting the extent of technology transfer.

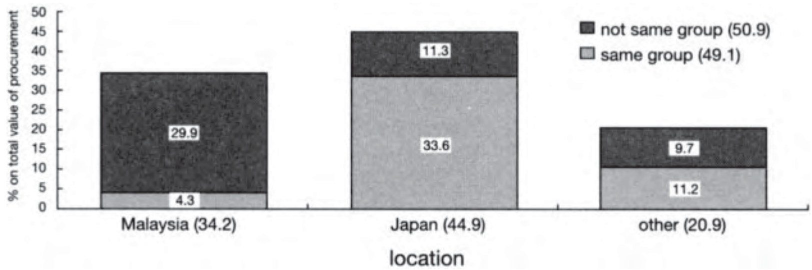
Third, the suppliers' absorptive capacity will be positively related to the input procurement ratio. It was argued earlier that the cost of technology transfer is reduced when the technology recipient has a higher absorptive capacity. This will in turn be associated with a lower cost of production, that will increase the procurement ratio of parts and components, so that a positive relationship between local sourcing and the absorptive capacity of firms operating in Malaysia can be expected.

Fourth, an increase in the availability of economic and social infrastructure as well as of human capital will be associated with a higher local input procurement ratio due to the decrease in production cost, reduction of delivery time and increase in the quality of parts supplied by locally based firms.

Findings by Fukao and Capannelli (1996) and by Belderbos *et al.* (1996)[22] for the world-wide operations of Japanese firms tend to confirm the expectations discussed above on the relationship between these explanatory variables and the extent of local sourcing, with the single exception of government local content regulations.[23] The signs of the firm-specific variables suggest, in fact, that local input procurement increases with longer production experience in the foreign location, but decreases if the local affiliate is established as a wholly Japanese-owned greenfield investment, and with higher R&D/sales ratio of the parent company. Similarly, the country-related variables show a positive sign for both the regional concentration ratio of the electronic parts industry as well as for the country's GDP per capita, which is used as a proxy for the presence of local absorptive capacity, human capital and infrastructure. However, regulations on local sourcing were, surprisingly, found to be inversely related to increasing the local input procurement ratio. While this result was contrary to expectations, it suggests that government local content policies may actually constrain the transfer of technology from foreign multinationals to local firms if impositions are too strict.

Another study only focusing on Japanese electronics subsidiaries in Malaysia was attempted using the same data set, hypotheses and specifications of the econometric model (Capannelli 1996a). The MITI survey included eighty-three responses by Japanese electronics firms in Malaysia, but the sample used for the regression was limited to only thirty-nine firms which provided complete information on their input sourcing. Interestingly, the local input procurement ratio of these thirty-nine firms was, on average, 34.2 per cent of the total value of procurements (Figure 8.21). This is quite consistent with our interviews with the nine CTV and VTR assembly firms, according to which the local input procurement ratio was 36.5 per cent (see Figure 8.20). Consequently, these results encourage us to believe, with a good degree of confidence, that during the first half of the 1990s, the locally sourced share of the total procurements of Japanese electronics subsidiaries located in Malaysia was around 35 per cent.

The specifications of the model – including the calculation of the dependent variable, the explanatory variables, the regression functions, and the expectations



Location	*Malaysia*	*Japan*	*Third country*	*(Asian country)*	*(Non-Asian country)*	*Total*
Capital ownership						
Same group	4.3	33.6	11.2	6.6	4.6	49.1
Not the same group	29.9	11.3	9.7	9.4	0.3	50.9
Total	34.2	44.9	20.9	16.0	4.9	100.0

Figure 8.21 Procurements sourcing of Japanese electronic firms in Malaysia (share of total value of procurements – population average of MITI sample, 1992)

of the sign of their coefficients – are described in Table 8.8. Although the restriction of the model to Malaysia excludes the possibility of using country-related variables, the MITI data enable us to consider government policy, as local procurement obligations were mentioned in the firms manufacturing licences. As a consequence, the regression included four variables describing the characteristics of local affiliates in Malaysia, two variables relating to the parent companies in Japan, and also one variable evaluating local sourcing regulations. Moreover, two dummies were introduced to distinguish the industrial and electronics parts makers from the assemblers of consumer goods.

Concerning the variables relating to local affiliates, a positive relationship for the local procurement ratio was expected for production experience (TIME) and the local sales ratio (LOSARA), but a negative relationship was expected in the case of greenfield investment totally owned by Japanese capital (JAGREE), while the influence of size (LNTOSA) was uncertain. With regard to parent company characteristics, both *keiretsu* affiliation (PAKEIR) and the R&D/sales ratio (PARDSA) were expected to have negative impacts on local procurement. Furthermore, the local procurement ratio was expected to increase with policy measures aiming to increase local content (RELOS), and to decrease if Malaysian affiliates were classified as manufacturers of industrial goods (INDS2) or electronic parts (INDS3). The results of the regression exercise are reported in Table 8.8. Apart from firm size, whose coefficient is not statistically significant, time experience, local sales ratio and the cases of wholly Japanese-owned investment all had significant and positive impacts for increasing the local input procurement ratio. The expectations for the signs were confirmed for production

Table 8.8 Tobit estimates of Japanese electronics MNCs' local procurement ratio in Malaysia

LOCOR	*Dependent variable* (*local procurement + value added*)/ (*total part procurement + value added*)*
	Explanatory variables
TIME	number of months from the start of production until March 1992
JAGREE	dummy: 1 if the affiliate's equity is 100% owned by Japanese capital and the investment is greenfield (0 otherwise)
LOSARA	affiliate's local sales ratio = (local sales/ total sales)
LNTOSA	natural logarithm of the affiliate's total sales
PAKEIR	dummy: 1 if the parent company in Japan belongs to one of the nine largest *keiretsu* groups (0 otherwise)
PARDSA	parent firm's R&D intensity = (R&D expenses/total sales)
RELOS	dummy: 1 if the company states the presence of government regulations on local sourcing (0 otherwise)
INDS	dummy variable to distinguish the industrial classification of the firm:
INDS(1)	consumer goods
INDS(2)	1 = industrial goods, 0 otherwise
INDS(3)	1 = electrical and electronic parts, 0 otherwise

* Note that LOCOR has been calculated as follows:
LOCOR = (total sales - total imports)/(total sales - imports of finished goods),
where value added = total sales - total procurement
total procurement = total part procurement + imports of finished goods
local procurement + value added = total sales - total imports
local part procurement + value added = total sales - imports of finished goods.

Dependent var. *LOCOR*	*1.*	*2.*
TIME	0.00121***	0.00120***
	(3.500)	(3.907)
JAGREE	0.21817**	0.21572**
	(2.695)	(2.945)
LOSARA	0.35642***	0.35907***
	(3.477)	(3.760)
LNTOSA	−0.00291	
	(−0.071)	
PAKEIR	0.01460	0.01553
	(0.176)	(0.190)
PARDSA	0.04225	0.02396
	(0.049)	(0.029)
RELOS	0.19477***	0.19630***
	(3.449)	(3.757)
INDS(2)	−0.11396	−0.11324
	(−0.877)	(−0.874)
INDS(3)	−0.18560	−0.18061*
	(−1.509)	(−1.785)
constant	0.24784	0.22131**
	(0.645)	(2.429)
Log likelihood	18.989713	18.987187
Pseudo R2	−2.2521	−2.2516
No. obs.	39	39

*** significant at the 1% level; ** significant at the 5% level; * significant at the 10% level; t-values in brackets.

experience (TIME) and the local sales ratio (LOSARA), which account for the quality differences. Nevertheless, the effect of experience appears to be low, with a coefficient of 0.00121, meaning that after 10 years of production operations in Malaysia, the ratio of local procurement was only increased by 14 to 15 per cent.

The results of the regression did not, however, confirm expectations about the mode of investment, as the dummy variable for total Japanese ownership and new investment (JAGREE) was positively related to an increasing local procurement ratio. This outcome is interesting, as it diverges from the findings on the world-wide operations of Japanese electronic subsidiaries presented above. A possible explanation for this difference may be the fact that since the concentration ratio of Japanese electronic firms in Malaysia is now very high compared to many other offshore locations, wholly Japanese-owned greenfield projects probably invest there specifically to interact with other Japanese suppliers and customers, whereas joint ventures established earlier have already formed supplier relations involving lower levels of local sourcing. Following the earlier discussion, one can also argue that an increase in a mother company's equity share in its Malaysian subsidiary will foster technology transfer from Japan, first to local affiliates, and then to locally based input producers through buyer–supplier relations. As a consequence, opportunities for the development of local supporting industries will be expanded.[24]

While the two variables related to the parent firm (PAKEIR and PARDSA) were not significant, a variable which performed quite well was that associated with policies for local sourcing (RELOS), whose coefficient was highly significant and positive. Interestingly, while this result confirms the expectations formulated above, it contradicts the world-wide regression findings, for which the presence of restrictions on procurements had an opposite effect to that intended by hostcountry authorities. Also, the high regional concentration of electronics in Malaysia might account for this divergence from the global sample. Moreover, this difference suggests that regulations for local procurement imposed by the Malaysian government are not so strict as to discourage further localization of input sourcing. We should, however, remember that RELOS is only an indirect measure of the role played by the local authorities which does not provide qualitative information on the actual effects of different policies.

The results of this econometric analysis show that Japanese electronics MNCs' procurement decisions are affected by both firm and host country characteristics. In the case of Malaysia, production experience, wholly Japanese-ownership of greenfield projects, local sales ratio and regulations for input sourcing are positively related to increases in local procurement. However, the data available from the MITI survey do not distinguish between the different nationalities of the suppliers. Accordingly, we do not know whether an increase in local sourcing will primarily benefit Malaysian, Japanese or third country suppliers. In any case, the earlier discussion has shown that industry relocation from Japan induces an expansion of local supporting industries in Malaysia and creates several opportunities for technology transfer through buyer–supplier relations: the firms most likely to benefit from it are those which have successfully invested in their own capacity to absorb such technology.

The problem of low procurement from Malaysian firms

Finally, let us reconsider the "made in Malaysia" versus "made by Malaysia" problem, which is related to the low input procurement ratio from local firms. Our findings have shown that in the case of Japanese consumer electronics affiliates, the share of parts and components procured from Malaysian-located firms is close to 35 per cent, while that procured from Malaysian-owned firms is below 7 per cent. Although judgment over the appropriate share of parts and components to be procured from Malaysian-located and/or Malaysian-owned firms is indeed arbitrary, what should we conclude from these results?

As the purpose of the present study is to investigate technology transfer generated via buyer–supplier relations involving Japanese consumer electronic firms in Malaysia, the low input procurement ratio appears to be a major constraint to the transfer of technology through this specific channel. In other words, one could say that approximately only one-third of the "potential" transfer of technology created via buyer–supplier relations is flowing to Malaysian-located supporting industries, and that only a small part of this (6.4 per cent) involves Malaysian-owned firms. However, while the problem of the low procurement ratio from local firms remains, this might not be the proper way to quantify the results, and before drawing conclusions, we should make proper qualifications and consider other related issues as well.[25]

First, evidence from the interviews has shown that the share of total procurement sourced from Malaysian-owned firms is far below its share of all supplier firms, and that the share sourced from Japanese companies, especially those located in Japan, is far above its share of the number of suppliers. This suggests that a relatively large number of Malaysian suppliers provide only low-cost, low-technology-intensive parts, while a relatively small number of firms supply the most expensive, high-technology-intensive parts from Japan. However, one should also keep in mind that the difference is due to the fact that just a few expensive parts account for a very large share of total costs, and that the channel of technology transfer via buyer–supplier relations is not effective in the case of high-technology parts, as the buyer is not usually a source of technology but, on the contrary, could easily be the recipient. Consequently, the analysis should only be restricted to medium- and low-technology-intensive parts which, on average, form no more than half the total cost of procurement for the two representative products (see Figure 8.5).

This restriction makes particular sense for a country like Malaysia, where the development of the consumer electronics industry is only a recent (albeit very rapid) phenomenon, and the average technological capability of locally-owned input makers is still far from the international technological frontier for highly sophisticated products, with the exception of a few selected firms, especially in the semiconductor industry in Penang. In this regard, one should also consider that the development of firm capabilities for technology-intensive production is a long-term process which requires expertise, huge investment in R&D and a favourable domestic environment. Accordingly, the co-operation with the assembler and a policy to support indigenous technological progress which stresses the formation of human capital and provides financial assistance to firms would greatly promote the gradual upgrading of locally owned input makers to higher technological levels.[26]

Second, according to both the interviews and the econometric exercise, some major determinants affecting a firm's input procurement decisions have been found to be the firm's local production experience, its sales strategy and government policy. In particular, Japanese firms tend to increase their local procurement ratio the longer their production has been relocated in Malaysia, the higher their local sales ratio and the stronger the government regulations encouraging local sourcing. Accordingly, one can speculate that the low procurement ratio from local firms is in part due to the relatively limited production experience in Malaysia, the fact that the average export/sales ratio was close to unity for almost all firms[27] and the overall ineffectiveness of regulations for increasing local sourcing from Malaysian firms.[28]

Third, the low share of local procurements from Malaysian firms is also determined by the limited presence of locally-owned firms and by the relatively low quality standards of many local companies. In fact, before the industry relocation process from Japan started, the local supporting industry in Malaysia was composed of only a few companies and, even today, the entry of locally-owned firms is relatively low in comparison to business opportunities. Nevertheless, during the last decade, a growing number of fairly successful joint ventures between local partners and third country firms have been established. Those in the consumer electronics sector are usually formed with Singaporean or Taiwanese companies that have acquired experience as suppliers to Japanese MNCs in their own countries. Moreover, it can be argued that past government policy shaped industrial structure, with a few small and medium-sized producers of electronic components, and that this has, in turn, facilitated the recent industry-wide relocation from Japan, in particular of many small and medium suppliers, for whom entry barriers from Malaysian competitors were relatively low.

Fourth, the figures show that the relatively low share of local procurement in Malaysia is also due to the very important role of Singapore as a sourcing country. Indeed, the large and long-term presence of Japanese firms in Singapore, now often used as a procurement centre for regional operations of MNCs, is a plausible explanation for this.[29] As a matter of fact, some of the Japanese assembly firms interviewed considered procurements from Singapore to be "local".

Fifth and last, the very high procurement ratio from other Japanese firms, wherever located, can also be explained by the importance that the Japanese sub-contracting system traditionally gives to long-term relationships, and also by the fact that many Japanese parts suppliers have strong incentives to follow the earlier relocation of their customers to Malaysia.[30]

The problem of the low procurement ratio from Malaysian firms is strongly influenced by these five factors. Indeed, local companies only receive a small slice of the pie, while their inclusion as suppliers to the Japanese MNCs would greatly help the technological upgrading of locally-owned supporting industries. The theoretical framework introduced earlier suggests that more effort is required, both for lowering the costs (or increasing the profits) to the buyers to shift to procurement from Malaysian sources, as well as for enlarging the local absorptive capacity of foreign technologies. Accordingly, actions should be taken on both sides.

Japanese government agencies, like the Japan External Trade Organization (JETRO) or the Japan International Cooperation Agency (JICA), can implement transfer programmes for specific technologies to complement the relocation of consumer electronics industry to Malaysia. For instance, the moulding technology for plastic injection operations is an interesting field where Japan has already accumulated great knowledge and experience. However, as a consequence of the relocation abroad of downstream industries, it is no longer vital for industrial growth in Japan and should be relocated abroad.[31] At the same time, the Malaysian government should actively promote the formation of local supporting industries through better-tailored policies. There are, at least, three important fields for improvement: (i) enlarging the stock of human capital and enhancing its quality; (ii) providing incentives to foster the development of local entrepreneurship; (iii) designing a more effective policy to promote the use of local vendors.

With particular regard to this last point, many Japanese buyers reported that they were asked by the Malaysian authorities to include some selected firms within their suppliers' network, as suggested by the "vendor development programme", a project aimed at increasing sourcing from local firms. However, while the Japanese MNCs were encouraged to take part in the project by the support provided by the government, they also pointed out two major problems. First, the firms included in the list were not competitive, even with respect to other Malaysian suppliers. Second, monitoring by authorities of actual project implementation was limited merely to counting the number of enrolled suppliers, without any check on the amount of procurement or product characteristics. This suggests the need for a revision of the policy, since it does not appear to be based on strong performance criteria, is probably not really fostering the actual development of locally owned supporting industries, and seems likely to discourage efficient production. In fact, without proper monitoring activities, buyers will be induced to fulfil government requirements by just providing a minimal volume of business transactions to Malaysian suppliers.

While there is room for significant improvements to government policies encouraging local sourcing, a major finding of the field work is that the chief obstacle was the scarcity of Malaysian suppliers with quality standards sufficient to compete with Japanese and other foreign supplier firms. Consequently, a first condition for the development of locally-owned supporting industry is that a larger number of Malaysian entrepreneurs enter these industries, and invest more resources in building their technological absorptive capacities. Only if local firms' absorptive capacities are raised, will they be able to internalize the benefits from the potential transfer due to the presence of foreign assemblers. This, in turn, requires the existence of both an innovative management approach, as well as sufficient capital for technology investments. While local firms may not have ready access to such assets, an effective way to acquire them may be through joint ventures with foreign partners, either Japanese or other nationalities.

In conclusion, we have seen that the surge of Japanese FDI to East Asia during the last decade has fostered host countries' industrial development. In particular, a process of industry relocation from Japan to Malaysia has occurred in the electronics sector. This process includes not only the transfer of final assembly operations, but also of intermediate parts and components production, and is contributing greatly to the expansion of local supporting industries. However, the participation of Malaysian firms in the different stages of production is still very limited and concentrated in low-end technology inputs. This is especially because only a small number of Malaysian suppliers operate in the industry and their technological capacity needs to be upgraded.

While recent economic literature has emphasized the role played by FDI in technology transfer, little attention has been placed on the particular channel of buyer–supplier relations between final assembly firms and their networks of locally-based makers of parts and components. The interviews with forty-three Japanese electronic firms in Malaysia revealed the importance of this channel, especially for the technological upgrading of local companies. However, the costs for Japanese assembly firms to increase their procurement ratios from local firms is still relatively high, while the technological absorptive capacity of Malaysian suppliers is not great enough to benefit fully from the presence of foreign multinationals.

Notes

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1 Several authors have stressed the importance of technology transfer processes involving FDI. See, for example, Ruffin (1993), Tran (1993), Petri (1995), Wakasugi (1995), Yamashita (1995).

2 The stimulation of local technology induced by the presence of FDI can also refer to

R&D contracts with local firms, but this work focuses only on the inputs' procurement activity.

3 This proposition can be considered as an adaptation of the "technology gap" theory, and accordingly will hold until the speed of knowledge creation of Japanese assembly firms is faster than that of Malaysian parts suppliers.

4 See the next two sections.

5 There are cases where the deliberate transfer of technology from the source only involves negligible costs such as the provision of technical specifications and "blueprints". However, in so far as they depend on decisions of the source, they are included in the first category of "intentional transfer".

6 The classification of the technology transfer process via buyer–supplier relations into four stages and the distinction between "intentional transfer" and "spillovers" are inspired by the seminal work of Wong (1991). For a more detailed discussion of this latter point, see Capannelli (1994, 1996b).

7 This approach was initially proposed by Aoki (1988) and then investigated by Asanuma (1988). Furthermore, an interesting contribution is also provided by Helper (1990) who presents an application of the Hirschman's "exit-voice" approach. See also Hirschman (1970).

8 The division of the rents captured in the final product market between the buyer and the supplier is decided by their relative bargaining power. In this regard, various models have proposed different ways in which this surplus may be allocated between firms. For instance, one could think that the price the buyer pays for components under a procurement contract includes a share of the extra revenues created through co-operation (Helper and Levine 1991). Or, on the contrary, one could argue that the procurement contract will allow the supplier a fixed profit over costs, leaving the entire rent from their co-operation to the buyer (Kawasaki and McMillan 1987). For a more detailed discussion on the implications of this rent-seeking approach, see Capannelli (1996b).

9 A firm's absorptive capacity affects its ability to perform three fundamental technological activities: imitation of product or process innovations; use of external knowledge for internal applications; and creation of new knowledge. Cf. Cohen and Levinthal (1989).

10 Here, the buyer is considered technologically more advanced and it can therefore only rely on its own R&D efforts (there are no indirect spillover benefits from the supplier).

11 To clarify this point, we can compare two different buyers (technology sources) with the same amount of R&D expenses, but with different strategies for transferring technology to their input suppliers, and argue that the increase in the firm's new knowledge will be larger for the buyer who invests more intensively in activities especially devoted to technology transfer.

12 According to Cohen and Levinthal, such absorptive capacity is a function of the firm's effort for new knowledge creation and of the technological sophistication of the manufactured input.

13 A formalization of this model of the "two faces" of technology transfer has been proposed by Capannelli (1996b).

14 As a matter of fact, the island of Penang is another major centre for electronic production in Malaysia, but due to both logistical problems and the relatively higher concentration in this area of electronic parts production of semiconductors and integrated circuits, the field work was limited to Kuala Lumpur and Johor.

15 Contact with these firms was kindly organized by the Kuala Lumpur office of Japanese External Trade Organization (JETRO) and by the Japanese Chamber of Trade and Commerce in Malaysia (JACTIM).
16 Interestingly, the local affiliates of the largest MNCs noted that in recent years their mother companies had tried to introduce systems for transferring back to Japan the experience of staff who had worked abroad, with exposure to different environments making a big contribution. While the case of Malaysia was said to be particularly interesting for the ethnic composition of its population, these new activities by the mother companies were generally supposed to improve the organizational structure of the whole group, especially through the introduction of new ideas and problem-solving approaches.
17 See the earlier discussion.
18 The formation of direct and indirect effects in a technology transfer process via buyer–supplier relations is discussed in relation to Figure 8.4.
19 Malaysian suppliers also suggested that the pervasive use of Japanese was quite an important problem for them.
20 More detailed results are presented in Capannelli (1996a).
21 The firms classified as “Malaysian” include the following: (i) 100 per cent Malaysian capital; (ii) minority joint ventures with Japanese firms; (iii) all joint ventures with third country firms (see previous section).
22 These two studies analyse the effects of firm and country variables on the local procurement strategy of Japanese electronics MNCs using a data set based on the “1992 Kaigai Jigyo Katsudo Kihon Chosa” (1992 Basic Survey on Foreign Affiliates Activity), Ministry of International Trade and Industry, Japan.
23 In these two studies, the determinants of the local input procurement ratio have been estimated using a Tobit model to account for the censored distribution, between 0 and 1, of the dependent variable. The dependent variable was calculated to evaluate the contribution to the whole economy of the host country. Accordingly, it included value added: [local procurement ratio = (local procurement + value added) / (total procurement + value added)].
24 The fact that an increase in the equity share of a local affiliate owned by the mother company is negatively related to the cost – and, consequently, positively related to the extent – of technology transfer is shown by Ramachandran (1993).
25 It should also be pointed out that the calculation of the local procurement ratio used to obtain these figures does not capture the real contribution to the local economy of the investment as value added is not included.
26 One can also observe that if Japanese assemblers were forced to source high-technology components from locally-owned firms which are still lagging behind the level of their foreign (especially Japanese) competitors, the increased cost of technology transfer to preserve product quality might induce them to shift their production facilities to other locations.
27 With regard to the importance of the domestic market, it should be pointed out that the local procurement ratio was much higher for firms which established their production facilities in Malaysia during the period of import-substitution, compared to those which relocated in recent years. In fact, the relatively lower quality standards required for final products destined for the domestic market could be met by a larger number of locally sourced inputs, while the stricter requirements demanded for exports favour a greater use of imported components.

28 The government has introduced some schemes for increasing local procurement such as the "vendor development programme". However, the impression received from interviews was that they have not been very effective in increasing the real participation of local firms in the networks of Japanese buyers.

29 See Chia (1995) on the role of Singapore as a centre for MNCs' procurement operations in East Asia.

30 With regard to this point, some critics insist that it is sometimes almost impossible for external firms, especially foreign ones, to enter the tight network of Japanese *keiretsu*.

31 Recently, some interesting programmes in this field have been promoted by JETRO, JICA and JACTIM.

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9

GOVERNMENT–BUSINESS CO-ORDINATION AND THE DEVELOPMENT OF ENG HARDWARE*

Rajah Rasiah

Malaysia had a fair number of small-scale metal engineering firms at the time of independence in 1957. The local metal engineering industry, owned primarily by ethnic Chinese, had developed with growing demand from tin mining, infrastructure maintenance, agricultural processing and consumer industries during the colonial period (Rasiah 1995: chapter 3; Malaya 1957). The industry was mainly characterized by simple fabrication and foundry work, and operated primarily as backyard workshops. Local firms had little experience in precision engineering works and no automated machinery development capabilities. They occupied the bottom rung of slowly evolving simple productive capabilities within the technology trajectory. The technological capabilities of these firms began to change substantially from the 1980s. Starting with simple backyard metal tooling activities, some ethnic Chinese firms in Penang began to engage in precision engineering operations in the 1980s. These firms had developed substantial high precision engineering and fully automated machinery manufacturing capabilities by the end of the 1980s. By the mid-1990s, these firms had acquired original equipment manufacturing (OEM) capabilities. Eng Hardware, along with its subsidiary Eng Technology,[1] is one such concern which has successfully carved out a niche in the high precision machine tool market.

Eng Hardware began as a typical Chinese family venture in 1976. Unlike most Chinese businesses which have developed by servicing the primary and inward-oriented manufacturing sectors, however, Eng Hardware's growth has been associated with export-oriented manufacturing – particularly semiconductor assembly and test operations in the state of Penang. Eng Hardware's successful growth initially took off following links established with American semiconductor firms in Penang and later with a wide spectrum of other firms.

To explain the quantum leap in Eng Hardware sales and involvement in high precision engineering technology, it is necessary to examine the governance factors that helped shape its evolution. It will be shown that changes within some transnational' production arrangements provided the impetus for the development of local machine tool firms in Malaysia. The relatively open managerial styles of American firms, compared, say, to Japanese firms, has meant that US companies continue to be the dominant players in Eng Hardware's development. Also, Eng Hardware's development has been correlated with growth in machine tool demand by semiconductor firms. Entrepreneurial development in Eng Hardware became particularly strong after strong buyer–supplier links were established with such transnationals.

This chapter examines the pull factors that attracted US semiconductor firms to Malaysia. It analyses the underlying rationale behind the growth of Eng Hardware's machine tool sales. The three major influences that have operated with varying intensities to account for Eng Hardware's rapid growth in machine tool production are then discussed.

Government role

Eng Hardware's main technology suppliers and output purchasers, semiconductor firms, located in Malaysia in direct response to federal and local state government efforts to woo foreign direct investment. The intermediary role of state government and its development corporation was critical for the initial establishment of links with foreign transnationals and for subsequent supply of infrastructure and other facilities, including federally coordinated incentives from 1989. Eng Hardware's production technology was simple and its markets small until transnational semiconductor firms fostered its expansion in the 1980s. The initial period of emergence and expansion involved little federal government support, biased against linkages, while cumbersome customs controls associated with FTZ procedures remained. The Chinese-led state government of Penang played a critical role in the establishment of buyer–supplier ties between semiconductor firms and Eng Hardware (Rasiah 1987).[2]

Much of the initial federal support for the evolution of machine tool firms came indirectly, and in some sense fortuitously. There was no clear intent to attract semiconductor firms in order to spawn local machine tool firms when the government first launched its export-oriented industrialization policy in 1968 with the Investment Incentives Act. Semiconductor firms only began relocating in Malaysia after the Free Trade Zone Act was enacted in 1971 and the subsequent opening of the zones in 1972. National Semiconductor – the first such firm to commence operations in Malaysia – built its factory in Bayan Lepas in 1971 and started production in 1972. The factors that drove semiconductor firms away from their original locations have been documented elsewhere (see Lim 1978; Rasiah 1987). Government efforts to woo export-oriented manufacturing firms have been critical in at least four important ways:

- Legislation offered financial benefits in the form of:
  – pioneer status, which gave tariff exemptions for imports and exports, and

tax holidays for five to ten years. Firms were thus exempted from corporate income tax, then of 35 per cent, and development tax of 5 per cent;
– upon expiry of pioneer status, firms have often been granted investment tax credit[3] which has provided further tax exemptions for five to ten years. The exemptions have been equivalent to approved investment. Losses during the allowance period can be "replaced" after the period;
– where FTZs could not be established, licensed manufacturing warehouses (LMWs) have been established. LMWs enjoy similar privileges to firms located in FTZs.

- Amendments to the Employment Act of 1955 in the late 1960s and the Industrial Relations Act of 1967 imposed tighter controls on labour organization. The government did not permit unions in the semiconductor industry until 1989 when "in-house" company unions were first allowed. Several firm managements still refuse to recognize some of these in-house unions.
- Government leaders offered unofficial guarantees to safeguard transnational corporate interests to ensure effective production co-ordination (e.g. reliable power supply and customs regulation).
- The Penang state government offered subsidized land, water, electricity and other physical infrastructure.

The generous initial package of incentives and promotional efforts, often by state government through personal visits to prospective investors' headquarters, helped attract firms to the already low-wage, union-free and fairly literate labour force in Penang. Penang's Chief Minister Dr Lim Chong Eu personally led a team, comprised of state and Penang Development Corporation (PDC) officials, to visit the presidents of several semiconductor transnationals, including Intel, Advanced Micro Devices (AMD) and National Semiconductor (NS) in the early 1970s.

However, the relocation of semiconductor firms to Malaysia did not in itself give rise to machine tool firms. Until the 1980s, semiconductor firms mainly sourced their machine tool supplies from abroad. Only National Semiconductor in Penang sourced its machine tool supplies from a subsidiary located next door, i.e. Micro Machining. Minor repair works and fabrication were done in-house in other firms. Intel initially opened a separate firm, Intel Automation, which it subsequently closed as local suppliers gained sufficient experience to service its demand.

Enhanced roles from around 1980 by the state government and the Penang Development Corporation in collaboration with business associations and transnational firms helped generate conditions for the rapid development of local machine tool firms. Eng Hardware was one beneficiary of this new environment. The state government's role has involved encouraging and establishing and coordinating sub-contracting between local firms and transnational firms, infrastructural support and human resource development. While growth in domestic demand for machine tool sourcing grew strongly, due to changes in production organization and the rapid rise in technological obsolescence, the supportive intermediary role of the state government and close ties between members of the state government (including its development corporation), employees of semiconductor transnationals and local machine tool firms were no less critical.

Eng Hardware was one of the many local machine tool firms that enjoyed special links with both the state leadership and the Penang Development Corporation. Every one of the supporting firm directories PDC published and supplied to firms operating in PDC industrial areas has contained its vital production statistics. In addition, the PDC has also arranged numerous meetings between Eng Hardware officials and potential transnational customers as well as government officials. As a consequence, Eng Hardware has been among the firms to obtain access to and successfully develop supplier ties with transnational firms.

Federal government arrangements initially stifled the growth of linkages between Eng Hardware and foreign semiconductor firms. Located in FTZs, semiconductor firms have continued to be able to obtain tariff-exempt imports from abroad so long as the items come from outside the principal customs area. Until 1986, when the double deduction relief for exports was introduced following the Promotion of Investment Act, Eng Hardware faced tariffs on imports and had no incentives to export. Until 1989, when it was awarded Licensed Manufacturing Warehouse (LMW) status, Eng Hardware also faced tariffs on its imports, including special ASSAB steel used to fabricate machines (Rasiah 1994).

Such biases against linkages affecting Eng Hardware were reduced when it obtained LMW status in 1989. It has since successfully imported intermediate and capital goods without tariffs. While the LMW status has somewhat reduced such biases against linkages, double tax deductions for exports have also substantially reduced the firm's tax liability. When skills shortages and poaching became a major problem in the late 1980s, the PDC also co-ordinated the formation of the Penang Skills Development Centre (PSDC), with Eng Hardware's director assuming a leading role in the development of training programmes for machine tool firms.

It can be argued that both markets and government played important roles in the relocation and expansion of semiconductor manufacturing in Penang, and the subsequent development of machine tool sub-contracting linkages between semiconductor firms and Eng Hardware. If allocative and exchange decisions are price determined by free demand–supply interactions between buyers and sellers, then the success of Eng Hardware involves forces besides markets. This chapter shows that while markets have arguably been important, Eng Hardware's evolution could not have achieved its present depth and scale if not for the important role of government.

However, as noted earlier, much of the federal government's role has been indirect. All four benefits it offered to semiconductor firms involved distorting relative prices. They were not attempts to offset anti-export biases since firms located in FTZs and LMWs face no customs restrictions, as they are considered outside the principal customs area. Financial incentives and, to a lesser extent, subsidized facilities effectively provided qualifying firms with substantial rents. The financial incentives also facilitated substantial transfer pricing activities by semiconductor firms (Rasiah 1996). Curbs on labour must have limited wages and other worker costs while government guarantees virtually removed uncertainties associated with underdeveloped infrastructure supply, especially for foreign firms.

Growth of the machine tool sub-contracting market

The growth of local machine tool firms in Penang has been the result of substantial changes in semiconductor assembly and test technologies. Changes in production necessitated a rise in proximate sourcing. Overall purchases of semiconductor firms domestically have tended to remain small. Fabricated wafers, which is the prime technology of semiconductor firms, are still imported. The sudden rise in machine tool sub-contracting demand locally emerged due to the changing nature of semiconductor assembly and test operations. The host government's policies had little influence on the shift towards flexible production systems and automation in semiconductor firms.

In addition, for semiconductor firms which exported all their output, domestic demand has been irrelevant. Indeed, domestic demand has been so small that transnational have never seriously tried to sell semiconductor devices directly to local users. The relocation of computer assemblers such as Dell in Penang in the 1990s helped attract direct orders from semiconductor and disk-drive firms such as Intel and Conner Peripherals. Although 20 per cent of output can be sold in the principal customs area without affecting a firm's tax and tariff holidays, this has never been utilized by semiconductor transnational in Malaysia when involving sales to local firms. Instead, local semiconductor users have had to import their chips from Singapore.

Apart from labour, construction, utilities and some services, semiconductor firms in Penang hardly sourced other inputs from local suppliers in the early 1970s (Rasiah 1995: chapter 7). When production inputs were acquired locally, these were usually from other foreign firms; e.g. Dynacraft manufactured lead frames. The key production input, fabricated wafers as well as machinery and components, was imported from abroad. Production operations in Penang, nevertheless, encouraged simple metal fabrications involving local firms from the late 1970s. Close collaboration between transnationals and the Penang state government (including the Penang Development Corporation), as well as business networking that facilitated co-operation between selected local firms and transnationals, started off the initial metalwork supplier links. However, local sourcing in the 1970s was small in scale and scope as it was generally limited to simple fabrication. It was during this time that Eng Hardware emerged as a tooling supplier to semiconductor firms. Its initial participation was limited to simple jigs and fixtures. It subsequently expanded operations to include mould and die production.

Advanced Micro Devices (AMD), which began production operations in Malaysia in 1972, first sourced simple off-peak metal fabrication from Loh Kim Teow in 1973. As with other semiconductor firms in Malaysia, AMD had its own in-house workshop which serviced the bulk of such demand, while National Semiconductor had its own machinery subsidiary in Penang, Micro Machining. Eng Hardware's links with AMD, and subsequently with other transnational firms in Penang, began when the state government began to invite local managing directors to meetings with managing directors of transnational firms located in the FTZs in Penang. In 1978, AMD first sourced some trolleys from Eng Hardware. The extent of flexibility in production, and its consequent impact on relatively low technological obsolescence, did not generate sufficiently large demand in the 1970s to stimulate viable local sourcing operations.

Eng Hardware was founded by a Chinese traditional physician, Teh Ah Ba, in 1976. The firm's activities in the 1970s were generally limited to repair work and simple metal fabrications. Demand from semiconductor firms in the 1970s was infrequent and often limited to single orders. Eng Hardware's total sales ranged between US$6,800 to US$11,000 annually in the period 1976–8. Few direct technology transfers from transnationals to local firms took place in this period. The parts and equipment locally sourced by semiconductor transnationals in the 1970s did not require high precision engineering. Indeed, Eng Hardware seemed like a typical backyard workshop, characteristic of Chinese urban metal tooling works across the country. Traditional artisans who carried on the skills of their fathers or acquired them through apprenticeships typified the skills utilized by Eng Hardware. Eng Hardware's early skilled workers were hired from the urban apprentice market.

Major developments in semiconductor assembly and test operations in the 1980s stimulated substantial demand for proximate fabrication and tooling support. It was during this time that extensive automation and cutting-edge process techniques were adopted in semiconductor firms. The acceleration of plant and machine modifications as a consequence created the demand conditions for viable proximate sourcing to emerge. The extent of outsourcing adopted by individual semiconductor firms, however, varied considerably.

Eng Hardware's meteoric rise as a machine tool supplier began following a switch in Intel's machine tooling strategy. Like most other semiconductor firms operating in Malaysia, Intel had used its own in-house workshop for repair work and fabrication. Only "extraordinary" minor fabrications were sub-contracted out to local metal tool firms nearby. Intel began sourcing such services from Eng Hardware in 1979. Intel then started an automation division to enhance its automation efforts in the early 1980s. As in-house activities were increasingly geared towards higher technology aspects of machine fabrication, minor processes were sub-contracted out to local firms. At this time, Lai Pin Yong was appointed Intel's Managing Director. Intel's move to accelerate the introduction of automation, and the spread of flexible production systems in semiconductor assembly and test operations from the early 1980s, accelerated rapid technological obsolescence in the firm, necessitating more frequent fabrication and development. Also, the growing sophistication of assembly and test operations, coupled with continuous shortening of product cycles, expanded the need for proximate metal tool support from simple fabrication to precision machine engineering.

Process flow, factory layout and machinery structures began to experience accelerated transformations from the early 1980s. Just-in-time systems were introduced in Intel in late 1984; it was the first among non-Japanese semiconductor firms in Malaysia to do so, and its impact included the doubling of productive capability with reduced physical inputs (Rasiah 1987). So rapid were the changes that it became uneconomic to import new machinery whenever layouts or production concepts changed. While new machinery continued to be imported, substantial process gains were achieved through constant in-house modifications. Also, the growing need for effective interfacing between machinery users and makers stimulated increased in-house machinery development. While generating substantial production synergies, these developments also created problems for the firm. Machinery production was not only uneconomic (as Intel's own in-house demand was too small to amortize such investments), but the firm could not effectively co-ordinate an entirely new product line.

Similar demand patterns emerged in the remaining semiconductor firms throughout the country. Interviews with Intel, Hewlett Packard, Thomson, AMD, Texas Instruments, Hitachi, Harris Semiductor, Motorola and Litronix indicate that foreign machinery firms were reluctant to relocate operations in Malaysia. Micro Machining and Texas Instruments in Singapore generally only serviced their own semiconductor subsidiaries. Local sourcing initially appeared impossible as local firms and infrastructure seemed too underdeveloped. Against such a background, market-determined prices alone were unlikely to have brought about the development of local supplier networks as local high precision engineering firms did not exist. While demand expanded, proximate supply capacities were too backward to figure in the qualitative and quantitative plans of semiconductor firms.

Exchange rate movements in the second half of the 1980s helped raise Eng Hardware's sales. The lowering of Eng Hardware's prices relative to import prices following a fall in the ringgit in the second half of the 1980s boosted local machine tool sales. It should, however, be noted that Eng Hardware's initial sales came in the early 1980s when the critical currencies in which most machinery import invoices were received – the yen, the won, and the Taiwanese, Hong Kong and Singaporean dollars – were fairly stable against the ringgit. Thus, exchange rate fluctuations did not begin Eng Hardware's expansion, though they may have helped enhance growth in the second half of the 1980s. As these currencies appreciated against the ringgit following the Plaza Accord and the Malaysian government's devaluation of the ringgit in 1985, Malaysian supplies became relatively cheaper. Currency movements, however, are unlikely to have been the most important explanatory factor in the rapid growth of Eng Hardware's local machine tool sales. Other small metal tool firms in the Kelang Valley facing similar transnational and currency effects rarely enjoyed similar growth in the technological sophistication of their metal tool sales (Rasiah 1994, 1996).

Government–business co-ordination

As discussed above, government policy and the changes in semiconductor production technologies did influence the evolution of machine tool demand in Malaysia. Equally, neither federal government policy nor markets alone were totally instrumental in the rapid transformation of Eng Hardware into a high precision engineering firm. Eng Hardware's development depended simultaneously on the intermediary role of the state (especially the local government), market development and trust drawn from ethno-political ties. The effective coordination of production and exchange involving command, relative prices and trust provided the opportunity for Eng Hardware to enter and expand in the high precision tools market. The entrepreneurial capabilities of the management merely enhanced the firm's move up the technological ladder.

Encouragement by the Penang state government and Lai Pin Yong's appointment as Intel's managing director were instrumental in the development of local supplier networks. Brought up in Penang and enjoying close relations with fellow Chinese in the state, including the ethnic Chinese state government leadership, Lai worked closely with the Penang Development Corporation and quickly forged links between Intel and Eng Hardware as well as Loh Kim Teow. Links were subsequently established with Prodelcon and Metfab – started in 1980 by former engineers of Micro Machining, again strengthened by ethnic ties and political as well as business relationships – which further facilitated effective development of buyer–supplier relationships between Intel and its local supplier firms. Thus, "trust" helped initiate as well as develop links between Intel and potential suppliers.

Given the technological sophistication and risks involved in manufacturing high precision machine tools, no local firm was initially willing to undertake such operations when first approached by Intel. Local metal working firms had neither the know-how nor the confidence to diversify operations from simple jigs, fixtures, moulds and dies to precision tooling work and automated machinery assembly. In other words, a local high precision machine tool supply market did not exist. With the help of the chief minister and officials from the Penang Development Corporation, Intel managed to convince Eng Hardware to upgrade their operations. Intel was able to offer capital up front to Eng Hardware to enable it to venture into risky precision machinery and tooling operations. Intel also offered know-how, guidelines and prototypes for the manufacture of machinery and components. In the initial stages, employees from Eng Hardware often visited Intel to acquire production skills. Engineers from Intel also frequented Eng Hardware during this period to ensure more effective production co-ordination as it was in the interest of Intel that Eng Hardware was successfully fostered and developed. After the initial breakthrough with Eng Hardware, it was easier to attract other local firms. Intel's efforts to foster Loh Kim Teow, Prodelcon and Metfab were aimed at reducing supply bottlenecks and at increasing competition among prospective suppliers. Apart from high precision tooling services, Eng Hardware was also manufacturing automated wire bonders and die attach machines for Intel by the mid-1980s. It should be noted that the changes – primarily in process technology in semiconductor assembly and testing – necessitated by the rapid introduction of more flexible production techniques and automation, as well as product cycle shortening, increased the demand for proximate machine tool activities.

Assisted by process engineers from Intel, Eng Hardware produced its first semi-automated wire bonders in 1981. Starting with technology support from Intel in the early 1980s, Eng Hardware has acquired and developed its own technology to be able to participate on a more equal basis in the development of machine tools by the 1990s. The firm had successfully introduced just-in-time, statistical process control, total preventive maintenance, quality control circles, time management techniques and professional accounting practices by 1990. As demand rose sharply, Eng Hardware moved its operations from Air Itam to Jelutong in the early 1980s, and then to Bayan Lepas in the mid-1980s. Eng Hardware's machining capability, as measured by the share of computer numeric control (CNC) and automated machines in total machinery, rose from none in 1978 to 12.9 per cent and 30.1 per cent, respectively, in 1993 (see Table 9.1). Eng Hardware's workforce rose from less than ten in 1976 to over 200[4] in 1993. The firm had four engineers, forty qualified technicians and supervisors, and fifty skilled machinists in 1993, compared to none in 1978 (see Table 9.2). By 1993, Eng Hardware was thus able to provide grinding and milling, as well as stamping services with tolerance levels, of ±0.00005 inch and ±0.001 inch, respectively.

Sales grew to US$320,000 per annum in the period 1982–3. Output dropped in the period 1985–6 with the downturn in the semiconductor industry (see Rasiah 1987). The upswing in the semiconductor industry from 1987 helped raise Eng Hardware's sales to US$6 million in 1990 and US$8 million in 1993. Growing sales and capital deepening[5] helped raise labour productivity, which grew at 30.5 per cent and 12.2 per cent per annum on average in the periods 1986–9 and 1990–3, respectively (see Table 9.3). Being conditioned by stringent quality and timing standards imposed by transnational purchasers, Eng Hardware began introducing state-of-the-art process technologies quite rapidly. Eng

Table 9.1 Eng Hardware: composition of CNC and automated machinery in total machinery, 1978–93 (%)

Share of total machinery	*1978*	*1981*	*1984*	*1987*	*1990*	*1993*
CNC machines	0.0	2.8	1.5	6.1	11.6	12.9
Automated machinery	0.0	8.3	13.1	16.9	25.8	30.1

Source: Author's interviews (1990–3).

Table 9.2 Eng Hardware: non-management staff, 1978, 1993

Occupational category	*1978*	*1993*
Engineer	0	4
Technical and supervisory	0	40
Skilled machinist	2	50
Semi-skilled machinist	5	74
Clerical	1	25
General workers	1	7
Total	9	200

Source: Author's interviews (1990–3).

Table 9.3 Eng Hardware: average annual growth rates, 1977–93 (%)

Period	*Output*	*Capital/Labour*	*Output/Capital*	*Output/Labour*
1977–9	3.3	−12.6	−15.6	−26.3
1980–5	41.2	18.2	0.3	24.6
1986–9	57.3	21.6	9.1	30.5
1990–3	15.5	5.2	4.5	12.2

Source: Author's interviews (1990–3).

Note
Output and capital figures adjusted using 1978 machinery prices.

Hardware's technology evolution is shown in Table 9.4. By 1995, Eng Hardware had acquired original design manufacturing (ODM) capabilities with substantial independence from Intel. Indeed, it sold over 60 per cent of its sales in 1993 to disk-drive manufacturers.

Like other successful firms, Eng Hardware's continued growth from the late 1980s was not just due to growing demand from Intel. Eng Hardware carefully considered its growing dependence on Intel, which, *inter alia*, controlled the use of technologies transferred from its development department, and also demanded priority for itself over its semiconductor rivals. Machinery, tools and parts designs provided by Intel were not to be used for sales to its rivals. Despite such constraints, Eng Hardware built on transferred technologies to redesign parts and components for Intel's rivals. It manufactured semi-automated machines and components for AMD, and also supplied precision tool services to Hewlett Packard and Litronix in the second half of the 1980s. Efforts to break out of the dependent relationship with Intel and increased initiatives by Eng Hardware's educated management in the 1980s led to further diversification of its activities in the 1990s (see Table 9.4). Technology transferred to Eng Hardware by trans-national and its own adaptations helped it upgrade its productive capabilities. The 1990s thus saw a gradual decline in the proportion of its sales to Intel.

Eng Hardware strengthened its relationship with the local state officials, using it effectively to forge a strong relationship with Maxtor, a disk-drive firm located

Table 9.4 Eng Hardware: evolution of technology and markets, 1976–95

Period	*Productive capability*	*Process techniques used*	*Extent of dependency*	*Markets*
1976–9	Manual milling, stamping and grinding of components, jigs and fixtures	Uncodified verbal instructions	Independent use of simple technology	Infrequent sales to varied horizontal markets
1979–81	Manual and electric-powered milling, grinding and stamping of components, jigs, fixtures, moulds, dies. Assembly of manual equipment	Codified work procedures	Rising dependence on Intel for technology and markets	Increasing sales to specialized markets, especially to semiconductor firms
1981–7	CNC milling, turning and grinding of components, jigs, fixtures, moulds and dies. Assembly of semi-automated and automated machinery	Time–motion studies, scheduling and accounting methods, quality control circles	Strong dependence on Intel for technology and markets. Extensive technology deepening	Around 83% of sales to semiconductor transnationals in Penang. Remainder exported to their subsidiaries abroad
1987–90	CNC high precision milling, turning and grinding of components. Assembly of semi-automated and automated machinery. Emergence of original equipment manufacturing (OEM) status	Just-in-time, statistical process control, quality control circles	Efforts to break out from dependent relationship with Intel.	Sales diversification with exports to disk-drive firms taking around 49% and the remainder going to semiconductor firms
1990–5	OEM status. CNC high precision milling, turning, grinding and stamping of components. Joint-designing of parts and automated machinery with purchasers. Original design manufacturing (ODM) capability but lacks markets for expansion	Just-in-time, statistical process control, quality control circles, total preventive management	Growing independence from Intel.	Sales to disk-drive firms exceed over 60%

Source: Compiled by author (1995).

in Singapore. By the end of 1990, 48.8 per cent of its sales were exported to Singapore. Eng Hardware's supply of disk-drive components (including actuators), using just-in-time delivery practices, convinced Maxtor to relocate in Penang. Also of importance were incentives offered by the Malaysian Industrial Development Authority (MIDA) and the Penang Development Corporation, particularly LMW status, which offered tariff-free imports of merchandise traded from outside the principal customs area. The 1990s saw the relocation of other disk-drive firms to Penang – Conner Peripherals, Readrite, Komag, Seagate and Quantum. Eng Hardware's main market changed from semiconductor firms to disk-drive firms in the 1990s. Unlike in the 1980s, however, Eng Hardware has maintained greater independence from the disk-drive firms: for example by using its own original equipment manufacturing (OEM) technology. It achieved original design manufacturing (ODM) in the 1990s, but has been awaiting capital funding and state support to "institutionalize" and thus reduce risks associated with expanding into such high-technology activities.

Extensions to production lines to include critical complementary but dissimilar activities facilitated some amount of in-house machine tool production in Malaysia. Underdeveloped local factor markets meant proximate sourcing options were initially unavailable. The frequency of technological change in semiconductor production, and the uncertainty associated with underdeveloped proximate suppliers, made out-house sourcing uneconomic. As Coase (1937) and Williamson (1985) have argued, in-house command governance through extensions to the firm hierarchy (internalization) initially appeared as the most economic solution. However, as involvement in entirely new product lines required different skills and control structures, semiconductor transnationals increasingly considered out-sourcing. Also, as the volume of machine tool demand generated by semiconductor firms could not achieve scale economies, managements found it undesirable to manufacture all their machine tool input requirements internally. Small and medium-size local firms – with paid up capital of less than RM1 million and fewer than fifty-one employees during 1979–86, and of less than RM2.5 million in paid up capital and under seventy-five employees since 1986 – do not require licensing under the Industrial Co-ordination Act of 1975, and thus face fewer bureaucratic obstacles in running small-scale operations. The flexibility of small and medium-size firms, enhanced by the use of multifunctional machinery, has facilitated effective co-ordination involving frequent changes in demand and production specifications.[6] Also, local firms have been able to amortize investments by supplying more firms which would not have been possible for any particular semiconductor transnational competing against the others.[7] It is mainly for this reason that Intel, AMD, Hewlett Packard, Litronix, Motorola, Thomson and International Device Technology – all with subsidiaries in Penang – did not seek regular supplies from National Semiconductor's mature machine tool subsidiary, Micro Machining.

Concluding remarks

Semiconductor transnationals' willingness to out-source their machine tool manufacturing requirements was not initially due to the presence of more economic proximate producers since local firms lacked high precision engineering technology. However, the close rapport Lai Pin Yong and other Sino-Malaysian managers had with the ethnic Chinese-dominated state government officials and local engineering firms brought about greater proximate out-sourcing in Penang. Also of importance has been the organizational and control structure of American subsidiaries. Unlike Japanese subsidiaries, in which key managerial positions remain controlled by Japanese managers, American firms offered greater autonomy for local managers to make production and sourcing decisions in their subsidiaries in Malaysia. In fact, Intel in Malaysia has been completely run by Malaysians since the 1980s.

Trust has helped strengthen buyer–supplier relationships between semiconductor transnationals and local machine tool firms.[8] Trust has not only compensated for market failure, but also emerged as a key governance component to ensure more effective production co-ordination.[9] Ethnic affinity between the Penang state political leadership and top American semiconductor firm managers, affiliations between local business and political associations and past employment contacts have all been important. Political circumstances have strengthened ethnic networking in Malaysia so that ethnic-based trust has grown stronger among ethnic Chinese (Khong 1991). Eng Hardware's family management has not included former employees of semiconductor transnationals, but has had access to the semiconductor transnationals' managers through channels organized by the state government and its development corporation. Critical for Eng Hardware's modernization has been the role of founder Teh Ah Ba's son, Alfred Teh, who qualified as an engineer at Birmingham University in the early 1980s. Alfred Teh has since become a major figure in the state–business coordination councils in Penang. He has also been a key figure in the evolution of PSDC's machine tool skills development programmes.

It is clear that semiconductor transnationals – Intel, in particular – have played an important role in the development of Eng Hardware from a simple backyard tooling workshop to a modern high precision engineering factory. The Penang state government and its development corporation have been critical in forging and strengthening links between Eng Hardware and semiconductor firms. Developments in the semiconductor industry favoured out-sourcing from proximate machine tool suppliers. With the underdeveloped factor supply market in Penang in the 1970s, supply arrangements through in-house command governance involving production was initially the best alternative mode. Rivalry among competing semiconductor firms and the consequent segmentation of markets among individual firms, as well as problems of production co-ordination of dissimilar but complementary products, made completely in-house production uneconomic. Intel's decision to foster local suppliers involved considerable trust requiring reciprocity. It was in Intel's interest that Eng Hardware and other supplier firms were developed. Increased out-sourcing by Intel and its direct role in the development of Eng Hardware were governed by a blend of trust, in-house command as well as pecuniary price–cost considerations.

To ensure improvements in the quality and promptness of supplies, Intel and, to a lesser extent, other semiconductor transnationals in Penang consciously transferred state-of-the-art machine tool technology to Eng Hardware and other suppliers. Such transfers, coupled with in-house adaptations and developments, have helped Eng Hardware upgrade its own technological capability. Eng Hardware has developed its technology sufficiently to enable it to reduce its dependence on Intel. Indeed, the firm has successfully diversified its markets, with disk-drive firms becoming its main customers in the 1990s. With the exception of 1985, when a cyclical trough badly affected the semiconductor industry, Eng Hardware has achieved double digit sales growth in every year since the 1980s.

Notes

* Based on fieldwork initially undertaken in the period 1990–3, and follow-up interviews in the period 1993–5. I am grateful to Chet Singh, Lim Pao Li, Lai Pin Yong, Mercer Curtis, Anuar Mohd Noor and Alfred Teh for their research support and to Jomo K.S. for his comments. The usual disclaimer applies.

1 Although Eng Hardware and Eng Technology are registered as two different firms, since they are owned by the same family and their operations are interconnected, they are examined together in this chapter.

2 See Hua (1983), Cham (1979), Jomo (1986) and Bowie (1991) for perspectives of the role of ethnicity and class relations in Malaysian politics.

3 This allowance was renamed the Investment Tax Allowance following the enactment of the Promotion of Investment Act of 1986.

4 When managers are included.

5 Concept refers to a rise in efficiency increasing capital stock and additions to capital stock that are necessary to perform more sophisticated tasks.

6 The greater flexibility of small and medium-size firms has encouraged the successful development of machine tool firms in Taiwan. In contrast, the lack of such size-related flexibility has, *inter alia*, limited the development of machine tool firms in South Korea.

7 See Brusco (1982) and Lorenz (1989) for a lucid account of the evolution of similar flexible relationships involving firms specializing horizontally in similar technologies but supplying a whole range of markets.

8 See Richardson (1960, 1972) for an excellent account of the role of co-operation in effective production co-ordination.

9 This runs against Williamson's (1985) argument that trust only emerges as a substitute to overcome market failures.

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10

TECHNOLOGY CAPACITY BUILDING IN THE MALAYSIAN AUTOMOTIVE INDUSTRY*

Hans-Georg Leutert and Ralf Südhoff

The establishment of Malaysia's Perusahaan Otomobil Nasional (Proton or National Automobile Enterprise) in 1983 not only marked the initiation of an ambitious "national car project" but also triggered major analysis and debate in the ensuing years.[1] The project attracted attention in Malaysia and abroad, as the creation of a truly local auto industry has great symbolic importance for the developmental success of newly industrializing countries (NICs). In addition, the fact that the Proton project was almost uniquely the creation of Malaysia's then new prime minister, Mahathir Mohamed, and established by the government, made it a case study for debates about the leading role of the state in late industrialization. Most studies have focused on specific aspects of the Malaysian automotive industry: for example, on Proton alone, or on its relations to autoparts suppliers. Such narrowly focused studies provide important thoroughness and detail; however, they often neglect the larger institutional and policy context necessary for a comprehensive evaluation of this key sector's development progress.

In order to take account of the complex interaction between the performance of automotive firms and the industry's context, it is important to draw on current theories of the new determinants of international competitiveness. The automotive industry is often studied as an example of new trends in international competitiveness, in which the development of technological capabilities plays a critical role. For this reason, two analytic approaches, widely discussed in recent years, provide the theoretical background for the following analysis. The first is Michael Porter's "cluster approach" (1990), while the second is a specification of that approach for developing country contexts: namely the concept of "systemic competitiveness" (see Figure 10.1) developed by the German Development Institute (GDI) in Berlin (Esser *et al.* 1995). Both approaches focus on the identification of new determinants of international competitiveness.

In the era of "Fordist" mass production, international competitiveness stemmed from "traditional" determinants such as macroeconomic stability and competitive advantages in labour and material endowments. Mass production of

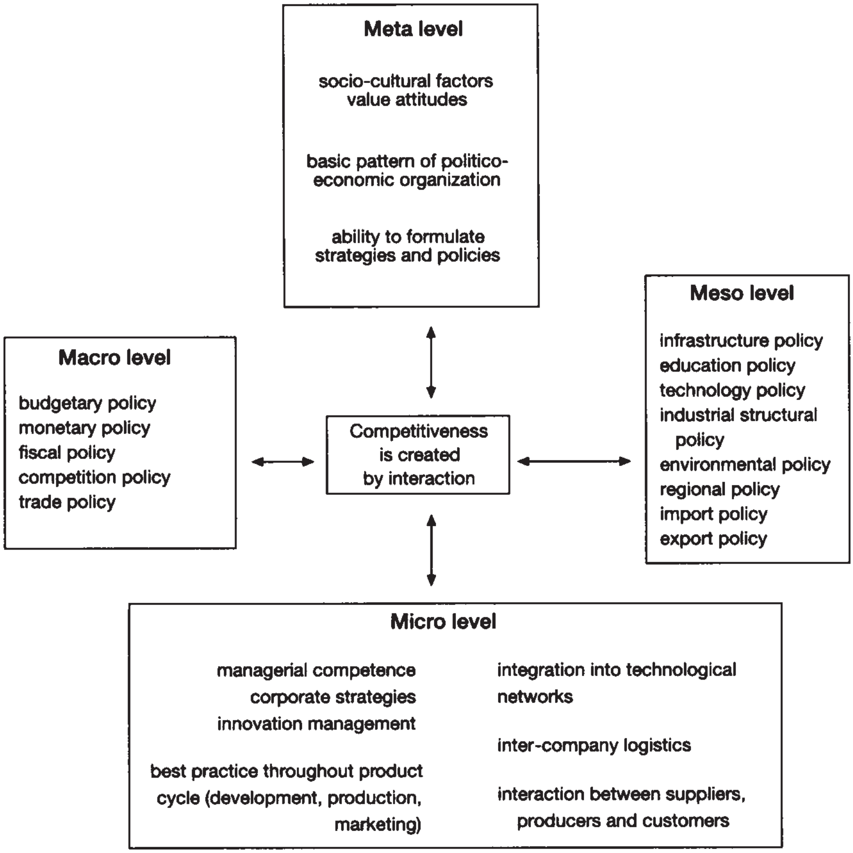

Figure 10.1 Determinants of systemic competitiveness (© GDI)

standardized products would allow national industries to penetrate global markets mainly on the basis of competitive pricing. While such factors remain important, in the new era of "flexible production" attention has shifted to the dynamic factors of innovation and technology. Here, the existence of an efficient system of innovation and technological development is crucial for regional or sectoral competitiveness. Competitive advantage results first and foremost from the flexibility of production processes which enables smaller product lines to be produced in shorter cycles, responding to increasingly fast-changing market demand for design and quality. The new issues under the rubric of flexible production, or what has been called "Toyotism", are flexible technology (computer-aided, multifunctional production plants), a horizontal structure of production (work cells, less hierarchy, promotion of employee competence), close inter-firm collaboration ranging from marketing to the lowest level of suppliers, zero-defect and just-in-time (JIT) production, total quality control, and the establishment of networks with educational, political and research institutions. One of the most important implications of the new approach is that the determinants of competitiveness tend to interact as a broad system. Hence, an industry's competitive success depends upon a "cluster" of relations extending far beyond the activities of a single firm to encompass the whole product cycle from innovation to distribution. A central aspect of this system is the growth of co-operation among firms, and between firms and supporting technology institutions as well as the state. Such co-operation, if successful, can lead to shortened product life cycles with faster quality and design improvements, thus accelerating innovation as a basis of competitive advantage.[2]

The concepts of Porter and the GDI focus on the central issue of "cluster-building" in contrast to both neo-classical and structuralist approaches. This is particularly a characteristic of the concept of "systemic competitiveness", which analyses the relevant actors and their interaction in the process of late industrialization. According to this concept, each actor's role in the process is not predetermined from the start, but is defined and developed through interaction. This is also true, for example, for the state, which is still held responsible for the creation and maintenance of stable macroeconomic conditions and a functioning infrastructure. At the "meso level", its role is to support or – if necessary – to actively establish a network of interaction among all relevant actors. However, this implies that its role is also limited by the interacting parties. A "too autonomous" state, taking a leading role in decision making without balancing influences by other actors, can become a serious obstacle to successful cluster-building. In short, the state is an important actor in this network but only one among others.

This new production paradigm has reached its most advanced development in the automotive industry, as large Japanese automobile manufacturers pioneered new practices and revolutionized production processes in the industry worldwide (see Jones *et al.* 1991, Jürgens *et al.* 1993, Karmokolias and O'Brien 1994). Even a new market entrant like Proton cannot avoid being influenced by such transformation of production organization. The development of technological capacities in the Malaysian automotive industry since 1985 will, therefore, be analysed in relation to the requirements of establishing an innovative industrial cluster, as described above.

Hence, this study will examine the Malaysian automotive industry's evolution into an innovative industrial cluster at three levels of analysis:

- the economic, political and cultural environment of the Malaysian automotive industry since 1985 (meta and macro levels),
- the development of technological capacity at the firm level (micro level), and
- the development of an efficient network of educational, research, and governmental institutions with relevant automotive industrial competencies (meso level).

The chief finding is that Malaysia's automotive sector has yet to develop the basic features of a technologically dynamic industrial cluster, notwithstanding the tremendous efforts to establish a genuinely national industry. Critical weaknesses on both the industry and government sides have frustrated the emergence of a network of co-operative interaction among the relevant economic agents. However, far-sighted reforms are in the pipeline. If they are implemented quickly and consistently, the Malaysian automotive industry may still succeed.

Economic, political and cultural environment

At the beginning of the 1980s, the automotive industry as a whole suffered from several structural problems. Inefficient assembly plants, dominated by foreign enterprises, produced very small volumes of a wide variety of models and brands. Despite numerous programmes aimed at increasing local content (LC) in the assembly industry, LC levels had stagnated at 18 per cent in the early 1980s, mainly reflecting production of technologically unsophisticated parts and components. Partly due to the variety of models and low volumes of each, local car parts and components were very overpriced (about 50 per cent higher than imports on average), while the components industry was highly inefficient (see Doner 1991). The multi-tier sub-contracting networks which characterize mature auto sectors were practically non-existent. Neither the assembly nor the parts sectors were poised to achieve efficient production, much less to develop links to a network of supporting institutions.

Faced with this situation, the Malaysian government decided to intervene drastically in the automotive industry. The national car project was therefore set up to create an independent automotive industry basically from scratch. Government support for the project was strong, including raising protectionist tariffs up to 300 per cent (see Proton 1992: 4). The government also invested directly in the project, with the state-owned Heavy Industries Corporation of Malaysia (HICOM) taking a 70 per cent stake in Proton.[3]

Thus, the project had significant political motivations and constraints. The political fate of the newly elected Prime Minister Mahathir seemed to be connected to the success of the heavy industry projects he had boldly launched. Moreover, in Malaysia's complex ethnic situation, the auto sector's limited existing capacities, largely owned by ethnic-Chinese Malaysians, were hardly incorporated into the project, but instead largely bypassed. Such factors affected both the initiation and implementation of the project.[4]

First, the government decided to collaborate with Mitsubishi Motor Corporation (MMC). Political pressure for rapid implementation, as well as lack of technical expertise on the side of the Malaysians in 1983, led to a joint venture contract with MMC, which, from the very start, was criticized as highly unfavourable for Proton (see Chee Peng Lim 1985).[5]

Second, the New Economic Policy (NEP) commitment to inter-ethnic redistribution had further effects on the project. While the NEP may have contributed to a stable political situation in Malaysia, it was economically problematic in the sense that the Proton project was not only expected to develop *Bumiputera* managers in Proton, but also to consider such ethnic factors in selecting staff and suppliers. Furthermore, the import substitution policy pursued since the 1960s had made a substantial impact on the industry's business culture. In order to maintain competitiveness in an age of global markets and rapid product cycles, a dynamic, innovative and world-market-oriented management and work culture is crucial. In Malaysia, however, years of protection and promotion had created a "subsidy mentality" and other expectations of virtually permanent government support. A lack of far-sightedness and long-term planning for competitiveness and innovation have proved to be impediments to faster technological progress for locally owned industry in general, and the automotive industry in particular. However, since the managerial reforms in the late 1980s after the early disastrous years, though not necessarily due to poor management of Proton, there has been some hope for improvements in the automobile sector. Chinese suppliers have become more involved, while *Bumiputera* as well as non-*Bumiputera* suppliers have to face stricter requirements by Proton in terms of price and quality (e.g. a new policy of "double-sourcing" may be practised to increase pressure on suppliers), and last but not least, the more commercial rather than ethnic orientation of the second national automobile project, Perodua, reflects significant changes.

In hindsight, the national car project was initiated without crucial preconditions for a dynamic industrial cluster, and more importantly, did not really try to create them due to other policy priorities.

Technology capacity at the enterprise level

The structural changes in the automotive sector after the national car project was set up had direct influences on the technological development of the automotive industry in Malaysia with different effects on state-supported industry, private domestic firms and foreign subsidiaries.[6] On one side, Proton and its suppliers were subsidized and protected, while the remaining assemblers and suppliers were undermined by intense competition from the national car project. To some extent, ironically, the policy of protecting Proton had the paradoxical effect of enhancing the quality and competitiveness of the non-Proton sector. The existing assembly industry, confronted with declining sales after 1985, experienced increased rationalization and modernization.[7] Several firms diversified into the parts sector and began to export significant amounts of parts and components. All non-Proton suppliers interviewed claimed a high level of technology assimilation in production processes.[8] On the other hand, Proton faced severe problems, including limited autonomy vis-à-vis Mitsubishi (its still-powerful minority joint venture partner),[9] the difficulties of establishing a supplier network under NEP conditions, and the poor innovation and modernization of the sector (due to heavy state protection).[10]

However, with the introduction of the second automobile project, Perodua, in 1992, the state-protected sub-sector appeared to be on the road to reform. At present, it is impossible to determine its impact on the industry in detail, but it is clear that the Perodua project seeks to avoid many of the obstacles Proton faced.

For example, Perodua has not been required to establish its own supplier network and can, of course, learn from earlier mistakes made by Proton.

Therefore, in recent years, the state and non-state automotive sectors have grown closer (partly because of the declining significance of the NEP since the late 1980s). The state-protected sector now increasingly orders parts from suppliers which previously only supplied non-state assemblers. However, the large number of companies involved, the small domestic market and the limited exports combine to frustrate the realization of scale economies which is a major obstacle to the further development and viability of the sector as a whole.

Moreover, several general conditions affect the development of firm-level technological capacities in Malaysia's automotive industry. The scarcity of skilled workers and engineers makes it difficult for firms to improve the sophistication of production techniques. The small domestic market requires that Malaysian firms export in order to capture scale economies which demands achieving international standards in process and product specifications. In this context, it is especially important to respond to the new trends of shorter product life cycles and higher flexibility. Given these basic factors, the local auto sector would be best served by a capital-intensive, high-technology and very flexible production structure concentrated on few firms.

However, technological capabilities vary significantly across the industry. Based on extensive interviews, we compare the three categories of firms in the Malaysian automotive industry (private domestic firms, state-supported sector and foreign subsidiaries) in terms of four aspects of firm-level competitiveness:

- the level of production techniques or process technology,
- the organization of production within the firm,
- the approach to acquisition and application of technological know-how, and
- the technical standards of the products produced.

Production technology

Most plants in the Malaysian automotive assembly industry have operated with out-of-date production techniques and at low levels of automation. Although a large portion of the enterprises surveyed had computer-controlled machines, these only represented a small share of all machines, and they were not used in integrated computer-controlled production systems.[11] At least 50 per cent of the surveyed Proton suppliers, as well as Proton, Perodua and non-state assemblers, used some robots, though primarily for simple work processes (e.g. welding for the production of wire mesh).[12] In particular, suppliers who assembled individual parts into components systems employed automated equipment for assembly and product movement. However, the overall incidence was low and the quality of automated equipment was usually of a low standard. The share of numerical control and computerized numerical control machines in the total number of machine stations averaged around 10 per cent across the sampled firms. Similarly, although 50 per cent of surveyed Proton suppliers had some computer-aided design (CAD) equipment (in one case, even CAD/CAM),[13] the systems were not well used, and reliance on principal assemblers and technology suppliers for designs was still heavy. Also, foreign enterprises partly avoided investing in complete state-of-the-art machinery due to uncertainties about the duration and success of their activities in Malaysia and to their desire to benefit from relatively low labour costs as much as possible.

In summary, the automotive sector's production techniques are generally characterized by labour-intensity and low flexibility. The sector's equity-per-worker ratio only rose marginally from 1985 to 1992 (see Table 10.1). In the components industry, it is the large Malaysian enterprises and foreign joint ventures which use modern equipment which, by contrast, is exceptional among locally owned small and medium-scale industries (SMIs).[14] Proton, too, employs labour-intensive production techniques. The assembly of bodywork and engines as well as of all other parts is hardly automated. However, the company plans to build a second factory incorporating a higher degree of automation. It may be surprising that labour-intensive production techniques are also employed in the relatively new Perodua factory, managers attributing this to a failure to anticipate the severity of the country's current labour shortage.

Government regulation is said to have caused slow progress in process technology upgrading. Proton's efforts to nurture numerous small start-up suppliers led to a fragmented autoparts industry structure (with about 300 suppliers!), thereby frustrating further achievement of economies of scale and scope. The initial decision to largely bypass the pre-existing autoparts industry in favour of new (mainly *Bumiputera*) firms meant that capabilities already developed by established parts suppliers were not much built upon.[15] The fragmented industrial structure is a major obstacle to firms' investments in upgrading their process technologies. About 50 per cent of the firms interviewed identified unfavourable return-to-cost ratios as the main reason for not investing in automated equipment. To what extent foreign investments will play a major role in this context particularly may depend on a change in Malaysian regulation linking the share of foreign investment in the capital stock of a firm to the export ratio.[16] Some firms with mainly foreign

Table 10.1 Fixed assets per employee in the Malaysian transport equipment industry

	1985	*1986*	*1987*	*1988*	*1989*	*1990*	*1991*	*1992*	*Growth rate 1985–92*
Fixed assets per employee (excl. land/ bldgs.) in RM	23,161	28,948	28,670	24,011	17,284	14,801	15,908	24,397	0.68

Source: NPC (1994): 112.

capital indicated a greater willingness to invest in real production plants, rather than merely in assembly lines for imported parts.

Production organization

The new paradigm of flexible production involves changes in production organization, both within the firm and at the level of inter-firm relations. Internally, firms in various industries have moved towards horizontal patterns of work organization, in which responsibilities are decentralized and regular inter-departmental meetings (e.g. R&D, production, marketing) support a high degree of transparency and co-operation. Such practices usually focus on incremental improvements in the production process to continually enhance product quality and process efficiency. Inter-firm structures are increasingly patterned according to the Japanese system of "lean production", in which assembler/supplier relations are regarded as critical. The system distinguishes between different types of suppliers and aims at a distribution of responsibilities and competencies among them. In the autoparts sector in Japan, a number of first-tier suppliers design and integrate entire component systems, in turn sub-contracting production of individual parts to lower-tier producers.

The analysis of internal production organization in all three sub-sectors of the Malaysian automotive industry clearly reveals the growing horizontal organization within individual firms. Regular meetings between management and shop-floor personnel, aimed at enhancing transparency, take place in many firms: 55 per cent of the firms briefed workers at the beginning of each shift, and a further 25 per cent held such a meeting at least once a week. Work teams existed in 60 per cent of the firms surveyed, though not in all production units. A rather high percentage of firms (40 per cent) have employee-suggestion schemes for production improvement. However, this does not necessarily signify decentralized decision-making authority. This becomes clear, for example, in quality control: only 35 per cent of the suppliers analysed devolved responsibility for quality control in production to their operators. Significantly, more firms (65 per cent) ensure the quality of their products through special departments and supervisors. Around 40 per cent control quality at the final product stage only, or rely on teams of supervisors carrying out sample tests at different stages of the production process; 20 per cent of the surveyed enterprises were in the process of transformation towards worker-based control at each production stage. In the future, Proton will move to a system where employees are mainly responsible for quality control, while Perodua and the surveyed private domestic assembly firms have already transferred some of these responsibilities to their workers.[17]

Efforts to improve production organization in line with international practice can be observed in the attitude towards ISO-9000 standards. Nearly half the companies analysed (45 per cent) already obtained ISO-9000 certificates. Of the remaining firms, more than half (63 per cent) had applied for certification. The fact that about 60 per cent of the firms carried out quality controls at each stage of production illustrates the increased awareness of quality and organization. For many small suppliers, inter-departmental co-operation from innovation to marketing is clearly less relevant due to their small size, which often involves no more than two departments (management/administration and production).

Integrating marketing with production and innovation decisions is an important feature of the flexible production paradigm. At Proton, the marketing function was provided by a separate enterprise, EON, which was established with the help of Mitsubishi in 1983. The contract regulating this "dual" structure soon turned out to be unfavourable for Proton since any losses (which were soon realized during the mid-1980s recession) were carried out by Proton alone. The firms have co-operated poorly in the after-sales parts market, and, apparently, have no common market strategies. The replacement parts market is dominated by Mitsubishi products. A further indicator of marketing capabilities (including those of the components industry) is the export ratio. Among the firms analysed here, exports are marginal; 35 per cent did not export at all, and another 35 per cent registered export ratios of less than 10 per cent of sales. A study by FMM in 1990 (FMM 1991: 21) indicated that 20 per cent of the suppliers did not export at all, while 80 per cent exported less than 20 per cent of turnover. A final aspect of the weak marketing performance of Proton suppliers is the breadth of their customer base; 65 per cent of the surveyed firms delivered more than 50 per cent of their production to Proton (see Table 10.2) and the total number of customers is often very small. Marketing strategies of assembly industry and foreign firms have still not met envisaged targets, but a certain trend is perceptible. Suppliers to the assembly firms enter the international replacement market step by step. Export ratios for parts and components of foreign enterprises are also rising within the ASEAN region, mainly to meet the demand of the Japanese automotive industry.

Despite Proton's vendor development efforts, its external supplier networks do not resemble the multi-tiered Japanese model, in which suppliers are distinguished according to their technological capabilities. The majority of suppliers deliver directly to Proton; while only five of the firms visited (four joint ventures, one Malaysian firm) have their own sub-contractors. Another study (Ragayah 1995) reveals that the effort to establish such a system is limited. Only 9.3 per cent of the suppliers co-operated with Proton on production techniques, and only 4.7 per cent co-operated on production organization. The study also shows the limited devolution of responsibilities, exemplified through Proton's quality controls of its suppliers' inputs. Proton controls the input procurement of 62.8 per

Table 10.2 Share of production for Proton

Share of production for Proton (%)	1–20	21–40	41–60	61–80	81–100
No. of enterprises (%)	25	10	10	25	30

Source: Interviews.

cent of its suppliers, and does quality checks of finished products from 67 per cent of its vendors.[18] Suppliers themselves do not sub-contract or practise just-in-time (JIT) with their materials suppliers. However, Proton does practise JIT in a limited way, with about 30 per cent of the vendors sampled delivering to Proton on a daily basis and keeping their own inventories at a minimum. Another two firms supply Proton daily but without limiting their own stocks.

The suppliers claimed that the primary obstacle to increased use of JIT is the unsteady and unpredictable volume of orders from Proton. Proton, by contrast, mainly criticized the suppliers' unwillingness to innovate. The supplier system, in general, was still rather unstable, meaning that Proton had to carry relatively large inventories to avoid all-too-common production stoppages. With regard to Perodua and the private assemblers, no great differences were found apart from the fact that the latter were less obliged to support a supplier network. Only one foreign firm could be identified as strictly practising "lean-production" and having established adequate relations with Malaysian suppliers.

In conclusion, the use of "lean production" and "best practice" internal production organization in the Malaysian auto industry is uneven at best. Significantly, Proton has only made slow progress towards realizing the new production paradigm. Its suppliers scarcely co-operate among themselves or with Proton, and they produce single (often very small) parts rather than component systems. Both Proton and Perodua rely on very large internal production departments to produce the majority of body parts themselves. The negative effects of these organizational weaknesses on Proton's competitiveness are illustrated by the fact that the average time needed per worker for a single assembly task is 96 seconds, 60 per cent higher than the 60-second average in the Japanese auto industry.

Acquisition of technological know-how

The auto industry shares the disadvantages of acute scarcities of technically skilled labour with the entire industrial sector. These shortages stem from the inadequate system of secondary and tertiary education and vocational training, and contribute to a poor accumulation and application of technological knowledge in production. Further, Malaysian enterprises generally show limited awareness of the need for accumulation, application and improvement of technology through internal research and development (R&D). Labour scarcities were not taken into account when the auto sector adopted labour-intensive production techniques. Though firms have sought to keep wages artificially low (e.g. through the employment of immigrant workers), wages have none the less increased rapidly along with the monthly rate of employment turnover, which amounts to between 2.5 and 10 per cent of the work force. Moreover, all companies have to compensate for shortages with extensive use of overtime.[19] One firm even created the equivalent of a third shift out of two by adding four extra hours to each worker's usual eight-hour shift.

The government has acquiesced to immigrant workers as a short-term solution to labour shortages, but this measure does not address the deficit in skilled labour, particularly at the technician and engineering level. Enterprise-based training has increased, but is still inadequate, partly due to firms' fears that investments in staff training for greater automation will be lost if employees move to other employment. As of 1992, all firms with more than fifty employees have been legally required to contribute to a Human Resource Development Fund (HRDF), which partially reimburses expenditures on training.[20] Of the surveyed firms 65 per cent make use of the Fund, although the amount flowing back to the companies is often still small; 90 per cent of the firms carry out in-house training, though more than half (55 per cent) this activity consists of introductory courses for new employees, a constant requirement in the face of rapid employee turnover; 65 per cent of the firms took advantage of training opportunities offered by machine suppliers and through joint ventures with foreign firms which accounts for most of the activity related to upgrading skills. In general, expenditures on training of the firms investigated were low and amounted to between 0.02 and 2.0 per cent of turnover.

The deficits in human capital clearly have an effect on R&D as well, but are not the only reason for poor performance in this area. None of the companies visited had a well-functioning R&D department, though many had engineering departments with some (often marginal) capabilities to make slight changes to product designs or to attempt some limited internal development of tooling. R&D investment is minimal,[21] and the government has largely failed to intervene effectively, for example, through the establishment of a research institute specifically dedicated to the automotive industry. Existing technology support institutions merely provide components testing facilities. Foreign joint ventures, especially assembly plants, but also some Proton suppliers, showed little interest in carrying out their R&D in Malaysia so as to transfer more technology to the country. Only one company interviewed was conducting research in reflector technology and was planning to expand R&D efforts in Malaysia.

Proton had a very large R&D department with about 230 employees as of 1995. However, this department only carried out marginal design changes and components testing, and is not much different from the general level of the Malaysian automotive industry. Proton's suppliers rarely have the facilities to develop innovative products. Their cost structures are too tight to allow for investments in R&D, and their experience in and awareness of technological innovation too limited for them to successfully co-operate with Proton in this area. Finally, it has to be stated that the automotive industry's poor performance in R&D also results from the lack of positive attitudes towards innovation. Consequently, high-tech material and parts which could conceivably be produced domestically have to be imported (see Table 10.3). An increase in R&D could contribute considerably to mastering the manufacture of those parts in Malaysia, thus reducing the country's dependence on imports and contributing to the formation of a real cluster (see Table 10.3).[22]

Table 10.3 Imported share of inputs

Input share (%)	1–24	25–49	50–74	75–99	100
No. of enterprises (%)	20	25	30	20	5

Source: Interviews.

Technological sophistication of products

In the medium term, Malaysia's automotive sector will need to increase exports to achieve economies of scale to become internationally competitive, and this will require tailoring products to niches to better serve particular export markets. In 1993, the components sub-sector exported 22 per cent of its production, of which 73 per cent were automotive electronic parts (radio sets, loud-speakers, etc., mostly produced by foreign enterprises) rather than functional components. The export ratio of the non-electronic components industry was only 5.9 per cent (JICA 1995: 20). Due to higher labour costs, even some low-tech products have become too costly to compete in export markets. As low-price competitors emerge, many parts makers must shift rapidly to producing more technologically complex products or go out of business. Unfortunately, production of technologically complex parts in Malaysia is limited. Locally produced parts mainly consist of bodywork, accessories, wheels, tyres, and electronic components. In contrast, engine parts, suspensions, shock absorbers and gearbox components are mostly imported. Equally, there are few companies capable of developing their own tools and moulds (for low-tech as well as high-tech products). Data on the industry's local content ratios also illustrate this weakness. Proton claims that it has a local content of about 70 per cent in terms of value (Proton 1995), though the industry's import ratio cast doubt on this figure. Although Proton demands that vendors use no more than 39 per cent imported inputs according to GSP regulations, our interviews suggest a much higher ratio: 55 per cent of the suppliers interviewed admitted that their shares of imported inputs on turnover were at least 50 per cent (see Table 10.3) though these figures have not been acknowledged by Proton. In addition, interviews with suppliers indicated that local content shares are often calculated with differing or incorrect methods, resulting in misleading figures. Thus, according to our own observations and calculations, perhaps half the components claimed as local content by Proton would be correctly labelled as such following GSP regulations. So, actual local content may be roughly estimated as around 35 to 40 per cent.[23] Finally, problems in the production and sale of replacement parts also illustrate the technical weaknesses of the Malaysian components industry.[24]

Classifying the twenty Proton suppliers according to their level of technological development, one can distinguish four levels: absorption, adaptation, assimilation and innovation. No firm had acquired full innovative capabilities, and about 75 per cent had only reached the stage of adapting imported technology. Another indicator of the low degree of maturity is the fact that 60 per cent of the Proton suppliers surveyed did not manufacture system components but merely supplied single parts. Moreover, only 25 per cent also supplied parts to other suppliers. Second and third tiers of suppliers were not evident, and as a result, product diversification and specialization are lacking.

Networks with technology supporting institutions

The "cluster" approach as well as the concept of "systemic competitiveness" link enterprise performance and inter-firm collaboration with the need for co-operation with a network of research, educational and government institutions. In order to be effective, such networks have to be adapted to the specific requirements of each industry cluster. Firms' links to supporting institutions are particularly important in cases such as Malaysia's automotive industry which confronted difficult conditions in the 1980s and is still characterized by limited commitment at the enterprise level to the need for innovation and technological development.

R&D and technology supporting institutions

First, we consider institutions able to perform R&D related to the automotive sector. Here, the relevant institutions are the Standards Research Institute of Malaysia (SIRIM), the Institut Technologi Mara (ITM), the National Productivity Corporation (NPC), and the universities. Among these, SIRIM has so far developed the closest contacts with the automotive industry. Its primary services to the industry are testing procedures for components which it carries out in its Mechanical and Automotive Engineering Testing Unit. Proton demands that all its suppliers submit components to SIRIM for testing. SIRIM also offers a service to develop prototypes and patterns through the Foundry, Technology, Product and Machine Development Centre, established in 1991. Additionally, SIRIM advises some suppliers on the organization of their production through a "Quality Practice Improvement Scheme". Finally, SIRIM co-ordinates ISO-9000 quality control systems certification and ITAF[25] subsidies for small-and medium-sized industries.

SIRIM's testing services are of special importance to Proton suppliers, who account for 80 to 90 per cent of the relevant unit's testing contracts. However, the interaction rarely goes beyond components quality testing, and does not involve co-operation in product development. This is even more true of other automotive firms like Perodua and the private assembly firms. Their parts and components are scarcely, if ever, tested or developed in co-operation with SIRIM. Since 1991, the Foundry, Technology, Product and Machine Development Centre has offered the possibility of developing plans or prototypes of components together with the respective moulds, e.g. for metals. In collaboration with Proton and some of its suppliers (so far, five from the metal sector), samples of parts are developed for which blueprints or samples from foreign technology suppliers are inadequate. Due to poor co-operation from technology suppliers, especially Japanese firms, this service is urgently needed since Malaysian firms are unable to identify outdated or faulty technical information, or the exact specifications they require from their foreign partners. This dilemma has been particularly acute in Proton's efforts to localize the production of engines in the face of Mitsubishi's resistance. That is why SIRIM currently develops designs and moulds for high value-added engine parts like camshafts or crankshafts[26] for which Mitsubishi has withheld detailed design technology.

All in all, however, SIRIM's activities appear to be limited to helping firms to adapt designs of low-technology components. Moreover, its links to industry do not involve innovative product development, extending much beyond the simple localization of Japanese parts and components production. Furthermore, the auto parts suppliers are usually uninterested in investing in innovation, in large part due to their small scale and production volumes. They tend to rely on continuous foreign licensing, with its attendant long-run costs, rather than investing in in-house technology development.[27]

Although ITM is the second largest technical education institution in Malaysia after Universiti Teknologi Malaysia (UTM), it only established an internal R&D department two years ago. It has very few contacts with the automotive industry (in contrast, for example, to the nascent aircraft industry), and only irregular meetings with Proton[28] and a single supplier have taken place. Lack of interest on both sides was reported to be the main obstacle to greater collaboration.

The NPC engages primarily in economic research, and 50 per cent of its R&D budget is used to draw up the National Productivity Report. Contacts with the automotive industry are again generally weak, with the exception of seminars on productivity management conducted during the last few years. Collaboration between universities and the automotive sector is as poor as that between universities and industry in general. Only two of the firms interviewed had some contacts with Malaysian universities. All in all, their importance as a source of technology was quite low.[29] This negative image is also reflected in various FMM studies. Only since the early 1990s, has university–industry cooperation slowly emerged. However, the bulk of this is limited to simple training courses or low-level technological issues (Felker 1995: 17–18).

In sum, Proton is not well supported by close co-operation with a network of R&D and technology institutions. Projects like the formally established HITEC Institute[30] are progressing slowly. Appropriately, the most urgent recommendation in the JICA report mentioned above is the immediate establishment of a "Malaysian Automotive Research Test and Information Centre" (MARTIC). The fact that such institutions are not yet set up reveals the double dilemma of lacking supply and demand for R&D efforts in the Malaysian automotive industry. Due to limited interest in obtaining up-to-date technology, and high protection at the enterprise level, demand for assistance, grants and supporting institutions has been as modest as private R&D investment. On the supply side, neither the government nor business associations have set up these institutions or otherwise promoted relevant R&D efforts sufficiently.

Educational and human resource development institutions

The automotive industry's links to human resource institutions are equally sparse. This is not only true of public universities, but also of the largest private institution for higher education, the Federal Institute of Technology (FIT), with 4,000 students. Of these, every year, about 80–100 graduate in automotive engineering; the course includes the application of computer-aided machines.[31] (FIT has no post-graduate courses, so students wishing to take higher technical courses still have to go abroad.) Yet, FIT has little direct interaction with the automotive industry, except for negotiations with Proton regarding evening classes for 30–40 technicians to obtain engineering degrees. The same situation is found at ITM and the universities. ITM, with a total of 43,000 students, offers a variety of five-year engineering courses; post-graduate courses were only introduced in 1997. Again, there is no information exchange with the automotive industry.

The establishment of the German-Malaysian Institute (GMI) in 1992 was a positive development which might provide a model for other such technical training programmes. Based on the German "dual apprenticeship" system, 132 apprentices are trained for skilled work while, at the same time, performing contract work for industrial firms. For Proton, for example, the German-Malaysian Institute developed samples of door hinges and suspensions for air conditioning systems. The institute's equipment includes a state-of-the-art, computer-aided fabrication plant. Similar French-Malaysian and Japanese-Malaysian institutes are planned.

Finally, the NPC offers a large variety of further education seminars, though these rarely deal with topics specific to the automotive industry. As mentioned above, especially in the areas of productivity and quality management, a wide range of courses are arranged. In 1993 alone, 633 courses, with a total of 14,500 participants, took place (NPC 1994: 39). These seminars provide training in basic techniques of productivity measurement which are prerequisites for training for productivity improvement. Finally, the NPC provides comprehensive information on productivity and quality issues through its Information and Research Centre.

All in all, institutions and programmes for human resource development are insufficient. It is estimated that there is a current shortage of 20,000 engineers and technicians in Malaysian industry. In order to build a fully industrialized Malaysia in the next 23 years in line with Vision 2020, roughly 50,000 engineers and one million technicians need to be trained. With the current "output" of about 2,000 to 3,000 skilled workers annually, there is a long way to go, despite existing expansion plans.[32] It is made even more problematic since investments needed at the enterprise level were lacking before the establishment of the Human Resource Development Fund, and locally owned firms' commitment to education and skills training is poor even today. Furthermore, there is a lack of institutional education for automobile-specific subjects. That is why the JICA report suggests the establishment of an Advanced Skill Development Centre for the Automotive Industry.

Business associations

A third issue in the cluster approach relates to co-operation within and through business associations. Such organizations play a vital role in facilitating information exchange among the often small, isolated firms within an industrial sector, and between industry and public institutions or government. Smaller firms, in particular, rely on associations for information on international technological and market trends. Malaysia's business associations display a mixture of strong and weak organizational traits and levels of professionalism. The automotive-sector-related associations have only limited capabilities and generally fail to provide transparent communication structures, and do not play a strong role in information exchange and technology diffusion.

The Federation of Malaysian Manufacturers (FMM), a peak association incorporating many industrial sectors, is considerably better organized. With ninety full-time employees, seven branches across the country, and an increasing number of members (1,700 in 1995), this association is highly professional. It publishes seven periodicals and four industrial surveys annually, and offers a wide range of training courses through the SMI Resource Centre, the Entrepreneur and Skills Development Centre, and the FMM branches.[33] Since the early 1990s, the FMM has even been involved in advising government economic policies. For the automotive industry, however, the FMM can only provide a broad framework within which other more specialized associations can take up the role of mediators. The automotive sector's umbrella association, the Automotive Federation of Malaysia (AFM), only partially fulfils this role, and concentrates primarily on lobbying the government regarding regulatory issues.

Of more relevance to technology dissemination is the Malaysian Motor Vehicle Assemblers Association (MMVAA) and the Malaysian Automotive Component Parts Manufacturers' Association (MACPMA). According to the MMVAA which represents private assemblers, the government is generally unwilling to co-operate, e.g. by supporting its collaborative efforts to raise technical standards.[34] Furthermore, the assemblers themselves are usually unwilling to collaborate among themselves. Due to their linkages to competing foreign principals, they are usually not independent, and instead tend to develop and rely primarily upon direct contacts with the government.

MACPMA is in a similar position. Although more than one hundred parts manufacturers are members, with only two full-time employees, this association is unable to organize more than a regular newsletter and three to four (poorly attended) seminars each year. However, MACPMA's lobbying role has been much more important, particularly in advancing mandatory localization of parts production. All in all, however, even its members are sceptical of the benefits the association can provide. A member of the board even described MACPMA as an "informal organization".

MACPMA's already weak position is undermined by the existence of a competitor organization, the Persatuan Pembekal Proton (PPP), the Proton Suppliers Association founded in 1992. Scarce resources are consequently split between the two organizations, whose members overlap but do not completely coincide. The PPP, too, has only one full-time employee and can therefore only offer limited services to Proton vendors. The association has offered regular meetings, a monthly newsletter, two visits to international automobile fairs, and some seminars in co-operation with the NPC (six since 1994) or SIRIM (two so far). However, the seminars were attended by only 20–25 vendors, which reflects the lack of interest in the association at the enterprise level. Up to now, the association has been unable to foster either close exchanges among vendors as a group, or R&D co-operation between specific firms producing related parts. Lack of co-operation between MACPMA and PPP represents a missed opportunity since the newer Proton suppliers would probably benefit from co-operation with the more experienced and technologically advanced MACPMA members. Unfortunately, Proton and the PPP seem uninterested in collaborating to accelerate technology diffusion.[35] Similarly, there is hardly any co-ordination of vendor development activities between the top management of Proton and Perodua.

Government institutions

Government institutions form the final feature of the institutional network of a healthy industrial cluster. Somewhat surprisingly, the surveyed firms generally approve of the role of major government bodies affecting the industry. The Ministry of International Trade and Industry (MITI) and the Malaysian Industrial Development Authority (MIDA) are regarded as competent and supportive.[36] In contrast, specific government technology incentives, such as the new Malaysian Industry–Government Group for High Technology (MIGHT), are assessed less positively. MIGHT has initiated working groups involving industry and government representatives for different high-tech industries in order to foster co-operation for joint technology and R&D strategies. Although the group dealing with the automotive industry is advised by fifteen full-time experts, it has had little impact as yet. There is no schedule for regular meetings, and Proton, which chairs the group, does not seem to make great efforts to co-operate with other industry players. This becomes apparent, for example, in the fact that they do not even send their top-level staff as representatives. Even according to internal sources, MIGHT does not provide much more than a "talking club" as yet.[37]

Government programmes to stimulate firm-level investments in technology are generally assessed sceptically. The limited financial means (RM11.9 million) provided for the improvement of automation under the Government Assistance Scheme had almost been used up by 1994; nineteen *Bumiputera* firms in the automotive industry benefited from this support (Ragayah 1995: 35). The

ITAF-Programme supporting SMIs, established in 1989 with a grant of RM50 million, was hardly more successful; twenty-six companies from the automotive sector received subsidies, though mainly small amounts. Until 1992, ITAF subsidies were only given out in rather ineffective small amounts of up to RM60,000 per firm.[38] That is why only RM9 million of the ITAF fund had been distributed up to 1994 (Felker 1995: 22). Lack of information, too much bureaucracy and the resulting lack of interest by companies are the main impediments to a more efficient programme.[39] The government's rejection of broader direct subsidies to private firms is the greatest complaint by businesses regarding government measures for R&D support. At present, firms can claim *ex post* tax incentives. Some representatives of the automotive industry demanded the establishment of an obligatory R&D fund, similar to the HRDF, to which, for example, leading enterprises would have to contribute a share of their export profits. Such a fund could also be used for an overall increase in R&D subsidies, i.e. the most important demand of the government by the firms interviewed.[40]

However, the problem also reflects a serious lack of transparency among the actors involved, which is a crucial precondition for an effective and close network in a complex cluster. The absence of communication and co-operation structures among firms as well as between industry and government creates problems for the assembly industry, as shown above, but also for the parts and components sector. Interviews revealed conflicting perspectives among Proton suppliers on the one hand, and government institutions on the other. Proton vendors hope for more government support in the future, while government officials expect all firms to begin to invest in innovation themselves.

Again, some changes have taken place recently. For example, both MACPMA and the FMM have been involved in preparing the new medium-term plan document to succeed the Industrial Master Plan, 1986–95. However, there is still a long way to go in developing a network characterized by real transparency and close communication between the government and the automotive industry as a whole.

Conclusion

The development of a competitive automotive industry is a very ambitious project for any developing country. The task is made more difficult by the ever-increasing international technology standards for cars and related production processes. In addition, scale economies play an important role (Proton has mentioned a minimum efficient scale of about 350,000 units a year), which can only be realized by exporting to the global market. These conditions pose major obstacles to new market entrants. In light of these challenges, Malaysia's progress in building an integrated automotive sector is certainly respectable. All in all, however, Malaysia has only progressed slowly (even for a 10-year period so far) towards the development of a competitive cluster based on innovation and technology. The problem is largely due to the problematic ethno-political environment of the project, as well as serious failures on the part of enterprises and the government.

Proton's great difficulties in gaining a greater measure of independence from its partner Mitsubishi hitherto allowed very limited progress in technological development. This has resulted in stronger government pressure to develop a genuinely Malaysian car (*Automotive International* 1995: 25). In recent years, Proton has made great efforts to gain technological independence through the expansion of its R&D department, the establishment of an internal casting plant, and increasing co-operation with new foreign partners (e.g. production of the Proton Tiara, launched in mid-1996, based on new co-operation with Citroën, as well as potential engine development with Rover). However, Proton has, thus far, not moved beyond the technological level of adaptation, and, as regards high-tech components, not even beyond basic technology absorption.[41] Perodua began from a more favourable position due to more market-oriented criteria for vendor selection as well as the selection of top management. Government objectives in the second national car project seem to have been developed on the basis of a more efficient recognition of market conditions. However, Perodua's labour-intensive production and the delay in the development of internal R&D activities underline the urgent need for changes in order to get beyond the level of simple technology absorption in the medium term.

In response to the introduction of Proton, the private assembly sector improved its efficiency, but is still constrained by small production volumes and labour-intensive processes to simple technology absorption. In the components sector, local content policies have achieved notable success in terms of the quantity of parts produced locally. However, components production is also inefficient and the technology basic due to small production volumes and labour-intensive techniques, particularly among new Proton suppliers. Supporting such inefficient vendors is a big burden for Proton, which is grappling with its own efforts to upgrade technology. According to some estimates, only 20 per cent of Proton vendors could "survive" in an open market.[42] This implies that the desired transition to higher technology products will continue to be jeopardized by the limited capabilities of locally owned suppliers. Some of the longer-established suppliers probably have a better chance of surviving in a competitive environment. However, the future technological development of the Malaysian automotive sector will still largely depend on foreign investors.[43]

The government expects investments, especially from European and US parts manufacturers who wish to establish footholds in the Asian market. However, it is questionable if Malaysia will benefit much from this investment push. Partial trade liberalization in the context of the ASEAN Free Trade Area (AFTA) may attract new foreign investment to the prospects of internationally competitive production scales and technologies. However, the still limited progress of the Brand-to-Brand Complementation (BBC) scheme gives no reason for optimism. As yet, only 50 car parts are traded under this scheme.[44]

The network of technical and human resource institutions supporting the automotive industry has major weaknesses. Despite greater efforts in recent years, strong initiatives are still needed to provide automotive-specific education and training, research institutions, R&D incentives and intensified support for small-and medium-sized enterprises to automate production. Moreover, these measures will only prove effective if the government is prepared to create genuinely open and transparent co-operative structures for the whole automotive industry. Only in this way, will it be possible to change attitudes at the enterprise level. Current attitudes result largely from mistrust and unfavourable perceptions of the future role of the state (and of Proton).

In summary, it has to be concluded that a cluster – or substantial parts of one – has so far failed to emerge, and the Malaysian automotive industry hardly benefits from the positive effects of a dynamic network (e.g. competitiveness based on innovation, rather than on pricing). The role of the state has to be critically analysed in this context. To a large extent, the strong policies of the government (top-down decision-making, splitting of the sector, lack of awareness for upgrading human skills and R&D, suspension of market forces, etc.) have not helped to build successful clusters in the Malaysian automotive industry. Some government measures have greatly distorted economic incentives, e.g. the unconditional protection given to Proton and to *Bumiputera* suppliers. Moreover, regulatory intervention in the labour market may have inhibited automation and innovation efforts in the domestic economy by keeping wage levels artificially low for a long time (e.g. by encouraging immigrant workers) (see Rasiah 1995).

However, market forces alone have surely not been sufficient either as is clearly revealed by the relationship between Proton and Mitsubishi. The lack of effective regulation to ensure technology transfer or local sourcing has delayed Proton's development for years. Moreover, in some ways, an interventionist state is certainly necessary for developing a competitive automotive industry, e.g. conditional protectionist measures as well as government assistance for the establishment of institutional networks are surely required.

It is rather difficult to estimate to what extent weak performance at the enterprise level is the result of government policy. But there is no doubt that a combination of factors at the enterprise level has resulted in little demand for support, resulting in limited efforts to build up efficient supporting institutions. A dynamic cluster and the development of competitiveness can only be achieved by strong interaction of the institutions and actors involved. While competitiveness may be obtained by pricing strategies for a while, this option has been difficult for Malaysia since costs were high from the very beginning – due to lack of experience and the small domestic market – requiring massive cross-subsidization by Malaysian buyers to buyers abroad.

Building the cluster now may still provide a chance to solve many current problems. The relevant actors would not have to completely change their strategies but rather modify them in interaction with one another.

External pressures from the world market and international institutions may have helped get some crucial reforms under way: an important step in the right direction is the fact that the government is aware of some of the problems in the automotive industry and in other sectors and has based the post-IMP on the cluster approach.[45] Furthermore, work on this industrial master plan has been based on closer co-operation with private business representatives than in the past. This new approach calls for linkages between all relevant actors within given industries as well as complementarity between state and market forces. The experience of technology capacity-building in the Malaysian automotive industry since 1985 also illustrates the need for such an appropriate balance of state intervention and market forces.

The post-IMP plan's cluster approach provides reasons for optimism about the prospects for the Malaysian automotive industry as well as the economy as a whole. However, there is not much time left to undertake strong developmental measures. The Malaysian government will not be able to evade the external pressures of AFTA and the WTO, and, in particular, may have to abolish the local content policy by 1998 and open the domestic market to ASEAN by 2003. Already, Malaysia is confronted with the imminent loss of its GSP exporter status to the US market as well as higher tariffs on exports to the EU, which have already affected automotive exports.[46] Moreover, competitors from other Asian countries (Indonesia, the Philippines, Vietnam) already have far lower labour costs to offer while the Malaysian component industry is not yet prepared to produce high-tech products. For this reason, the next five to ten years will be of crucial importance in determining if the industry develops into a competitive cluster with substantial technological capacities within this period, as many of our interviewees suggested.

Notes

* This chapter is the result of a three-month research project in Malaysia in 1995. The results presented here are based on about fifty interviews, comprising visits to twenty parts manufacturers, interviews with ten representatives of Malaysian car producers, and numerous interviews with representatives of Malaysian research and educational institutions, business associations and government institutions. These interviewees are not named in this chapter since anonymity was promised. The authors would like to thank all interviewees and all persons and institutions who made this research project possible. Special thanks to our hosts at Universiti Kebangsaan Malaysia in Bangi, the Institute of South-East Asian Studies (ISEAS) in Singapore, the ASA Programme of the Carl-Duisberg Gesellschaft (for financial support), Katharina Liebsch, Susanne Willner, Katja Grimme, Jasmin and Roy Aeria and children.

1 See Chee (1985), Shiode (1989), Doner (1991), Kreischer and Roy (1992), Jayasankaran (1993), Jomo (1994), Machado (1990/1994), Tharumagnanam (1994), Ragayah (1995).

2 Traditional determinants of competitiveness, such as a large pool of human resources or material endowments, can even prove disadvantageous in certain phases of development because they decrease pressures to innovate and, thus, have a slowing-

down effect on development. In the case of Malaysia, this aspect could provide scope for future research.

3 Since the start of the national car project, the stockholders' structure has changed significantly. In the first place, stocks were sold on the Malaysian stock market, reducing HICOM's stake in Proton to 27.4 per cent, while Mitsubishi Motors Corporation kept 17 per cent. Second, in November 1995, the government sold HICOM to the Malay businessman Yahaya Ahmad, owner of Diversified Resources Bhd. Thus, Yahaya now holds the biggest share in Proton. However, it is too early to analyse the potential consequences for the national car project.

4 The objectives of the first national car project, stated at the time of its introduction, illustrate how difficult progress towards a competitive automotive industry was expected to be. Apart from the four objectives laid out (rationalization of the automotive sector, development of a parts and components sector, greater involvement of *Bumiputeras*, strengthening national technological capacities), the development of a competitive car manufacturer is not even mentioned as an objective.

5 The MMC did not want to decide on future localization programmes for parts and components, necessary technology transfers, Proton's export policy, etc. Apparently, far-reaching agreements were made with the Mitsubishi Group concerning future business transactions with Proton vendors.

6 Finally, attention should be drawn to the specific role of foreign enterprises which set up local production following the establishment of Proton in 1985. A study undertaken for the Ministry of International Trade and Industry of Malaysia (MITI) in May 1995 (JICA 1995:22) noted that 40 per cent of automotive suppliers had foreign equity. Foreign investment plays a large role in the sector for two reasons. First, foreign companies want to establish a foothold in the Malaysian market in order to benefit from stable demand in a protected industry. Second, Malaysia is often chosen as a base for potential expansion into other ASEAN countries.

7 Interviews by the authors indicate rationalization efforts and higher productivity.

8 Assimilation is used in this study as one of four technology capacity levels. Absorption describes the mere importation of parts. Adaptation refers to the assembly of products developed by others (similar to imitation). Assimilation means that products developed elsewhere are slightly changed to serve firm-specific purposes. Re-innovation refers to significant changes to products developed elsewhere.

9 Concerning purchase of raw materials, parts and machinery, both Proton and many suppliers still have obligations to buy from the Mitsubishi Group (interview with a high-level official of a governmental agency).

10 In particular, the establishment and support of its own suppliers with priority for *Bumiputeras* impedes Proton's development. In 1994, more than half (53 per cent) of the vendors were small- and medium-scale industries (SMIs, with capital stock of up to RM2.5 million), of which about 80 per cent were *Bumiputera* enterprises. Not to be underestimated is the fact that these suppliers have been in the industry for no more than 10 years, and hence, have relatively little experience.

11 However, more than half the firms have no such machines, or their share is marginal.

12 Proton does not even employ robots for welding, but is equipped with a large welding department where work is carried out manually.

13 One of the interviewed vendors for Proton and Perodua uses CAD/CAM in designing and cutting covers for upholstery. Patterns designed with the CAD-computer are directly transferred to the cutting machine, where they are cut automatically. However, only part of the production is done in this way, and manual cutting still exists.

14 None of the six analysed *Bumiputera* firms owned a CNC machine, two had NC machines, while three had disposed of their robots. Two firms had a CAD-system; however, one of them claimed it was hardly ever used.

15 Examples here are two analysed firms which had both produced and exported quality car parts before. However, for political reasons, they were only admitted to the group of Proton vendors much later.

16 The Industrial Coordination Act of 1975 linked foreign investment in the capital stock of an enterprise to the export rate as follows: foreign firms are allowed to hold 100 per cent of capital stock if they export more than 80 per cent of their production. They are allowed to hold up to 51 per cent of capital stock if their export ratio is of the order of 51 to 79 per cent. The capital share for foreign firms is limited to between 30 and 51 per cent if the export rate amounts to between 20 and 50 per cent. A maximum capital share of 30 per cent is provided if the export ratio does not exceed 19 per cent.

17 Interviews by the authors.

18 Of all engineers and technicians at Proton, fifty-two, i.e. only 15 per cent, supervise suppliers.

19 The regularly high number of extra working hours (up to four hours daily) for employees often results in a doubling of their income. The basic wage is about RM500–600; with extra hours, incomes can reach RM800–1,000 or even more.

20 In 1992, the Malaysian government established the HRDF. All firms with more than fifty employees are obliged to pay 1 per cent of their pay roll to the fund. A refund is available for training expenses when courses are conducted at institutes recognized by the government.

21 The Malaysian government set a target of R&D investments of 2 per cent of GDP by the year 2000. However, in 1995, R&D investments were estimated at only 0.4 per cent of GDP, so the government changed its target to 1.6 per cent in 2000 (Felker 1995: Appendix). A FMM survey in 1991 demonstrated that 81 per cent of Malaysian enterprises spent less than 2 per cent of turnover on R&D. More than 51 per cent did not invest in R&D at all (FMM 1991: 27).

22 The weak performance of the Malaysian automotive industry had a considerable impact on the Malaysian trade deficit. "Machinery and transport equipment constituted the largest import component accounting for RM55.1 billion and remained the largest contributor to the increase in total import value" (*New Straits Times*, 17 August 1995).

23 Government institutions calculate local content in yet another (misleading) way: for them, value is not the only criterion, but a points system is used which privileges *Bumiputera* components, both in comparison to non-*Bumiputera* and imported inputs (interview with a high official of an assembly company).

24 According to JICA (1995:20), 21.6 per cent of automotive parts and components produced in Malaysia were sold on the domestic after-sales market. Since the car industry realizes most of its profits on this market, the above mentioned share still seems too low. The high share of parts and components from Mitsubishi in the Proton after-sales market also illustrates the weaknesses.

25 ITAF was set up in early 1990 with the purpose of providing grants to SMIs (maximum paid-up capital of RM2.5 million), and consists of the following four schemes:

- ITAF 1: Consultancy Services Scheme, maximum grant: RM40,000;
- ITAF 2: Product Development and Design Scheme, maximum grant: RM250,000;
- ITAF 3: Quality and Productivity Improvement Scheme, maximum grant: RM250,000;
- ITAF 4: Market Development Scheme, maximum grant: RM40,000.

The above-mentioned grants by the government are understood as 50 per cent of total investment. The other half has to be contributed by the firm.

26 Here it becomes clear that Proton's capacities in technology and design are still very limited. This is not only true for high-tech parts and components but also, for example, in the area of body-stamping which, despite early localization, is still completely carried out on the basis of Mitsubishi drafts.

27 Twelve of the interviewed parts manufacturers have so far not undertaken R&D at all. The R&D departments of the remaining eight firms cannot be described as fully developed. The import of technological know-how from abroad as well as the financial problems of smaller firms are given as the main reasons for that.

28 A Memorandum of Understanding with Proton at the end of the 1980s for joint R&D has never been realized. Elsewhere, it was pointed out to the authors that this was not followed up due to pressure from Mitsubishi officials.

29 On average, the interviewed firms assessed their co-operation with universities at 2.5 on a scale from 1 (very poor) to 10 (very good).

30 Although Proton was to be the main user and beneficiary of this institute, these long-existing plans were hardly known at the management level.

31 The degree only corresponds to a basic education as technician. This, for example, is why the Malaysian three-year course is considered only to be equivalent to the first year of a UK bachelor's course in engineering.

32 As a matter of fact, numerous educational institutions were created in the last few years, with ten in the Klang Valley alone. The GMI is to be emulated by the French and Japanese respectively.

33 In 1994, the Entrepreneur and Skills Development Centre arranged eighty-nine seminars with 1,450 participants. The FMM itself organized a further forty-one courses. In 1995, the FMM alone expanded its programme to 200 courses, of which many were carried out in co-operation with ministries or other institutions. For the automotive sector, several conferences on investment opportunities under the national car project were organized in 1995.

34 For example, the thirteen members of the association (eight assembly firms, five franchisers) found out from the press about the decision to introduce a second national car project. The long-term plans of the government regarding the liberalization of the sector are unknown at the highest levels of the MMVAA (interviews by the authors).

35 This could prove to be a great mistake in the long run: in the JICA report, the lack of an efficient business association was identified as a problem. MACPMA is considered to have the potential to fulfil this role in the future. Surprisingly, the PPP is not even mentioned once in the report.

36 The interviewed firms assess the co-operation with both ministries at an average of 8.2 on a scale from 1 (very poor) to 10 (very good).

37 Interviews by the authors.

38 Here, an intervention of the FMM led to the distribution of larger subsidies to individual firms in the following years (Felker 1995: 22).

39 Interviews by the authors with the enterprises concerned, as well as with a top-level MITI representative, who described the engagement of parts manufacturers as generally "very sluggish".

40 With an average of 9.8 on a scale from 1 to 10, this question was given most points, even above those for increased support of capacities for technical education, as the most urgent task for government.

41 According to a high-level employee of the Proton R&D department, for example, it

will take at least 10 to 15 years before Proton can develop internal design capacities. At least the same period of time is estimated to be necessary to make Proton a fully fledged manufacturer.

42 Interview with a consultant to the Malaysian government and with a high-level representative of a business association in the automotive sector.

43 The Malaysian regulations in the assembly industry and the protection of Proton and Perodua were named by a representative of one of the largest assembly firms as the main reasons for much larger investments of international automotive enterprises in Thailand than in Malaysia. Further factors are the small domestic market and the limitations on foreign capital stakes.

44 Interview with a MIDA employee responsible. The BBC scheme, initiated by multinational enterprises, involved co-operation between Thailand, Malaysia, the Philippines and, only recently, Indonesia, on the car parts market. The agreement intends to reduce tariffs for car parts and components among these countries by 50 per cent.

45 This was clear in interviews with members of government commissions and ministries as well as in the talk given by the Director of Transport of MITI at the Automobile Conference in Kuala Lumpur. The JICA report also confirms the results of this analysis.

46 For example, after years of duty-free exports to the UK, Proton had to accept a 7 per cent EU tariff when it started to export to Germany, Belgium and the Netherlands. In coming years, this tariff will be increased to the level applied to Japanese cars.

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11

PROMOTING INDUSTRIAL AND TECHNOLOGICAL DEVELOPMENT UNDER CONTRASTING INDUSTRIAL POLICIES

The automobile industries in Malaysia and Thailand

Kamaruding Abdulsomad

The decisions to establish import-substituting automobile industries in Malaysia and Thailand were made by national leaders. Probably no industry has become as politicized as the automobile industry, which is now regarded as vital to their respective national economic development strategies. This is partly because an automobile is a complex product, consisting of about 3,000 parts and components, and involving different production processes and considerable specialization. The industry brings together an immense variety of components and parts, many of which are manufactured by independent supplier firms in other industries such as textiles, glass, plastics, electronics, rubber, steel and other metals. Hence, the employment effect of developing the automobile industry is expected to be strong because of the considerable linkages with other industries. Foreign auto makers are also expected to make various contributions to the host economy, in terms of technology transfer, skills training, technical progress and stimulating the development of small- and medium-scale industries.

This chapter will compare the development of the automobile industries of Malaysia and Thailand, which represent two distinct experiences of automobile industry development. The former may be characterized as state-led, while the latter is more representative of "private-sector-led" automobile industry development. I will examine the impacts of different industrial policies on the industrial and technological development of the automobile industries in both countries. It is my contention that differences in industrial policy between Malaysia and Thailand have produced different patterns of industrial and technological development in the two countries. This, in turn, has had different implications for industrial deepening in both countries and for the technological capabilities of their local firms.

The chapter is divided into four parts. The first part provides an overview of the different paths of automobile industry development in Malaysia and Thailand over the past three and a half decades. The second part deals with the state's role in the development of the automobile industries in the two countries. The third part examines the impacts of the different industrial policies on the patterns of industrial and technological development in the two automobile industries. A conclusion is offered in the last part.

Two paths of automobile industry development

No industry distinguishes Malaysia's industrialization experience from Thailand's as much as the automobile industry. Before the 1960s, automobiles in both countries were mostly imported from Europe, Japan and the United States. Local assemblers in Thailand and Malaysia started to assemble vehicles using imported completely knocked down (CKD) kits in the 1960s. During this period, the automobile industries in both countries had similar features and achieved comparable levels of development.

The structure of the industry in the two countries only became quite different after a new automobile industrial development policy was introduced in Malaysia in the early 1980s, when Malaysian Prime Minister Mahathir began a state-initiated "national car" project. The new industrial policy transformed the country from a vehicle importer and vehicle assembler into a full-fledged car manufacturer by launching its first national car company, Perusahaan Otomobil Nasional (Proton), in 1985. In contrast, Thailand's industrial policy for the same sector has remained private-led with strong protection by the state since the early 1960s. Since 1991, the Thai automobile industry has shifted from being a protected to becoming a competitive industry, thus encouraging foreign auto makers and component manufacturers to invest in Thailand, making the country a centre for automobile and auto parts manufacturing in the Asian region.

As a result, automobile industrial development in Malaysia and Thailand has seen two different trajectories. The automobile industry in Malaysia has been state-led since the early 1980s by the Heavy Industries Corporation of Malaysia (HICOM) while private-led automobile industrial development continues in Thailand. In Malaysia's automobile industry, joint ventures between the state and foreign automobile manufacturers now produce "national cars" for the domestic market and for export. The "national car" projects in Malaysia have provided the basis for the development of local component industries as well as enhanced utilization of local components.

In contrast, in Thailand, the majority of local private firms rely on joint venture or licensing arrangements with foreign automobile and components manufacturers to assemble vehicles for the domestic market and, more recently, for export. Both local assembly and components industries in Thailand have involved strong links with foreign auto makers and components manufacturers, especially from Japan and the USA, to make Thailand a centre for vehicles production and development of the parts and components industry in Asia.

The state and development of the automobile industries

Malaysia and Thailand encouraged the automobile assembly industry from the 1960s through similar government promotion efforts despite little experience in automobile-related manufacturing. Production of automobiles in both countries would not have started without promotion by the state and participation by foreign automobile manufacturers. In line with their import-substituting industrial promotion programmes, both Malaysian and Thai governments granted approval to foreign automobile assembly plants to start operations in their countries. The automobile industry was regarded as an "infant industry" in both countries, and the two governments' policy objectives for the automobile industry were quite similar during the formative years. The goal was gradually to increase domestic value-added from semi-knocked down (SKD) to completely knocked down (CKD) assembly and more substantial manufacturing activities with an increasing proportion of domestically made parts and components.

Various policy interventions by the state are best seen in terms of the stages of automobile industry development. According to Bloomfield (1978) and Torii (1991), automobile industrial development in developing countries can generally be divided into the following four stages.

Stage 1: Import and sale of completely built-up (CBU) cars by local retailers.
Stage 2: Assembly of imported CKD parts, and domestication of parts production.
- (2a) Domestic production of replacement parts and components (REM).
- (2b) Domestic production of Original Equipment Manufacturer (OEM) parts for car assembly.
- (2c) Domestic production (OEM) of key parts: engine and engine-related components.

Stage 3: Domestic production of materials for cars and components
Stage 4: Domestic design of car bodies and other components.

Government policies towards the automobile industries in Malaysia and Thailand over the past three and a half decades have emphasized protection of local industry and local content requirements to promote the local auto parts industry to ensure rapid development of the automobile industry.

Malaysian government policies towards the automobile industry[1]

The development of government policy towards the automobile industry in Malaysia can be divided into two phases.

First phase: encouraging local assembly and content (1967–82)

As part of its import substitution industrialization efforts after independence in 1957, the Malaysian government developed a policy in 1963 to promote an integrated automobile industry to strengthen Malaysia's industrial base. The main objectives of the government in promoting an automobile assembly industry were to reduce imports, save foreign exchange, create employment, develop strong forward and backward linkages with the rest of the economy, and transfer industrial technology (see Jayasankaran 1993, Jomo 1994). After the secession of Singapore from Malaysia in 1965, the Malaysian government had to review the policy which had involved Singapore. From 1966, Malaysia restricted the importation of cars from Singapore. All imports became subject to quotas and protective tariffs were imposed on all CBU vehicles brought into Malaysia. Further, all distributors and dealers in Malaysia were required to obtain import licences renewable at six-monthly intervals for built-up vehicles.

The first phase of government policy towards the automobile industry in Malaysia may be characterized as a period of protective promotion of local assembly. In the late 1960s, the Malaysian government granted approval to six assembly plants to start operations in Malaysia, namely: Kelang Pembena Kereta-Kereta Sdn Bhd (Fiat and Mitsubishi), Swedish Motor Assemblies Sdn Bhd (Volvo), Oriental Assemblers Sdn Bhd (Honda, Peugeot, others), Cycle & Carriage Bintang Bhd (Mercedes Benz), Assembly Services Sdn Bhd (Toyota, Daihatsu) and Associated Motor Industries (M) Sdn Bhd (Ford, Chrysler, Land Rover). The first car was assembled by Swedish Motor Assemblies in Batu Tiga in 1967. In 1977, the Motor Vehicle Assemblers Committee (MVAC), an inter-departmental agency set up under the Ministry of Trade and Industry to oversee the automobile industry, licensed another five assemblers for whom approval criteria were modified to favour "*Bumiputera*" (indigenous) assemblers. Thus, the industry expanded to eleven assemblers by 1980 (Jomo 1994).

The government had also accepted the Walker Report[2] of 1970, which recommended an expansion of local content to 40 per cent by weight over the next ten years beginning in 1971, rising from 10 per cent in 1972 to 35 per cent in 1982 (i.e. an expansion by approximately 3 per cent per year). A list of penalties for non-compliance was included in the Report. The local content requirements and penalty system were designed to reduce the variety of makes and models, and thus promote standardization of major components.

After automobile assembly began in 1967, completely built-up unit imports decreased while the import of CKD packs rapidly increased. The decrease in CBU imports is directly attributable to government protection through high tariffs, stringent import licensing and quantitative restriction. However, the proliferation of makes and models from the eleven assemblers made it very difficult for local parts makers to achieve economies of scale. As a result, local parts were expensive, and local content only averaged 8 per cent in 1979. Dissatisfaction with the slow development of the automobile industry after more than a decade of private business operations can be said to have prompted the government to attempt to rationalize the industry through state-led development of a "national car" from the early 1980s. The industry was controlled by foreign manufacturers and their mainly ethnic Chinese Malaysian partners until the first national car project was established in 1983.

Second phase: the national car project (1983–present)

The second phase of the development of the automobile industry in Malaysia can be characterized as state-led. There were many reasons for the Malaysian government's new policy for the development of the automobile industry. The limited success of the government policies in the 1960s and 1970s, and the desire to promote greater *Bumiputera* participation in the industry, seem to be the main explanations for the policy shift. After more than a decade of local assembly of imported CKD kits, in 1980 some eleven assemblers were producing twenty-five makes, 122 models and 212 variants of commercial and passenger vehicles with an average 8 per cent local content. This was considered very low in relation to the local content regulations set by the government in 1972, whereby local content had to increase from 10 per cent in 1972 to 35 per cent in 1982. In addition, the large variety of makes and models being assembled for a small market made it difficult to produce parts locally and components competitively which created an industrial structure that became an obstacle to further localization.

The government response to this dilemma was the dramatic change to a national automobile project run by state-owned enterprise. In late October 1982, the prime minister of Malaysia announced that Proton (an acronym for Perusahaan Otomobil Nasional or National Automobile Enterprise would be set up. A joint venture agreement was signed between Mitsubishi Motor Corporation (MMC) and the trading company Mitsubishi Corporation (both with 15 per cent each) and the Heavy Industries Corporation of Malaysia (HICOM), with 70 per cent, to produce a Malaysian-made vehicle known as the Saga (with 1,300cc and 1,500cc engines) for the domestic market. Production was to begin in 1985, with an output capacity of 5,000 vehicles in the first year, increasing to 120,000 annually by the 1990s. The national car project was expected to rationalize the automobile industry, promote related industries (such as the parts and components industry and other supporting industries), enhance greater utilization of locally made components, encourage the upgrading of technology, engineering and technical skills and increase *Bumiputera* involvement in the automotive industry, which foreign and Chinese capital had long dominated.

As it began production in 1985, Proton suffered from a collapse in local demand due to recession, exacerbated by higher unit prices, due to appreciation of the yen. Not surprisingly, Proton recorded losses from 1985 until 1988. In 1989, Proton's turnover was RM820 million, with a pre-tax profit of RM32.6 million. Proton cars immediately became the best-selling vehicles in the domestic passenger car market and captured 73 per cent of market share in 1994. Following the recovery of the Malaysian economy from 1987, Proton's production increased rapidly, with 70 per cent of the increase in domestic vehicle production between 1987 and 1993 from Proton. In 1986, Proton first exported twenty-five cars to Bangladesh. By 1994, the number of vehicles exported was around 21,000, accounting for 23 per cent of total sales. Proton cars have been exported to twenty-eight countries, with the United Kingdom still its major foreign market.

The rapid growth of Proton has undoubtedly been due to strong support, protection and preferential treatment measures by the state. Proton has enjoyed reductions of and exemptions from import tariffs as well as sales taxes. Low interest rate loans have also been given to civil servants for purchasing the Saga. The government has also played an important role in giving technical, financial and other assistance through a special vendor development programme to develop *Bumiputera* parts and components manufacturers.

Besides Proton, the state has also played an important role in promoting a second national car project and other new initiatives. In 1993, the second Malaysian national car project, Perodua (short for Perusahaan Otomobil Kedua, or Second Automobile Enterprise), was set up to produce a smaller Malaysian car, the Kancil. Explicitly intended to advance the interests of their *Bumiputera* shareholders, it initially involved Permodalan Nasional Bhd (PNB), Daihatsu Malaysia Bhd, Mitsui Company, UMW Holdings Bhd, Med-Bumikar MARA Bhd, and Daihatsu Motor Company of Japan (an affiliate of Toyota).

Partly to enhance Proton's leverage vis-à-vis Mitsubishi, the government also encouraged the production of new "car projects" through further joint ventures involving Yahya Ahmad's Diversified Resources Berhad (DRB) and Proton with Citroën of France and Rover of England. HICOM plans to open Proton's second plant, with an annual capacity of half a million units, in a new Proton City in the state of Perak which will have twice the production capacity of the first Proton plant in Shah Alam (*New Straits Times*, 23 March 1996). Proton's second plant will concentrate on producing 1,300cc to 1,800cc car models for both domestic and export markets. According to HICOM, Proton's second plant will boost Proton's entire production capacity to 750,000 units, and Proton cars will use 100 per cent local content by the next decade. A summary of the major national automobile projects is presented below.

- First National Car Project (PROTON) Passenger Cars (1,300–2,000 cc)
- Second National Car Project (PERODUA) Mini Passenger Cars (660 cc)
- PROTON-DRB Car Project, SATRIA, TIARA and other variant vehicles (1,300–1,600 cc)

- PROTON-CITROËN Car Project, new variants (1,000–1,300 cc)
- National Truck Project by HICOM, DRB and Isuzu (2–3 ton GVW small trucks)

In conclusion, since 1985, the Malaysian government has launched several "national vehicles", including the Proton Saga, Iswara, Wira and Perdana (with Mitsubishi technology), Perodua Kancil and Rusa (with Daihatsu technology), Proton Satria and Tiara (with Citroën of France and Rover of England technology), and in 1997, the government negotiated a national truck programme with Isuzu of Japan to produce 2 to 3 ton GVW small trucks. The new national trucks will be produced at Automotive Manufacturers Malaysia (AMM), which currently assembles Isuzu small and large trucks.

Thai government policies towards the automobile industry

Although Thailand has maintained minimal state intervention compared to Malaysia in so far as the automobile industry is concerned, specific sectoral goals and policies have been practised. Over the past 35 years, Thai automobile manufacturing policy has shifted from high to low protective measures and from an inward-oriented to a more export-oriented strategy. The development of government policy towards the automobile industry can be divided into three phases.[3]

Early promotion and initial protection (1960–70)

Nevertheless, the automobile industry is probably the only Thai industry that has specific sectoral goals and policies, and has been protected by various import restrictions and very high tariffs for the last three decades. These policies have been sought to protect the Thai car industry from overseas competition and to promote the Thai parts and components industries.

Automobile manufacturing development began when the government offered generous tax incentives to automobile assemblers and protected the domestic market behind high tariff barriers. The automobile industry was among the first industries to enjoy special promotional privileges from the Board of Investment (BOI). It was classified under category B, allowing a 50 per cent reduction of import duties and trade taxes. Between 1962 and 1970, import duties on CBUs were 60 per cent for passenger cars, 40 per cent for commercial vehicles and 20 per cent for trucks; hence duties on CKD units for local assembly were 30, 20 and 10 per cent, respectively. These incentives encouraged a number of multinational automobile manufacturers from Japan, the US and Europe to set up joint ventures to assemble passenger cars and commercial vehicles from CKD and SKD kits for the domestic market.

By 1969, there were six assemblers – Siam Motor & Nissan, Toyota Motor Thailand, MMC Sittipol (Mitsubishi), Isuzu Motor Thailand, Thai Hino Industry and Thonburi Automotive Assembly (Benz) – five of which were Japanese-related enterprises (Ministry of Industry (MOI), Thailand). The number of automobiles assembled locally increased from 525 (310 passenger cars and 215 trucks) in 1961 to 12,140 in 1969. In 1969, when the tax incentives granted to the first group of promoted assembly operations were expiring, it had become apparent that the automobile assembly industry generated negative trade balances, in sharp contrast to the intentions of government promotional policy. As a result, in 1971, the Ministry of Industry announced a new rationalization plan for the development of the Thai automobile industry. The Automotive Development Committee (ADC) was set up by the MOI, and the BOI stopped granting promotional privileges to new assembly plants.

Industrial rationalization through local content requirements (1971–86)

In July 1971, the Ministry of Industry announced rationalization guidelines restricting the number of models. According to the guidelines, an assembly plant was required to produce either passenger cars or commercial cars. Existing producers of passenger cars were allowed to produce no more than three models, of which only one model could have a 2,000cc engine. New passenger car assemblers were only allowed to produce one model with a 2,000cc engine. Existing assemblers of commercial vehicles were not allowed to produce more than five models while new assemblers were limited to just three models. These restrictions on vehicle types, models and engine size were undermined by collusion between Thai government officials and assemblers to circumvent these restrictions. The guidelines were revoked before they could become effective and were finally abandoned. In early 1975, local content requirements were introduced at 25 per cent for passenger cars, 20 per cent for commercial vehicles with windshields and 15 per cent for commercial vehicles without windshields.

In early 1978, the government totally banned CBU imports and increased import duties on CKD kits to 80 per cent. This measure favoured Japanese automobile producers because they were the largest producers in the market. In September 1978, new local content requirements were announced; according to these regulations, the local content of passenger cars had to be at least 25 per cent, increasing to 35 per cent within two years, and going up 5 per cent every year thereafter up to 50 per cent. It was also stipulated that all assembly plants should achieve 40 per cent local content by August 1981. The government also introduced "mandatory deletion" of specific parts from imported CKD kits, e.g. brake drums and exhaust systems, which had been locally produced for some time.

As a result of the development of sub-contracting and supporting firms in metal, plastic, and rubber parts, several complete motor vehicle systems could be locally manufactured or assembled, including exhaust systems, brake systems, fuel systems, suspension systems, lighting systems, pressed parts and assemblies, and interior trim (BOI 1995). Local parts and components producers increased substantially during this period. According to the BOI report for 1995, technically simple parts and components – such as alternators, exhaust pipes, filters, radiators and starters – were produced by local producers while a range of more sophisticated parts and components were produced by Japanese affiliates and Thai–Japanese joint ventures.

Liberalization and internationalization (1987–present)

The period since 1987 has been characterized by a transition towards liberalization of Thai automobile sector policies in line with a more outward-looking strategy beginning in 1987, when 488 passenger cars and forty buses were exported to Canada by MMC Sittipol, a Thai joint venture with Mitsubishi of Japan. This was followed by a number of parts and components firms breaking into export markets, especially for safety glass, ignition coils, wiring harnesses, air and oil filters, and related products (BOI 1995). Despite growing exports, the local automobile market remained highly protected from 1987 until 1991 (see Table 11.1). Imports of CBUs under 2,300cc were still banned, and CBU cars over 2,300cc faced a 300 per cent import duty. Total taxes for a 2,300cc passenger car, for example, were over 616 per cent for CBUs and 125 per cent for CKDs. The high levels of protection made the domestic prices of automobiles in Thailand higher than for comparable models in other countries.

With the high demand for pick-up trucks and the localization policy, plans to establish local production of engines were revived after having been dropped in the early 1980s. Four Japanese joint ventures – involving Toyota, Nissan, Isuzu and Mazda – were promoted by the BOI for the assembly of diesel and gasoline engines. Imports of engines were banned and a progressive local content requirement programme began. A summary of major automobile industry policies is shown in Table 11.1.

With the establishment of the Anand Panyarachun government in 1991, the Thai automobile industry experienced changes which have transformed Thailand's automotive sector into an internationally competitive industry. The first steps were to lift the import ban on CBU cars and to completely restructure the tariff system on cars and car parts in July 1991 (BOI 1995). These moves forced the Thai assembly and auto parts industries to improve efficiency and produce higher quality cars to meet international standards for export. In 1996, local content requirements still remained, but were being reviewed as Thailand signed the Uruguay Round of the General Agreement on Tariffs and Trade (GATT) in 1993 which disallows such measures and committed itself to creating the ASEAN Free Trade Area (AFTA). The Thai government has been forced to reassess the import duty structure for finished vehicles, kits, components, as well as raw materials, and to plan for the gradual phasing out of local content regulations, and the implementation of the ASEAN Brand-to-Brand Complementation and

Table 11.1 Thailand: summary of major automobile industrial policies since 1960

Year	*Policy*
1961	1960 Industrial Investment Promotion Act provides incentives for the automobile assembly plants. Assembly operations established using CKD kits.
1962	1962 Industrial Investment Promotion Act granted privileges, especially a 50 per cent reduction in tariffs and trade taxes on CKD kits. Tariffs on imported CKD kits for passenger cars (PCs), pick-ups (Ps) and trucks (Ts) were 30 per cent, 20 per cent and 10 per cent, respectively.
1969	MOI sets up Automotive Development Committee (ADC). 20 per cent increase in tariffs for imported CKD kits for PCs, Ps, and Ts (new rates: 50 per cent, 40 per cent and 30 per cent, respectively).
1971	MOI restricts the number of locally assembled PCs, Ps and Ts. Government announces local content requirements (LCRs) to begin in 1974.
1974	LCR became effective (25 per cent for PCs from January).
1976	Number of locally assembled PC models limited to twenty-four; this limit was subsequently lifted by the MOI.
1978	Government bans CBU imports and increases import duty on CKD kits to 80 per cent. Government bans new assembly plants due to over-capacity. Tariffs on CBU PCs increased to 150 per cent and on CKD PCs to 80 per cent.
1982	LCRs for all vehicles frozen at 45 per cent.
1985	Mandatory local-content list imposed. Ban on imported CBU vehicles (with engines over 2,300cc) lifted.
1986	LCRs for PCs raised to 54 per cent. List for compulsory and non-compulsory parts imposed.
1989	Ceiling on production capacities at existing assembly plants lifted.
1991	Ban on imported CBU cars lifted. Tariffs reduced for all imported CBUs and CKD kits.
1993	Ban on new assembly plants lifted.
1994	New excise tax category for off-road vehicles.
1995	BOI plans to promote new engine assembly operations. New exhaust emissions schedule announced.
1996	MOF new vehicle financing regulations.
1997	Mandatory inspection of 5-year-old cars. Stricter emission standards enforced on diesel fuel vehicles.
1998	Projected date of LCR termination.

Source: Board of Investment (BOI) and Ministry of Industry (MOI).

Industrial Joint-Venture programmes (see BOI 1995). As a result, many Japanese and US multinational automobile assemblers and auto parts manufacturers are transforming Thailand into a major assembly and component manufacturing export base for their world-wide operations.

Since 1991, when the Thai government changed the import duty structure on CKD kits and CBUs, the automobile industry has begun preparing itself for increased competition from international manufactures. Consequently, the Anand government decided to slash import duties on motor vehicles. In 1991, import duties on CBU vehicles over 2,300cc were reduced from 300 to 100 per cent while CKD duties were reduced from 112 to 20 per cent. This has substantially reduced the total tax from 617 per cent to 211 per cent for CBUs and from 125 per cent to 106 per cent for CKD kits. The decision by the Anand government has transformed the Thai automobile industry from a highly protected one, reflecting its origin as part of an import-substitution strategy, to one exposed to external competition as part of an export-oriented strategy. The same decision has also led to intensification of competition among automobile manufacturers in Thailand.

Consumer demand for automobiles has increased with the rapid growth of the Thai economy since the 1980s and the liberalization of 1991. From 1987 to 1992, the local market for cars and trucks grew at an unprecedented average annual rate of 30 per cent (BOI 1995). This pressure has forced automobile assemblers to expand their production facilities to cope with the rapid increase in domestic demand for automobiles and the related demand for parts and components. A number of parts and components firms, especially in safety glass, ignition coils, wiring harnesses, air and oil filters and related products, have also begun to look outward to new export markets (BOI 1995).

The appreciation of the Japanese yen after the Plaza Agreement of 1985 eroded the international competitiveness of Japanese firms and industries. In addition, rising domestic labour and other production costs as well as Japanese trade disputes with its main trading partners, especially the US, adversely affected Japanese exports, encouraging production abroad instead. The Japanese government responded to these changes by encouraging a massive inflow of capital and firms to South-east Asia and other parts of the world, to lower production costs and to preserve market shares for Japanese products. The automobile industry was affected by these developments, partly because many Japanese multinationals operating abroad still sourced their inputs from their parent companies in Japan. The yen appreciation encouraged these companies to relocate, especially in countries where Japanese affiliates were in operation. Such pressures encouraged Japanese car assemblers and their component suppliers to relocate manufacturing operations in South-east Asia. Some local auto parts manufacturers in Malaysia and Thailand also benefited from these changes. However, discouraged by Proton's monopoly in Malaysia, more new private investments were made in Thailand where Japanese automobile manufacturers such as Toyota, Mitsubishi, Nissan and Honda have put in more than US$1 billion to expand their production capacity in Thailand since 1994 (BOI 1995). The largest Japanese automobile manufacturer Toyota has spent US$600m to expand its production capacity in Thailand since 1994. They are expanding capacity to offset the adverse effects of the rising yen, meet rising Thai domestic demand and export to emerging markets in neighbouring Vietnam and Myanmar, as well as to Japan, Europe and North America. However, while the financial crisis in

Thailand from mid-1997 has reduced domestic demand for automobiles, the cheaper baht is likely to make automobile exports from Thailand more competitive in foreign markets. This will boost export prospects for Japanese automobile manufacturing in Thailand.

Thailand's acceptance of the Uruguay Round on the General Agreement on Tariffs and Trade (GATT) and the ASEAN Free Trade Area (AFTA) in 1993 has also encouraged liberalization and greater outward orientation of the Thai automobile industry, forcing the government to reassess some of its old sectoral policies. Consequently, the Thai government is planning gradually to phase out local content regulations, considering ASEAN Brand-to-Brand Complementation and Industrial Joint-Venture programmes, and modifying the import duty structures for CBUs and CKD kits, components and parts, and raw materials. As a result, the US "Big Three" (General Motors (GM), Chrysler and Ford) and many Japanese automobile and auto parts manufacturers have already applied for new plants and are expanding existing operations. They now target Thailand as a base for their regional vehicle manufacturing and assembly operations for sales in the domestic and regional markets

Impact of industrial policies on industrial and technological development

Before examining the impact of various industrial policies on industry and technological development, it is appropriate to look at the structure of the automobile industries in Malaysia and Thailand. The automobile industry consists of final assembly, parts and components industries supporting industries, repair services, franchised distributors, and financial agencies (UNIDO 1983), but this chapter mainly focuses on final assemblers, parts and components producers, and supporting industries, which may be represented as in Figure 11.1.

In principle, every industry providing inputs to other producers can be considered a supporting industry. Metal forging, heat treatment, mould and die making, and plastics compounding are some examples of supporting industries in the automobile industry. Parts and components producers manufacture original equipment manufacturing (OEM) and replacement equipment manufacturing (REM) components. Their finished products are sold to final assembly, repair shop and general customers in the replacement market for used vehicles. The vehicle final assembly level is the last stage in the automobile production system where the final product is manufactured from components and parts. In 1997, there were twelve automobile assembly and manufacturing plants in operation in Malaysia (MIDA 1997). Eight of the plants produce both passenger and commercial vehicles, three solely produce commercial vehicles, while Proton only manufactures passenger cars. The total production capacity of these plants is 390,000 units of passenger and commercial vehicles per year. According to the Ministry of Industry (MOI), there are currently sixteen automobile assembly

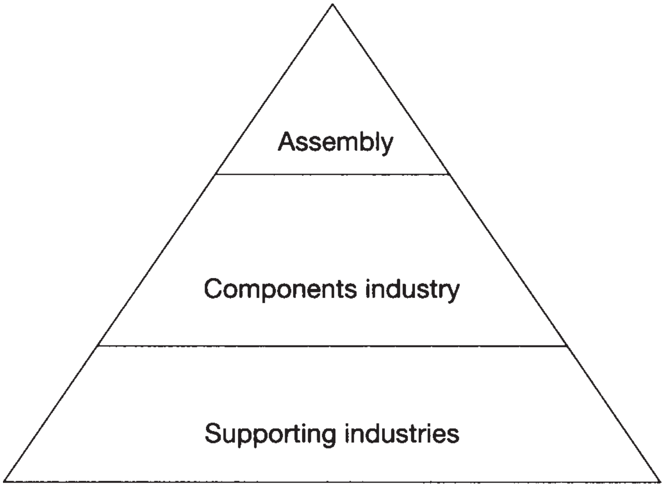

Figure 11.1 Structure of automobile industry in Malaysia and Thailand

and manufacturing plants in Thailand, which have a production capacity of 800,000 units per year.

The next step is to look at how various industrial policies in Malaysia and Thailand have affected the development and structure of their respective automobile industries. Figure 11.2 shows the structure, ownership and control of the automobile industry in the two countries with different industrial policies. As a result of these differences, the Malaysian automobile industry – which had previously encouraged CKD assembly under the control of foreign manufacturers and their local Chinese partners – came to be dominated by state-initiated enterprises (1), involving joint ventures between the state and foreign manufacturers and increasingly involving ethnic Malay investors with strong support from the government. Meanwhile, foreign automobile manufacturers (mostly

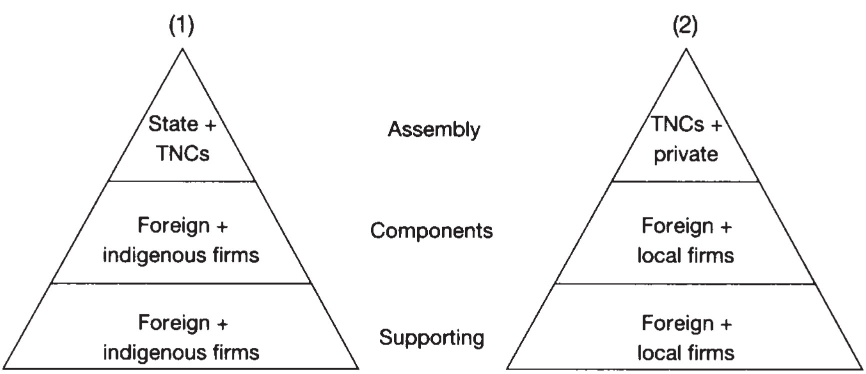

Figure 11.2 Ownership and control of the automobile industry in Malaysia and Thailand

Japanese) have increased their control of the production of automobiles, parts and components supplied under a more private sector-oriented industrial policy in Thailand (2). What have been the implications of the different strategies for industrial and technological development in Malaysia and Thailand? The following analysis will compare the national car project in Malaysia and private sector-led automobile industry development in Thailand. However, a brief discussion of industrial and technological development prior to the 1980s is also needed.

Industrial and technological development during the 1960s and 1970s

Malaysia and Thailand entered the second stage of automobile industry development under similar constraints with some limited experience of automobile assembly related manufacturing in the 1960s and 1970s. Local distributors of imported CBU vehicles became partners with foreign automobile manufacturers to assemble imported CKD parts and components for the domestic market. During this period, domestic supporting and auto parts industries hardly existed. Local auto part manufacturing in both countries started by producing REM parts, and most parts and components were imported by the assembly plants from parent companies in the country of origin. The automobile industries in both countries were characterized by the presence of numerous foreign automobile manufacturers producing small volumes of a wide array of models sold at high prices behind protective tariff walls (UNIDO 1983).

One of the biggest obstacles to industrial and technological development in the automobile industry in both Malaysia and Thailand during this period was too many assemblers producing small numbers of a wide variety of vehicles in relatively small, protected markets. There were eleven assemblers producing 122 models in Malaysia, and twenty assemblers producing about 150 models in Thailand (Jomo 1994, Higashi 1995). Most of these assembly plants were joint ventures between Japanese and local partners in both countries. Once established, these joint ventures quite easily resisted weak host government efforts to increase local content and remained largely assembly operations until the early 1980s. In Malaysia, local content ratios were 8 and 18 per cent in 1979 and 1982, respectively, with local content largely limited to tyres, batteries, paint, filters, seat-belts and glass items.

Similar developments occurred in Thailand in the 1960s. Thai firms supplied tyres, batteries and leaf springs. In the 1970s, local supplies increased, but parts produced by Thai firms were technically simple, e.g. starters, alternators, filters, exhaust pipes, radiators, safety glass, and other mostly peripheral equipment (Kaosa-ard 1993). A range of more sophisticated parts and components were produced by Japanese affiliates and by Thai–Japanese joint ventures (BOI 1991).

During this period, local employees in both countries were trained by Japanese auto makers to diagnose and repair vehicle breakdowns and keep the assembly line moving. Technology transfer was concentrated in sales and after-sales service (Sato 1993). The training of local staff in Malaysia and Thailand was mainly achieved through on-the-job training (OJT) at their assembly plants in both countries and short-term training at facilities in Japan. As a consequence of such developments, both countries achieved modest levels of industrial and technological development in their automobile industries during this period. In the early 1980s, the Malaysian government decided to restructure its automobile industry through its national car project, while Thailand continued to develop a progressive localization scheme before liberalizing to ensure the international competitiveness of the Thai automotive production capacity.

Industrial and technological development since 1983

The automobile industries in both Malaysia and Thailand have achieved dramatic growth since the late 1980s, leading to a substantial increase in vehicle production. The average annual output growth rate in Malaysia during 1988–93 was 17.7 per cent, of which 70 per cent came from the increase in Proton's production. In 1995, 207,411 vehicles were produced in Malaysia of which 160,000 vehicles were produced by Proton (Proton 1995: 5). Between 1994 and 1995, output increased by 19.8 per cent in Thailand and 434,001 vehicles were produced. In Malaysia, Proton captured 73 per cent of the domestic market, while five Japanese automobile assemblers (Toyota, Isuzu, Mitsubishi, Nissan and Honda) controlled 76 per cent of the passenger car market and 98 per cent of the commercial vehicle market in Thailand. The domination of Proton in Malaysia and Japanese automobile manufacturers in Thailand has had various effects on industrial and technological development in both countries. This section will analyse cross-national variations in industrial and technological development in the automobile industries in Malaysia and Thailand.

Rationalization through increasing economies of scale

The presence of numerous foreign automobile producers who produced low volumes with rapidly changing models has led to market fragmentation and hindered the development of local parts firms. The large number of assembly plants involving excess capacity and rapid proliferation of models has caused short production runs, uncertain demand, and greater learning difficulties for local parts and components producers in both countries. This, in turn, has caused locally produced parts and components to be more expensive and poorer in quality. Both Malaysia and Thailand have attempted to increase economies of scale in their automobile industries by: (1) limiting the number of makes and models, as well as the frequency of model changes, and (2) promoting the standardization of parts used by different manufacturers and models (Doner 1992). According to Doner (1992), South Korea and Malaysia have been the most successful in achieving rationalization by reducing the number of models produced, thus creating a more conducive environment for the development of their automobile industries. Hyundai spent six years producing a single model, based on the Ford Cortina, before advancing to more sophisticated models (Shin 1984). Hyundai's connections with Ford during the 1968–73 period resulted in mastery of assembly-line design, tool selection and general worker education necessary for subsequent absorption of more sophisticated technologies involving engine blocks, transmissions and rear axles, as well as factory construction and layout (Kim 1984).

In Malaysia, problems such as the proliferation of models and makes, which were the main obstacle to the successful development of local auto parts firms, have been overcome with the national car project. Proton's operations have significantly affected the development of the automobile industry in Malaysia. Between 1985 and 1993, at least two Chinese-owned assembly plants, operating in the early 1980s, closed down, while two others merged with larger firms and diversified into parts manufacture (Doner 1992, Yong 1995). Since then, all other assembly plants have resorted to assembling more makes to keep up the volume of manufacturing activity. The national car project has also increased production, as initially envisaged, thus providing greater opportunities for the local production of automobile parts and components. Since the Saga in 1985, Proton has launched a few more passenger car models: the Saga Saloon and Aeroback in 1987, Proton Saga CARES (Clean Air Regulation Emission System) and Iswara in 1992, Proton Wira in 1993, Proton Perdana in 1995 and Proton Tiara in 1997, all mainly for the domestic market. In 1994, Proton had 73 per cent of the domestic market (Proton 1995: 6).

During the early period of automobile manufacturing development in Thailand until the early 1980s, Japanese automobile manufacturers fragmented the Thai market by offering many models and frequent changes, which effectively created entry barriers for others. In 1983, about 300 models were being produced by over fifteen assemblers in Thailand. However, Thai policy makers realized that the mere presence of foreign automobile manufacturers was not sufficient to stimulate and ensure technology transfer to local parts and components firms. In 1984, the Thai government's Automotive Development Committee (ADC) limited domestic assembly of passenger cars to forty-two series, with each series limited to two models. The aim was to achieve economies of scale by setting limits on the number of models and series, and by promoting the localization of parts and components. However, attempts by the Thai state to rationalize model proliferation have been less successful compared to South Korea and Malaysia (see also Doner 1992 and EIU 1985).

Local content

Local content requirements have been imposed on foreign assembly plants by the Malaysian and Thai states – as a condition for granting foreign automobile manufacturers access to their local markets – since the early 1970s. Not surprisingly then, in both Malaysia and Thailand, the strongest backing for localization has come from local auto parts and components firms (Doner 1991 and 1992).

Many of these firms began manufacturing replacement parts and were eager to expand into the original equipment market (OEM) to supply local car assembly plants and even to export. Over the past three decades, foreign automobile manufacturers have often agreed to participate in government-initiated localization programmes, but have subsequently attempted to lower the original targets by arguing that local firms were incapable of meeting OEM parts price or quality requirements (Doner 1992).

Local content levels in Malaysia increased from 8 per cent in 1979 to 18 per cent in 1982 before the national car project and to 30 per cent in 1986 (Jomo 1994). Proton formulated a localization programme to increase local content of the national car project and to help develop the local automobile component industry. By the end of 1985, the number of Proton's locally sourced components totalled 228, of which 176 were produced in-house, including body side mouldings, wiring harnesses, exhaust systems and carpets. In 1986, besides in-house operations like metal pressing and sub-assembly, a further ninety-seven components were added to the list, achieving 40 per cent local content by value. When another forty-eight new locally sourced components were included by November 1988, local content exceeded 60 per cent based on General System of Preferences (GSP) criteria. By 1995, Proton had managed to source 3,511 components domestically – 394 in-house, 3076 from domestic vendors and forty-one resources. Using GSP criteria, Proton had achieved 67 per cent domestic local content (Proton 1995: 9, Buranathanung 1995, Tharumagnanam 1994). By its own local material content policy (LMCP) criteria, Proton had 80 per cent local content in 1995 (Proton 1995: 9, Rasiah 1997).

In Thailand, rationalization – through the ban on new assembly plants and limiting the number of makes and models – was much more difficult than increasing local content requirements. Local content of passenger cars rose gradually to 35 per cent in 1980, and the minimum local content requirement was set at 25 per cent for commercial vehicles. Local content has been rising gradually since then, reaching approximately 45 per cent in 1982 and 54 per cent in 1986 (see Table 11.1). This is partly because Thai parts firms have been well organized enough to pressure the government to advance their interests against foreign assembly plants. In addition, Thailand has been successful in achieving about 80 per cent local content in locally assembled one ton pick-up trucks (FTI 1996), but Kaosa-ard (1993) argues that most parts and components produced locally are by foreign subsidiaries, and that the local parts industry has not been able to produce major parts, such as those for power transmission.

Promotion of local component firms

Local content regulations and different measures have been used by the Malaysian and Thai governments to enhance the growth of local parts and components ancillary firms in the automobile industry in the two countries. Therefore, the interplay among foreign automobile manufacturers, the state and local firms has been important for automotive industrial and technological development in both countries.

Malaysia

By setting up the national car project[4] in the early 1980s, the Malaysian government has had three main objectives besides developing national automotive manufacturing capacity: first, to enhance *Bumiputera* involvement in the automotive industry; second, to promote industrial linkages among small-, medium- and large-scale industries; and third, to upgrade low-level local technology and to improve technical skills in the country (see Proton 1995:1, Rasiah 1997). This proved to be problematic for the Malaysian government, because implementing the ethnic promotion policy has involved reducing the efficiency and competitiveness of the national car project. This is partly because rents have to be created by the state to stimulate risky and lumpy investments of inexperienced new start-ups by parts firms. Protection has been imposed to protect Proton from foreign competitors including foreign producers assembling domestically. The government has made major efforts to match local vendors with reputable foreign producers to transfer technology to and enhance the level of technology in the local automotive components industry. The government has required Proton to share its handsome rents with *Bumiputera* vendors. In line with the *Bumiputera* promotion policy, Proton has to source parts and components from government-designated *Bumiputera* vendors who often charge higher prices.

Since the recovery of the Malaysian economy from 1987, Proton's production and the total number of vehicles produced in Malaysia have increased rapidly. Proton's rapid expansion led to the firm doubling its annual production capacity from 80,000 cars in 1985 to 170,000 cars in 1996 (ARA 1997). The Perodua Kancil quickly became the second best-selling passenger car in Malaysia. In 1995, 39,006 Kancils were sold in the domestic market, and the number increased to 46,971 in 1996. Kancils were exported to the United Kingdom in late 1997. By the year 2000, production of Kancils is projected to reach 70,000 units (MACPMA 1996). In March 1996, Perodua added another vehicle to its line-up with the sales launch of the Perodua RUSA, the first national multi-utility vehicle (MUV). In 1996, 7,400 Rusa vehicles were sold, i.e. 10 per cent of the commercial vehicle segment in Malaysia (ARA 1997). As a result of rapid expansion in the production of vehicles in Malaysia, demand for components and parts has also increased. According to the Malaysian Industrial Development Authority (MIDA), there are approximately 300 firms in the auto parts industry, of which 70 per cent are engaged in OEM production (MIDA 1997). Kawakami (1995) argues that the recent growth of components industries in Malaysia may have been the result of the "top-down" policies of the Malaysian government through the national car projects.

Thus, Proton and Perodua have become important platforms for generating new start-up *Bumiputera* components suppliers. Despite limited management and manufacturing experience, new start-up *Bumiputera* vendors have been encouraged to supply components to Proton. Since 1985, Proton has been aggressively developing and sourcing components from local and overseas vendors. In 1992, Proton sponsored the formation of the Proton Vendors Association to institutionalize communication channels with and among different segments of the local auto parts industry, and to consolidate its programmes for the advancement of this sector. By 1995, a total of 138 local vendors had been developed (Proton 1995). These local vendors supply more than 3,000 locally produced parts and components to national car projects.

As part of its vendor development strategy, mainly intended to promote *Bumiputera* parts suppliers, Proton's procurement and vendor development department has attracted foreign technical assistance and investment in joint ventures to produce components for Proton to emerge as a world-class manufacturer of passenger cars. Proton received RM7 million under the Fifth Malaysia Plan (1986–90) and an additional RM15 million under the Sixth Malaysia Plan (1991–5) from the Ministry of International Trade and Industry (MITI) General Technical Assistance Scheme to help small- and medium-sized *Bumiputera* entrepreneurs venture into automobile components manufacture and to extend *Bumiputera* participation in high-technology component manufacturing and supporting industries such as forging, electroplating, tool-making and machining.

Thailand

In Thailand, the state has not attempted to share ownership in automobile assembly or manufacture to rationalize the industry and to develop the local components industry as in Malaysia. Most local component firms started by producing replacement equipment as part of the import-substitution industrial policy, and were eager to produce OEM parts. Since the early 1970s, the government's localization policy has mainly sought to reduce the automobile sector's trade deficits rather than foster greater national automobile technology capabilities (Kaosa-ard 1993). There has been no systematic programme to provide technical, financial and marketing assistance to local parts firms, as seen from the late 1980s in Malaysia. Local firms did not invest heavily in technology while enjoying higher government protection, but instead lobbied the government for more protection and higher local content requirements. Kaosa-ard (1993) argues that the lack of complementary sectoral policy in the Thai automobile industry is one of the main reasons for the inefficiency and low-level technological capabilities of the Thai firms involved. According to statistics from the Federation of Thai Industries (FTI), in the mid-1990s there were about 334 firms producing OEM components for assembly plants, and 200 to 250 firms manufacturing spare parts for repairs (REM). The majority of the firms producing OEM components are joint ventures with Japanese component firms.

It was argued that since the inception of the national car project in Malaysia in 1983, the state has played an important role in promoting local components firms (Kawakami 1995). In the Thai case, one Japanese scholar argues that Japanese automobile manufacturers have been as important for the growth of local parts firms as the host country policy. I shall now examine Higashi's (1995) argument by examining how Japanese automobile manufacturers responded to the Thai government's increased local content requirements.

As the local market grew and the Thai government insisted on localization of parts and components, Japanese automobile manufacturers quickly coped with more aggressive localization policies by the Thai state of the 1980s. They managed to meet local content requirements through various strategies such as implementation of a satellite strategy, inter-assembler collaboration and regional sourcing of auto parts to strengthen their regional and global automobile production strategies.

First, the Japanese automobile manufacturers responded by implementing a satellite strategy (Co-operation Clubs), bringing their Japanese parts suppliers to Thailand and locating them around their assembly plants (see Kaosa-ard 1993, BOI 1995, Doner 1991, 1992). By relocating their own parts suppliers, the Japanese assemblers maintained quality while reducing costs of production. This shift coincided with the massive relocation of small- and medium-sized industries from Japan and the other East Asian NICs due to the appreciation of their currencies after the Plaza Agreement of 1985 and rising labour costs in these economies. Thailand received a large number of small- and medium-sized Japanese and East Asian NIC firms in various industrial sectors after 1985, of which the automobile and electronics industries were among the largest. The BOI (1995) estimated that almost half of all important Japanese parts and components manufacturers in the automobile industry had some commercial and technical co-operation arrangement in Thailand. These Japanese parts and components makers not only produce for local Japanese assemblers but also operate as international suppliers, exporting an increasing volume of their products to the USA, Europe, Australia, the Middle East and Japan (BOI 1995). The satellite strategy has also been implemented in the electronics industry in Thailand (see Abdulsomad 1994).

Japanese automobile assemblers operating in Thailand – such as Toyota, Mitsubishi, Nissan and Isuzu – have developed their own suppliers (comparable to the *keiretsu* system of suppliers in Japan) and generally have fifty to seventy suppliers (Kaosa-ard 1993, Buranathanung 1995). They are three classes of suppliers – affiliates, close associates and general vendors distinguished by their relationship to the assembler and the amount of control the latter has over them (TDRI 1991). Affiliates are suppliers with whom the assemblers have made joint investments while close associates are regular sub-contractors, and general vendors are local suppliers who do not fall into either of these two categories. Japanese automobile assemblers deal with local firms as vendors, who are screened by Japanese automobile assemblers to ascertain whether they have adequate technical capacity and are reliable, before appointing them as sub-contractors.

Technology transfer between Japanese assemblers and their suppliers through a co-operation club is an important feature of Japan's automobile industry. Through this channel, Thai parts firms obtain technology from Japanese automobile manufacturers. Japanese automobile manufacturers transfer both software and hardware – such as machinery and plant operations, blueprints, on-the-job training (OJT) in both Thailand and Japan, quality control (QC) and marketing know-how – to their co-operation club members. However, Japanese assemblers neither provide technology to Thai firms free of charge nor train them from scratch (Kaosa-ard 1993). The transfer and replication of supplier relationships from Japan have created entry barriers to OEM by non-members, particularly for Thai firms. Many Thai auto parts firms have to set up joint ventures with Japanese counterparts to obtain technical and managerial assistance, in order to penetrate the (OEM) markets and to join the co-operation clubs of particular Japanese automobile producers.

Another Japanese automobile manufacturers' response to the localization policy in Thailand has been inter-assembler collaboration. Such efforts started when the Thai government planned to increase the local content requirements for one ton diesel engine pick-ups from 60 per cent in 1994 to 70 per cent in 1998. Previously, collaboration had been difficult due to mutual suspicion, as each company tried to protect its technology by preventing others from visiting its factory, but the common challenge of the localization policy changed the relations from suspicion to collaboration. Such collaboration lowered costs and increased competitiveness while complying with the local content policy imposed by the host government.

Also, the major Japanese automobile manufacturers' strategy of sharing engine parts also led to long-term standardization of components used in the development of engines. The standardization of automobile components has encouraged inter-assembler collaboration and strengthened regional and global production strategies of Japanese automobile manufacturers. This new tendency can be seen in local procurement by Japanese assemblers in Thailand which is dominated by inter-firm transactions involving affiliates and close associates. A survey by Kato (1992) showed that Japanese manufacturers procured about 70 per cent of their parts from their own subsidiaries. The pattern of inter-firm transactions varied with the nature and technological levels of the products. Thai firms supply labour-intensive and low value-added components, such as interior glass, while Japanese affiliates and close associate firms accounted for the high technology and value-added products, such as engines, pistons, body parts, and disc and drum brakes (BOI 1995, Buranathanung 1995).

Finally, Japanese automobile manufacturers – such as Toyota, Nissan, Mitsubishi and Honda – have actively supported the ASEAN brand-to-brand complementation (BBC) scheme since the early 1980s. This scheme promotes the parts trade among auto companies operating in ASEAN member countries at reduced tariff rates. The BBC programme allows assemblers in each participating country to import components from any of the other countries as local content while also enjoying a 50 per cent reduction of the import duty. In addition, the scheme also allows for a 50 per cent reduction of the import duty on CKD kits and CBU passenger cars, vans and pick-up trucks made in the participating countries. This arrangement seems to bolster the regional and production strategies of Japanese automobile manufacturers more than it benefits participating ASEAN countries. Japanese automobile manufacturers have begun importing parts and components from other ASEAN countries under the BBC scheme to replace imports from Japan (Buranathanung 1995).

Research and development

In order to achieve greater and more coherent localization of the Malaysian automobile industry, research and development in upstream design technologies and automotive engineering are necessary. Proton invested more in R&D than any other local company in Malaysia. In 1992, Proton spent about RM82 million on R&D. In 1993, a new Proton Research and Development Centre was established to carry out full-scale research on model making, computer-aided engineering design and manufacturing. Proton's component and engine emissions testing laboratories have been accredited by the UK Department of Transport. With its new facilities Proton's Research and Development Centre will be able to initiate its own development, planning and design of cars. Proton's second plant in Tanjung Malim is also expected to engage in R&D and operate its own Research and Automotive Training Institute.

Most Japanese automobile manufacturers conduct their R&D activities in Japan and some in-house parts manufacturing activities in their assembly plants. Isuzu was the first and has been the only Japanese automobile manufacturer in Thailand to invest 10 million baht (about RM1 million), primarily to develop products for the Thai market. Thailand has not had much government support for its local parts and components industries, relying instead on foreign, mainly Japanese, automobile manufacturers. In South Korea and Malaysia, however, the governments have actively supported R&D and various training in the automobile industry to advance their national car projects.

Human resource development

The national car project in Malaysia has also contributed to human resource development. According to the terms of their joint-venture agreement, Mitsubishi Motor Corporation (MMC) was responsible for plant construction, training and supervision of preparations for production and technical assistance in localization. The national car project has required that all Proton staff (engineers, researchers, designers, managers, mechanics) be trained according to Japanese standards and procedures. Malaysian employees of Proton – from production workers to managers – have been sent to MMC in Japan since 1983 for training. Up to 1991, around 500 had been to Japan for training, while another 178 went in 1992 (Chew *et al.* 1993). Proton employees have received training in various aspects of car manufacturing such as production control, welding, painting, trim and final, maintenance, tooling, stamping engineering and quality control (Chew *et al.* 1993: 45). The Proton workforce has been trained in Japan as well as in Malaysia, and is still supervised by Japanese. Many specialists from MMC have also been despatched to the Proton plant to train Proton employees in Malaysia. In 1991 and 1992 alone, about 200 Japanese specialists from MMC were in Malaysia to provide training under the Technical Assistance Agreement with Proton (Chew *et al.* 1993).

Japanese automobile assemblers in Thailand have promoted human resource development in two ways. Besides providing a comprehensive education and training system for their own employees, dealers and parts makers, Japanese assemblers also provide funds to universities, technical colleges and various vocational training programmes. All this is intended to provide training in automobile engineering to upgrade skills in coping with the shortage of university-trained engineers in Thailand. In addition, Japanese private sector and some government agencies have also provided funds and various programmes through the Thai–Japan Technology Promotion Association (TPA) in Bangkok to upgrade the training of technical high school graduates to the level of engineers and provide technical assistance to Thai firms.

Conclusion

This chapter has argued that since the early 1980s, Malaysia and Thailand represent two different types of selective industrial development policy, especially in the development of their automobile industries. The Malaysian experience has been characterized by strong state intervention since the 1980s, while Thailand has been more liberal, relying more on mainly foreign private investors and market forces. The main argument of this chapter has been that these industrial policies and other related state interventions in automobile manufacturing in the two countries have affected industrial and technological development differently despite earlier similarities in the preceding two decades.

By setting up the national car project in the early 1980s, the Malaysian government has had three important objectives besides developing national automotive capacity: first, to expand *Bumiputera* involvement in the automotive industry; second, to promote industrial linkages; and finally, to upgrade low-level local technology. Unlike its South Korean and Thai counterparts, the Malaysian government has had a certain handicap from the outset because it has sought to implement its *Bumiputera* promotion policy while developing the national car project, which would be hard enough even without this additional policy objective. Proton has enjoyed special treatment from the state in the form of various rents, including subsidies and protection. The efficiency and international competitiveness of Proton will depend on how quickly the government can and will reduce its protection and how quickly local vendors and Proton enhance and upgrade their technology in order to lower production costs and to increase the higher value-added components produced locally, In contrast, the more modest but none the less specific sectoral policies for the automobile industry in Thailand – e.g. capacity regulation and the local content programme – have given the Thai state few policy instruments to support the growth and eventual international competitiveness of local parts and components firms. As Thailand began to open up its protected automobile market to more competition from 1991, many foreign automobile assemblers have expanded their plant facilities and output in Thailand in response to greater demand. The demand for parts and components has also increased with rising domestic demand for vehicles as well as greater exports.

Japanese automobile assemblers have responded to the new situation by expanding their in-house capabilities and encouraging affiliated Japanese components and parts manufacturers to move to Thailand, instead of by promoting Thai firms. Thus, the domination of the Thai automobile industry by Japanese automobile manufacturers has exacerbated technological dependence on Japanese firms. Though Thai firms have been protected by the localization policy, they have generally not significantly upgraded their technological capabilities except through joint ventures and technical agreements with Japanese parts and components manufacturers. Hence, while these Thai auto parts firms have been under greater pressure from international competition, they have not enjoyed enough rents and other support to significantly advance their technological capabilities. Growing international and domestic pressures for economic liberalization will probably further limit the likelihood of greater significant progress in the Thai automobile industry beyond that which coincides with the interests of transnational, especially Japanese, automobile manufacturers.

Notes

1 Information for this section is mainly drawn from the following sources: Chee and Fong 1983, Doner 1991 Jayasankaran 1993 Jomo 1994, Kawakami 1995.

2 Three industrial consultant reports were used by the Malaysian government to assess the state of the automobile industry in Malaysia after Singapore's separation. These were the Arthur D. Little Inc. Report, the Walker Report of 1970 and one by the Malaysian Motor Vehicle Assemblers Association. The government accepted the Walker Report as its main guide to localization policy (for more details on this issue, see Chee and Fong 1983).

3 Information for this section is mainly drawn from the following sources: Kaosa-ard 1993, Higashi 1995, Nawadhinsukh 1983, Siroros and Doner 1995, Doner 1991, Board of Investment (BOI) 1995.

4 Information about the development of the national car "Proton" is mainly drawn from the following sources: Tharumagnanam 1994, Proton, *Corporate Profile* 1995, *New Straits Times,* 23 March 1996, Kawakami 1995, Jomo 1994 and Doner 1991, 1992.

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12

TRUST AND THE DYNAMICS OF JAPANESE JOINT VENTURES IN MALAYSIA*

Richard Butler and Jas Gill

Increasing attention has focused on joint ventures and other types of alliances as firms have shifted emphasis from strategies based on competition, to ones incorporating notions of co-operation. Such collaborative agreements are becoming increasingly important sources of competitive strength and advantage as rapid changes take place in markets, products and technology. This phenomenon is not limited to national or domestic markets, but characterizes operations on a global scale. Hillebrand (1996) therefore argues that promoting co-operation by policy makers in industrializing countries is crucial if they are to cope successfully with industrial and technological change in a turbulent international environment. To date, joint ventures involving multinational companies are one of the most common forms of co-operative arrangement in these countries (Freeman and Hagedoorn 1994). Government policy makers in these countries have often encouraged joint ventures as a mechanism for transferring advanced technology and modern managerial practices to local firms as part of their industrialization strategies. Yet, despite their widespread nature, managing joint ventures has been problematic due to the multiple ownership and thus scope for potential conflicts between joint venture partners.[1] Moreover, joint ventures may not meet parent expectations. For example, the performance of nearly two-thirds of their joint ventures in the industrializing countries were considered to be unsatisfactory by the managers of multinational corporations (Beamish 1984). It is therefore unsurprising that joint ventures have a high rate of dissolution. Consequently, joint ventures may not be particularly effective as mechanisms for technology transfer and industrialization, unless their dynamics are better understood.

Empirical studies on the successful formation and operation of co-operative relationships have highlighted the crucial importance of intangible factors such as trust (Schaan and Beamish 1988, Faulkner 1995). Trust is a key factor in co-operative strategies (in contrast to competition) which involve an assumption of mutual obligations (Buckley and Casson 1988, Thompson 1967: 34–6). However, understanding of joint ventures remains incomplete and the main streams of research in this area remain disconnected and separate (Parkhe 1993). Parkhe (1993) suggests that an explicit focus on trust and related concepts such as forbearance and commitment may allow integration of theories developed to explain different forms of business organization and behaviour.

This chapter develops a framework for analysing the inter-organizational dynamics in joint venture formation and operation to achieve a better understanding of these processes and to consider the potential implications for government policy makers, and is structured as follows. The next section presents a conceptual framework for understanding the dynamics of joint venture formation and operation. Trust is a central concept in this framework. Factors that can foster trust include firm- or venture-specific factors as well as those emerging from the wider political, economic and technological contexts; these are also examined. The following section gives an overview of industrialization strategies in Malaysia, identifies factors affecting technology transfer and analyses two Japanese joint ventures in the automotive components sector based on empirical research carried out in November and December of 1995 using this framework. The local partner in both cases was Chinese-Malaysian; a group of Malay individuals had a minority stake in one joint venture. Data collection was primarily by in-depth interviews with senior Japanese personnel (the MD/ GM in one case and the technical director in the other) and the Chinese-Malaysian general manager in each joint venture, supplemented by company literature. Each interview lasted between two and three hours using a semi-structured questionnaire which focused on the six key factors identified in the conceptual framework (i.e. interdependence, competition, ambiguity, trust, autonomy and performance). The conclusions and policy implications are in the final section.

Conceptual framework

A joint venture is usually formed when two parties' organizational objectives cannot be achieved by other non-co-operative means. For the venture's parents, the most important factors are the proposed venture's strategic fit with their business strategies, their past experience of joint ventures and the negotiations leading to formation. When the partners do not know each other, their respective goals are ambiguous or opaque to each other, and any agreement reached is likely to be tentative and open to re-interpretation. *Formation* is thus likely to be a critical phase in the development of an effective joint venture. Over time, the parent companies gather experience and information about the joint venture's performance, and use this knowledge to redefine their goals and expectations, thus creating a new context for the venture. This feedback process from the joint venture to the parents is the *learning* phase.

The interaction of context – goals, strategies and expectations – with the joint venture's performance, may be captured in a simple framework. The framework has three main sets of variables (Figure 12.1). First, a set of *contextual factors* which set the initial interactions and motivations for joint-venture formation. Second, *outcomes* which are the various aspects of the joint venture's actual performance, as assessed by the parents, the joint-venture management and other interested parties. Third, *intermediate variables* which mediate between context and the outcome and include trust. The framework has to be seen in a dynamic perspective due to feedback and interactions between its various components. Three contextual factors are identified: interdependencies between the parents and the joint venture, the degree of competition between the parents and with the joint venture, and ambiguities between the organizations in the joint-venture arrangement. Trust is at the centre of the framework and linked to the concept of joint-venture autonomy, which in turn affects the outcome (i.e. joint-venture performance). Put most simply, trust reduces uncertainty and perceived risk.

Trust and autonomy

Over the last decade or so, interest in trust has increased dramatically and attracted the attention of sociologists and economists as its crucial social and economic importance has become more apparent (for a recent example, see Fukuyama 1995). This extensive literature on trust will not be reviewed here, but simply used to identify key aspects relevant to understanding relationships in joint ventures. The focus is on how organizations search for potentially suitable partners

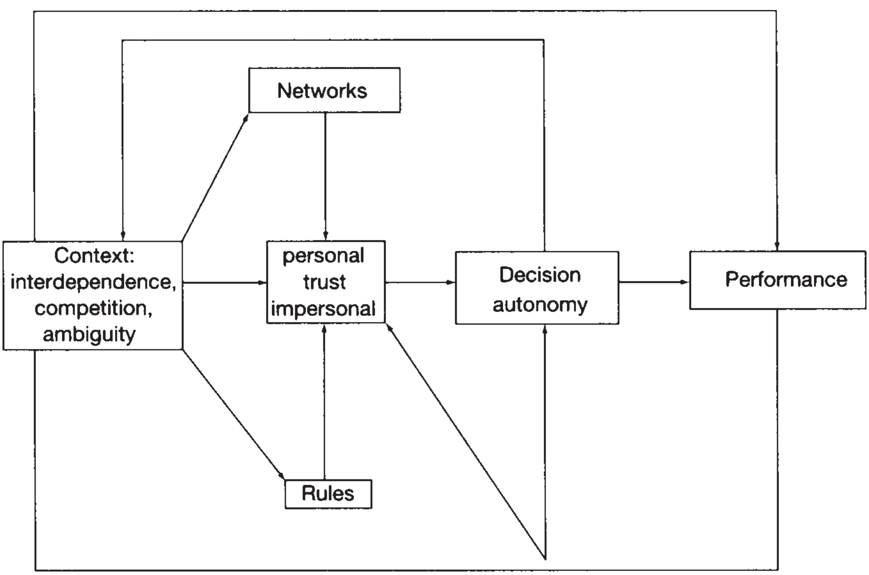

Figure 12.1 Context, performance and trust in joint ventures

and form a joint venture to fulfil objectives that may not be well defined and which are likely to change over time (Parkhe 1993).

In the framework presented here, trust is considered as a mechanism for reducing uncertainty and increasing the predictability of desired outcomes. Trust here is conceptualized as being placed in individuals (personal trust) (Granovetter 1985) or in institutions (impersonal trust) (Shapiro 1987). Each of these consist of promissory, goodwill and competence components.

Promissory-based trust is the degree of confidence that a party can be relied upon to carry out a verbal or written promise. This follows Rotter (1967:651) who uses trust to mean "an expectancy held by an individual or a group that the word, promise, verbal or written statement of another individual or group can be relied on". This component of trust would be expected to increase slowly, if individuals or organizations carry out the written or declared actions, that is if promises are kept. Conversely, not keeping promises is likely to lead to sharp falls, though it would be expected that the larger the problems created by failing to carry out any particular promise, the bigger the fall in trust.

Goodwill-based trust is the degree of confidence that a party can be relied upon to engage in actions which benefit the other party or refrain from action which will disbenefit or damage the interests of the other party. This component of trust is closely related to the concept of forbearance. Forbearance refers to the situation where one party to a transaction will accept a time lag between fulfilling another partner's expectations and having their own expectations fulfilled in return. Therefore, an essential aspect of trust is being open to the risk of parties reneging on a deal.

Competence-based trust is the degree of confidence that a party can be relied upon to have the knowledge, skills or expertise they claim or are believed to have; this is drawn from Sako (1992).

Overall, personal and impersonal trust are likely to be developed in different ways. Personal trust emerges in networks in which individuals engage in complex bartering of favours to build up mutual obligations (Blau 1964). Processes of personal trust require intensive social interaction (Butler 1983) starting with minor exchanges whereby actors test each other before moving to bigger transactions (Blau 1964, Shapiro 1987: 625). Impersonal trust develops in institutions with well-defined rules, and is thus closely related to the processes of decision making.

Autonomy is used here to refer to the extent to which the joint venture has discretion to take decisions rather than constantly having to defer to the parents. It is suggested that the higher the level of trust in the joint venture by the parents, the greater the autonomy of the joint venture, and vice versa. Again, there will be feedback loops from performance to trust and autonomy. So, for example, high joint-venture performance would be expected to lead to greater autonomy. Other work also suggests that high joint-venture autonomy is associated with high performance (Butler and Sohod 1995).

Contextual factors

Three contextual factors are highlighted as being important: interdependence, competition and ambiguity.

Interdependence Organizations will seek a joint venture arrangement when unable to achieve particular objectives on their own, or through other arrangements. These objectives may be explicit, ambiguous or hidden to some degree. In effect, a joint-venture arrangement represents a configuration of interdependencies between the parties involved. Three generic types of interdependence can be defined (Thompson 1967): pooled, sequential and reciprocal (Figure 12.2). The form of interdependencies is likely to affect the dynamics of trust needed for success.

Pooled interdependence occurs when both parents expect the joint venture to provide an output, but have no direct dependence on each other. Their relationship is mediated through the joint venture; for example, parent 1 (P_1) may see the joint venture as a means of satisfying anti-monopoly legislation, while parent 2 (P_2) may be interested in the profits that the joint venture (JV) can provide. Sequential interdependence occurs when P_1's expectations are directly met by the joint venture, but P_2's are mediated by P_1. For example, P_2 sees the joint venture as a means of utilizing productive capacity, but depends upon P_1 for gaining access to the market. Reciprocal interdependence occurs when there is mutual causation between the parents and the joint venture: for example, P_1 and P_2 wish to develop a new product requiring different technological knowledge from each while the joint venture is expected to provide this learning to each. There are a number of possible implications for the development of trust deriving from the patterns of interdependence. In the pooled case, we can see that J (the joint venture) is in a potentially awkward situation if the aims of P_1 and P_2 are in conflict. In the sequential case, P_2 is highly dependent upon P_1 and open to the risk of exploitation. The reciprocal case appears to be one of balanced power between the partners, but is open to asymmetries which might later emerge.

Competition will positively or negatively affect trust between the joint-venture partners, depending on whether the source of competition comes from outside (exogenous) or inside (endogenous) the joint-venture arrangement, and on whether

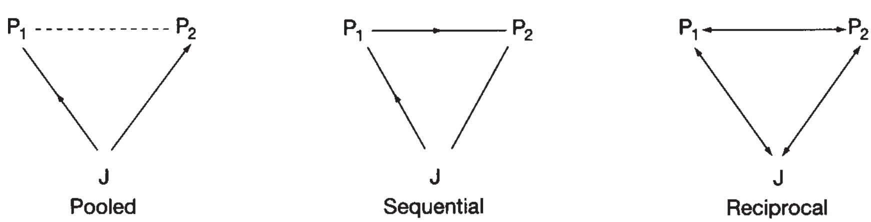

Figure 12.2 Types of interdependence in joint ventures
Note: P denotes a parent company
J denotes the joint venture

competition increases or decreases. Increased competition in an area of activity covered by the joint venture originating from outside the partnership, i.e. exogenous competition, will increase the need for trust within the partnership. However, this would also tend to increase cohesion within the joint venture on the basis that an external threat to a body with a common interest increases cohesion. Increased competition between the partners or with the joint venture will lead to strains. Endogenous competition is often identified as a reason for poor joint-venture performance, and also relates to the various types of interdependence. If one partner starts competing with another or with the joint venture, trust is likely to break down. This situation would increase the need for trust, but will act against the factors that are needed to foster trust, especially networking. Therefore, it is unlikely that parents engaged in competition elsewhere will continue to build networks with each other or around the joint venture. If no action is taken, then such a situation is likely to destabilize the joint-venture arrangement. For the joint venture to survive, mechanisms to regulate, reduce or remove this source of tension would be necessary.

Ambiguity refers to a situation where there is uncertainty, misunderstanding or lack of clarity over the joint-venture objectives and the means to achieve them. The focus here is on the relationships between the organizations in the joint-venture arrangement. Ambiguity may be the result of inherently conflicting or contradictory objectives which lack well-defined performance criteria, or when technology is ill defined (i.e. has a high tacit component), or is liable to frequent change.

Outcome (performance)

Determining the performance of a joint venture is more problematic than with many other forms of business organization. This is because the objectives of the parents need to be taken into account, and most joint ventures are located in a triangle of relationships in which there can be conflicting signals as to what is regarded as good performance (Butler and Sohod 1995, Harrigan and Newman 1990). It is unsurprising then that there appears to be no general agreement on the definition or measurement of joint-venture performance in the literature, though partner indicated "satisfaction" with the joint-venture has commonly been used (Butler and Gill 1994). Hence, a simple measure of joint-venture performance would be the extent to which parent objectives are met. However, objectives may change and be subject to both unresolved conflicts and immeasurable aspirations. In effect, the criterion of performance assessment is affected by the contextual factors (i.e. environment) of the joint venture. Changes in these factors – for example, the entry of new competitors or shifts in parent strategies – will influence how joint-venture performance is perceived. However, interactions between the joint-venture environment and its performance operate in both directions. For example, joint-venture performance which is higher (or lower) than anticipated may lead to changes in parent objectives and hence in the context.

Such interactions are incorporated through feedback loops in the conceptual framework (Figure 12.1).

In sum, trust is posited as a central intermediate variable acting between the contextual and performance variables in a framework for evaluating joint-venture performance and therefore survival. Trust is a particularly important mechanism for managing the problems of interdependence, competition and ambiguity. A number of other variables affect trust; in particular, personal trust is related to the social networks involved, while impersonal trust is based upon a coherent set of well-understood rules of operation. Learning in the joint venture is the degree to which there is feedback from performance to context and trust. This represents a double loop (Argyris and Schon 1978) or deep (Van de Ven 1986) learning which goes beyond the fine tuning of a system to ensure adherence to a fixed standard (i.e. parent objectives) but involves changing the standards against which performance is measured.

Japanese joint ventures in Malaysia

Industrialization policies in Malaysia

Malaysia is a major producer of primary commodities characterized by sharp price fluctuations and declining terms of trade. A policy of reducing dependence on primary products was initiated in the late 1950s by post-colonial government import substitution policies. This was followed from the late 1960s by the promotion of export-oriented manufacturing, mainly by attracting foreign direct investment (FDI) through the establishment of free trade zones (FTZs), also termed export processing zones (EPZs). EPZs were successful in generating mass employment and boosting exports of high technology products, most notably in consumer and component electronics, but generated few links to the rest of the economy (Lim 1993:4).

Meanwhile, the New Economic Policy (NEP) had been formulated as a result of race riots by ethnic Malays concerned that the Chinese-Malaysians were too dominant in the economy (Jesudason 1989). The NEP had a goal of 30 per cent Malay ownership and control of the corporate sector by the year 1990. In the early 1980s, the Prime Minister Mahathir Mohamad shifted Malaysia onto a path of heavy industrialization, involving economic and political dimensions (Machado 1989–90). Economic aims included promoting economic diversification and modern manufacturing capabilities beyond the EPZ enclaves, creating linkages between industries and reducing the import dependence of export-oriented industries.

Industrialization, especially import substitution, has been primarily through the transfer of technology from foreign multinationals in which joint ventures have been important. According to the Fifth and Sixth Malaysian Five-Year Plans, 148 joint ventures were approved over the period 1981–90, representing just over a tenth of the total number of technology transfer agreements, in second place after technical assistance/know-how agreements. Some joint ventures were directly initiated by the government – for example, through the Heavy Industries Corporation of Malaysia (HICOM), a 100 per cent government-owned holding company set up in 1980 by Mahathir (then Minister of Trade and Industry) (Jayasankaran 1993: 512).

By the early 1990s, Malaysian government policies had continued to evolve, with increasing attention paid to management processes in the manufacturing sector. "New technological adaptation and substantial capital investments will be necessary for increasing value-added of the manufactured products and productivity as well as expanding the manufacturing capacities. These developments will entail increasing mechanisation and automation as well as *management capabilities* which contribute to total factor productivity" (Malaysia 1993: 9, emphasis added). A critical source for developing these capabilities has been technology transfer from foreign multinationals which needs to be examined further.

Technology transfer: definition and meaning

A detailed examination and review of the technology transfer literature is beyond the scope of this chapter. Technology will be used here simply to mean a body of knowledge about techniques or the tangible embodiment of that knowledge in an operating system using physical production equipment (Freeman 1982). The focus here is primarily on the former, rather than the latter; thus, technology transfer will be defined as "a learning process wherein technological knowledge is continually accumulated into human resources that are engaged in production activities; successful technology transfer will eventually lead to a deeper and wider accumulation of knowledge" (Shiowattana 1991: 175).

This definition emphasizes two aspects of technology transfer: first, that knowledge acquisition by human resources is dynamic and continuous, and second, the critical role of human resources in this transfer process. In effect, this process involves more than the transfer of physical equipment, but also augmentation of human capital through the accumulation of technological knowledge. Shiowattana (1991: 175–6) considers the learning process by the engineers, workers or operators to have both "width" and "depth". "Width" refers to knowledge of new production or related technologies, and "depth" to the degree of understanding of a particular technology. Depth of knowledge is subdivided into four inter-related stages (acquisitive, operative, adaptive and innovative), and each subsequent stage reflects an increased level of technological capability (Shiowattana 1991: 175–6).

Acquisitive capability is the ability of an organization to search, evaluate, select, negotiate, acquire, and install the technology or process in a plant as well as carry out test runs before start-up. *Operative* capability refers to the efficiency with which the technology is used or operated by an organization, and involves activities such as process operation and control, quality programmes, human resource development programmes, maintenance, sub-contracting and so on. *Adaptive* capability is the ability to carry out incremental improvements to the existing plant, processes and product design. This would require in-depth knowledge of the product and involve the establishment of an in-house R&D facility. *Innovative* capability is the ability to carry out, or invent, major or radical changes to products or processes.

Human resources are at the core of these processes, as they accumulate technological knowledge – which may then be codified into manuals or become part of the organization's routines (Nelson and Winter 1982) – and in their conscious and deliberate drive for wider and deeper knowledge. In the case of joint ventures in industrializing economies with foreign multinationals, such knowledge should be transferred to the local partner, and thus aid the process of human capital formation.

Kimbara (1991) and Kawabe (1991) take a more detailed view and divide technology into nine categories. Anuwar Ali (1994: 120–1) emphasizes the crucial importance of in-house R&D activities as a component of technological capability, and argues that Japanese joint ventures or subsidiaries in Malaysia are more likely to lack these facilities compared with US companies, a feature which leads to greater technological dependence. Others have similarly been critical about the degree of technology transfer by Japanese firms in the Malaysian automobile sector (Jomo 1994, Machado 1994).

Factors affecting the effectiveness of technology transfer

Teece (1981) identifies four main interrelated factors affecting the technology transfer process: the technology (i.e. knowledge) being transferred, the supplier, the recipient and the institutional mode of transfer.[2] These issues are brought up to date through groundbreaking work by Millar *et al.* (1996), who examine knowledge production and assimilation between organizations and emphasize the interrelations between these factors, the dialectical nature of the knowledge transfer process (i.e. learning) and the critical importance of the form that such mediated learning takes:

> the structure of technology interchange [i.e. transfer] activities mediates ongoing relationships between joint-social activity with technology and the socio-institutional context which are responsible for the technological outcomes of the learning process. The structure of technology interchange activities guides the production of knowledge and, in turn, dialectically influences the process by which knowledge is produced during learning.
>
> (Millar *et al.* 1996)

The technology being transferred

Technology transfer is a process of intangible or embodied knowledge transfer. Embodied knowledge is transferred through capital or other equipment in which it has been codified. Intangible knowledge involves much more complex transfer mechanisms since it has both codifiable and tacit (sometimes referred to as "implicit") components: "know-how cannot always be codified since it often has an important tacit dimension. Individuals know more than they are able to articulate. When knowledge has a high tacit component, it is extremely difficult to transfer without intimate personal contact, demonstration, and involvement" (Teece 1981:86).

The ease, cost and effectiveness of transferring such knowledge depends on the extent it can be codified, i.e. "the transformation of experience and information into symbolic form" (Teece 1981: 83). Transfer of codified knowledge can rely on impersonal methods such as technical manuals. However, "uncodified or tacit knowledge. . . is slow and costly to transmit. Ambiguities abound and can be overcome only when communications take place in face-to-face situations. Errors of interpretation can be corrected by a prompt use of personal feedback" (Teece 1981:83).

In effect, different technologies will have varying degrees of codifiable and tacit knowledge components which may change over time. Effective technology transfer will therefore require different methods to take these factors into account. Firms from different countries may have preferred modes of foreign investment or technology transfer. According to Hennart (1991: 493), "tacit knowledge" is a crucially important source of Japanese competitiveness, which derives from "production expertise, production engineering, and quality control, advantages which are difficult to codify and therefore must be exploited abroad through FDI".

However, certain Japanese practices affecting the speed of localization, which may be a result of the importance of the transfer of the tacit component of knowledge, are often regarded unfavourably by the host country:

> local governments, economists and journalists are under the firm impression that the withdrawal of foreign staff from a foreign owned subsidiary signals accomplishment of the technology transfer process. For this reason European and American firms have a good reputation in this area, because their staff is called back home quite soon after operations commence and technicians are only sent when problems arise.
>
> (Yamashita 1991: 17)

However, Yamashita (1991: 17) argues that Japanese personnel stay longer to train local employees (i.e. transferring knowledge with a high tacit component) so that they are able to solve problems and carry out a range of other activities (e.g. machine repair, maintenance, quality control, technical improvements, factory management and so on) themselves. This contrasts with the much greater focus on transferring highly codified knowledge taken by American and European companies, and sending technicians to solve problems which arise.

Supplier

Suppliers will have different motivations in transferring technology. These will depend on strategic and financial costs and benefits of such transfers. Financial costs may be incurred in codifying knowledge or through the loss of an opportunity to sell technology. Strategic costs may result if the transfer leads to the creation of a potential competitor. This may be avoided by limiting the depth of technology transferred so that a potential competitor will not emerge, or by imposing restrictions on the use of such technology to only allow production for a particular geographical market.

> Limitations on the use of technological know-how are often needed to provide adequate incentives for the buyer and seller to effect a continuous transfer of the knowledge in question. If the seller is limited in his use of the know-how, the buyer can rely more confidently on the seller's full disclosure and co-operation in the buyer's use of the know-how. Where the seller contemplates some use of the know-how himself, limitations on the buyer's use of the know-how in competition with the seller are necessary to provide the seller with the incentive to transfer this know-how and to share fully in his mental perceptions, understandings, working experience and expertise.
>
> (Teece 1981:90)

Another is by maintaining technological dependence since:

> technology is constantly evolving. Indeed, static technology is generally obsolete technology. Accordingly, a buyer of intangible know-how needs ongoing, future co-operation from the seller to obtain the full benefit of the know-how purchased, since all of the learning and experience of the developer of the know-how can be captured in the codified descriptions, drawings, and data that are amenable to physical transfer.
>
> (Teece 1981:90)

Technology suppliers may gain strategically, for example, by market access via a joint venture in a country where direct investment is prohibited. Financial benefits can be derived from payments for know-how, the supply of personnel, capital equipment or other inputs specified in the technology transfer agreement.

Recipient

The degree of technology transfer depends on the recipient's desire for technology and existing level of technological knowledge. The former is important since technological learning is not an automatic, costless process in which the recipient plays a passive role, but involves deliberate activity and explicit resource commitments (Bell 1984). The latter is important since the recipient's level of knowledge affects their capacity to absorb technology: "Whether information so transferred will be considered meaningful by those who receive it will depend on whether they are familiar with the code selected as well as the different contexts in which it is used" (Teece 1981: 83). Thus, Abdul Razak Abdul (1984: 285) found that technology absorption by the local partner in Malaysian joint ventures was constrained by the lack of sufficient personnel who could read the blueprints or manuals.

Such knowledge is also important for organizations concerned with monitoring technology transfer agreements. In the industrializing countries, state agencies often have a key role in ensuring effective technology transfer, but may be handicapped by their lack of appropriate knowledge and high monitoring workload. Thus, according to Anuwar Ali (1994: 115), the experience of the Malaysian Ministry of Trade and Industry "shows that it is difficult to ensure effective technology transfer given the Ministry's lack of experience, expertise and capacity to assess the 'technology content' imparted to domestic licenses or local personnel, not to mention the meticulous task of trying to keep track of the increasing number of technical assistance or joint venture agreements submitted for approval".

Institutional mode of transfer

A variety of methods may be used to transfer technology. These range from markets through to the use of a bureaucratic hierarchy. One of the simplest market mechanisms is the one-off contract. However, such a contract is likely to be incomplete for a number of reasons. One is that further assistance or know-how may be required due to changes in technology or operating conditions. Moreover, technologies with a high tacit component of knowledge are difficult to codify, and therefore problematic to specify contractually. Unilateral contractual agreements, such as licences, have very limited flexibility since "unexpected changes must be accommodated by renegotiation, and this exposes one or more parties to significant business risks" (Teece 1992: 191).

Teece considers market mechanisms to be most appropriate under the conditions where:

> the know-how at issue is not recent in origin so that knowledge of its existence has diffused widely; the know-how at issue has been commercialised several times so that its important parameters and performance in different situations are well understood, thereby reducing the need for start-up assistance; and the receiving enterprise has a high level of technological sophistication.
>
> (1981:87)

However, market failure may occur due to information asymmetries (Arrow 1971). For example, an opportunistic seller may misrepresent the technology to a less informed buyer. Conversely, a purchaser may acquire a technology without cost because they are unable to value it until there has been sufficient disclosure by the seller.

Reliance on hierarchies, i.e. intra-firm technology transfer to a foreign subsidiary, may avoid a number of these market problems. For example, there is likely to be better disclosure, avoidance of the hazards of opportunism, and better governance. The problem with the hierarchical mode of transaction governance or institution is that it requires the ability to precisely specify the knowledge to transfer. When technology is ambiguous, this is difficult. Ambiguity is a result of change and difficulties in analysing processes (Perrow 1970).

Transfer modes intermediate between the market and hierarchies are alliances such as joint ventures. This type of organizational form has greater flexibility than market contracts, and is useful where the technology is not well developed, future learning is very important and leakage is a potential problem (Teece 1992: 191).

Overall, then, these views do not explicitly consider issues of trust in technology transfer. However, the reliance on formal contracts, the emphasis by state agencies on monitoring contracts or setting down conditions for technology transfer payments suggest lack of trust between the various parties. Negotiations are therefore seen largely in terms of the relative bargaining power between the industrializing country government and foreign multinationals under conditions of distrust. Thus, for example, in Malaysia, the role of MITI is:

> first, to ensure that the [technology] agreements *will not be prejudicial to the national interest*, second to ensure that the agreement *will not impose unfair and unjustifiable restrictions* on the Malaysian party, third to ensure that the *payments of fees*, wherever applicable, *will be commensurate with the level* of *technology to be transferred* and *will not have adverse effects* on Malaysia's balance of payments, and last to *ensure meaningful transfer* of technology.
>
> (Anuwar Ali 1994: 112, emphasis added)

Issues of trust are likely to vary depending on the institutional form of technology transfer adopted and the previous history of interactions between organizations. The joint venture attempts to create a more collective institutional form (Butler 1983) in which the fostering of trust is a key element. The particular social networks and the processes of mutual adjustment that this form of organization attempts to engender are key to understanding their operations. Overall, though, trust in technology transfer arrangements can be seen in terms of the three components identified earlier (i.e. promissory, goodwill and competence-based trust) and is applied to two joint ventures in Malaysia.

The case study joint ventures

The focus is on the passenger and commercial vehicles sector which has been targeted by the Malaysian government in its industrialization strategy, and where joint ventures (mainly with Japanese firms) have played an important role in technology transfer. Two joint ventures are examined, COMPJV and INTEGJV (Figure 12.3), formed in the early 1970s and early 1980s respectively. Each formation took place under different policy environments which affected partner motivations in making these collaborative arrangements. Both are in the automotive components sector, therefore dependent upon demand derived from the final customer, and hence extremely sensitive to fluctuations in this market. Over time, the number of Japanese personnel in each joint venture has decreased to two, as previously required by law – one in a technical position, the other in senior management. For COMPJV, these positions were factory manager and managing director/general manager, while for INTEGJJ, they were the positions of technical director and joint managing director.

COMPJV

COMPJV manufactures commodity components for automobiles and motorcycles and was established in the early 1970s by three groups: JMCOMP, a Japanese

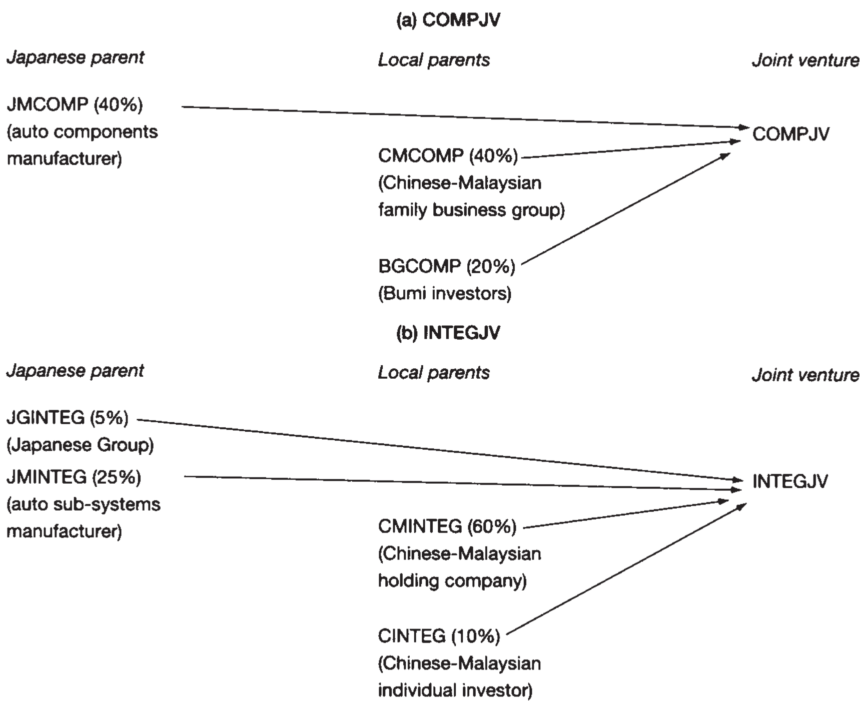

Figure 12.3 Key organizations in the Japanese joint ventures

manufacturer; CMCOMP, a Chinese-Malaysian-family-controlled group which, by the 1990s, had operations in financial services, passenger and commercial vehicle dealerships, property and hotels in Malaysia; and BGCOMP, a group of around twenty or so individual Malay investors, to represent *Bumiputera* (hereafter referred to as "Bumi") interests. Both JMCOMP and CMCOMP hold 40 per cent equity each with the remainder held by BGCOMP. Sales are for the OEM (original equipment manufacturer) and replacement markets. The presence of Bumi investors qualifies COMPJV for OEM sales to domestic manufacturers such as Proton and Perodua. Historically, sales have been dominated by the motorcycle market, which has begun to saturate, while the automobile market continues to grow. In 1995, 40 per cent of sales were to the automobile market, up from 35 per cent a few years earlier. Motorcycles in the Malaysian market are from four main Japanese companies: Honda, Yamaha, Kawasaki and Suzuki. Sales in the car market are dominated by Proton, which, together with Perodua, accounts for 80 per cent of the market, with the balance equally shared by Ford and Honda. In 1995, COMPJV employed just over one hundred people, of whom nearly two-thirds were Malay, and had annual sales of just under RM35 million, up from around RM22 million in 1991. Overall, COMPJV is highly successful, has a dominant market position in Malaysia and can be characterized as largely inwardly focused (in so far as it has concentrated on the domestic market, which accounts for 95 per cent of sales).

INTEGJV

INTEGJV manufactures one of the system sub-assemblies, principally for use in passenger and commercial vehicles, but also in other auto parts and motorcycles, and has four shareholders: JMINTEG, a Japanese manufacturer of these system sub-assemblies; JGINTEG, the leading company in a Japanese *keiretsu*, of which JMINTEG is a member; CMINTEG, a Chinese-Malaysian company which was issued with a manufacturing licence for this system sub-assembly; and CINTEG, a Chinese-Malaysian individual with minority equity. CMINTEG registered the name of the joint venture when it obtained a manufacturing licence for motorcycle sub-assemblies in 1979; however, it took several years to find a suitable partner, and the joint venture contract and technical assistance agreement were not signed until 1983, with manufacturing initiated the following year. The joint venture rapidly diversified from the production of sub-assemblies for motorcycles, to sub-assemblies for auto parts, and then for passenger and commercial vehicles. A manufacturing licence for auto parts system sub-assembly was approved in early 1984, and for passenger and commercial vehicles in mid-1986. Over time, sales to the passenger and commercial vehicles market have come to dominate production, accounting for nearly 90 per cent in 1995, with just under 10 per cent for auto parts and less than 1 per cent for the motorcycle market. The initial period was characterized by sales for the domestic market, but by the late 1980s, it was also exporting to Japan. In 1995, it employed 500 people, and had sales of around RM35 million (over the first 9-month period). However, the absence of Bumi investors in the joint venture has meant that it is unable to supply Proton, which dominates the domestic market, and has therefore concentrated on Japanese automobile assemblers. In effect, while INTEGJV is a successful commercial enterprise, it has restricted access to customers in the Malaysian market, which has induced it to expand overseas and may therefore be characterized as being outward looking. As a consequence of pressure to look to outside markets, both JMINTEG and CMINTEG separately set up automotive system sub-assembly joint ventures in the 1990s in another Asian country with a potentially large domestic market.

Parent motivations for using a joint venture as a mode of collaboration

Alternatives to a joint venture include technical or licensing agreements. However, these were considered unsuitable by the local parents and the Japanese companies for a number of reasons. First, in both joint ventures, the local partner did not have any expertise, track record or reputation in automobile component/ sub-system manufacture. Second, from the point of view of the Japanese firms, product quality would be compromised by a non-joint venture arrangement. A licence would only involve royalty payments and periodic visits by the licenser. In contrast, a joint venture would involve greater commitment, long-term secondment of Japanese technical personnel and more effective technology transfer; the physical presence of these personnel would be crucial for facilitating the effective transfer of knowledge with a high tacit component. According to JMCOMP, a licensing agreement would mean that the "Japanese would not have confidence in the local company being able to . . . [make] . . . the product [and to the required quality]", which would adversely affect sales and damage the Japanese company's reputation as a manufacturer of high-quality products. The representatives from each of the parents were clear that non-joint-venture collaboration would mean lower commitment and assistance from the Japanese side. Thus, according to the Chinese-Malaysian general manager of INTEGJV, "if only technical assistance . . . very different. They just help you. Whether you are successful or not successful, they don't care."

Third, in the case of motorcycle system sub-assembly, a non-joint-venture agreement would not provide crucial linkages to motorcycle firms. Fourth, the Japanese firms in both joint ventures stressed that the success of their joint ventures resulted from using this particular organizational form, rather than a licensing or technical agreement. For example, the Japanese MD of COMPJV stated that even after 20 years of operation, the local plant still experienced problems which required the expertise of the resident Japanese factory manager, and sometimes, help from Japan. "Because we Japanese [are] here . . . [when there are problems], action will be taken immediately through the resident Japanese engineer . . . we can solve [problems] ourselves . . . if we cannot solve [them] by ourselves, [we report] back to Japan." This leads to a speedier resolution of problems than would be the case with licensing or technical agreements. Similarly, JMINTEG considered that INTEGJV was perceived by its customers as having superior performance, in terms of product quality and delivery, compared to its local competitor, which received limited help as it was not a joint venture.

Overall, then, a joint-venture arrangement would be expected to be characterized by a higher level of commitment from the Japanese parent which would be likely to have positive implications for joint-venture performance.

Partner selection

The following discussion will show that contextual factors (i.e. interdependence, competition and ambiguity) generally favoured the formation of both joint ventures, and that trust was an extremely important factor in partner selection.

COMPJV

Prior to the formation of COMPJV, JMCOMP supplied automobile components to its importer, CMCOMP, in Malaysia from its production base in Japan. However, in the early 1970s, "high duties" were imposed on imports to Malaysia. In order to avoid these duties and maintain sales, JMCOMP and CMCOMP needed to set up production in Malaysia. To set up a manufacturing facility, CMCOMP was dependent on JMCOMP for technology, production know-how and plant personnel, while JMCOMP would benefit from CMCOMP's knowledge of the local environment. A key factor in partner selection was their previous business relationship. According to the Japanese MD of COMPJV, CMCOMP was considered to be a "trustworthy" and "reliable partner", for example, by its punctuality in making payments. At the same time, the previous relationship had reduced ambiguities between the parents over time. Partnership between these firms was also favoured since they did not compete with each other. Overall, there was congruence in the parents' objectives in forming the joint venture, namely to avoid duties, maintain sales and profits, and increase market share.

INTEGJV

JMINTEG is a cautious sub-system manufacturer for passenger and commercial vehicles, motorcycles and auto parts. Up to the late 1970s, it had confined production to Japan, unlike its main Japanese rival, which had set up a number of overseas operations. JMINTEG wanted to enter Malaysia in order to get new business, but would only be able to do so by setting up production facilities with a local partner holding a manufacturing licence. At the time, JMINTEG was especially cautious because of its first experience of a joint venture in Taiwan. This had failed, and JMINTEG had lost its entire investment due to financial irregularities by the local partner. JMINTEG was vulnerable to financial misrepresentation since the staff it seconded to any joint venture would usually be technical specialists rather than have financial accounting expertise and knowledge of operating in an unfamiliar regulatory, business and cultural environment. Finding a "reliable" partner was thus a key additional selection criterion.

CMINTEG had been awarded a licence to manufacture an automobile sub-system in the late 1970s. From CMINTEG's perspective, its partner had to be technologically capable, have established relationships with motorcycle firms, and be willing to set up a manufacturing plant and to transfer technology to its Malaysian partner while holding minority equity. Since the Malaysian motor cycle sector was served by companies based in Japan, the partner had to be Japanese.

Technical competence and close relations with automobile and motorcycle firms are particularly critical elements for the success of sub-system suppliers. Technical competence is crucial because the design of these sub-systems is highly complex (usually undertaken with computer-based tools) and because problem rectification is costly. Close relationships are required between the sub-system supplier, the customer firm and related suppliers, to co-ordinate the modifications associated with model changes or new designs.

Approaches to Japanese firms were made by a senior Chinese-Malaysian official in MIDA (Malaysian Industrial Development Authority) to attract production facilities to Malaysia. This official acted as an intermediary between CMINTEG and JMINTEG. JMINTEG regarded this official as being very trustworthy by virtue of his position in a government department, and he was subsequently appointed managing director of INTEGJV.

CMINTEG's first choice was JMINTEG's rival, a leading Japanese manufacturer of this type of sub-system. However, this firm was only willing to establish a joint venture in which it had a significant majority share, and this option was therefore rejected. JMINTEG was subsequently approached and selected as a joint-venture partner as it was willing to have only minority equity and to establish a manufacturing facility in Malaysia. Negotiations took around two years, involving many visits by the Japanese to Malaysia. Neither party was in competition, which could have introduced instabilities in the joint-venture arrangement, and these visits and meetings served to reduce ambiguities over time.

Contextual factors in joint-venture operation

Interdependence

Both joint ventures are characterized by reciprocal interdependencies, i.e. each organization is dependent upon the other(s) to achieve its objectives.

For COMPJV, the local parents have provided political legitimacy and manufacturing licences, which allow JMCOMP to have production facilities in Malaysia and thus avoid import duties. Equity participation by the Malay investors (BGCOMP) ensures that the joint venture is able to supply Proton (and other

Bumi companies) on an OEM basis, with positive knock-on effects in the replacement market. Both local parents obtain financial benefits from the dividends distributed by the joint venture. Financial dependence is highest for the Bumi investors, but is now not so significant for CMCOMP, which also has other financial interests, or for JMCOMP. These benefits depend on the financial success of the joint venture. Capital expenditure is now financed internally by the joint venture. COMPJV is dependent upon JMCOMP for KD (specialist knock down parts) not made in Malaysia, two engineering personnel and technical inputs. In addition, staff from JMCOMP come periodically to check the local factory and each process. Capital equipment is made by each auto component supplier in the sector, and supplied by JMCOMP. Over time, localization has reduced the proportion of such equipment sourced from Japan, and by 1995, one-third of capital equipment was from local suppliers. JMCOMP gets income from sales of KD parts, capital equipment, and engineering services to the joint venture, in addition to the dividends declared. COMPJV is important to JMCOMP for access to the Malaysian market, which accounts for 20 per cent of its Asian market sales and 4 per cent of its total sales.

INTEGJV is similarly dependent upon its local partner, CMINTEG, for political legitimacy and licences to manufacture. In this case, however, there is no Bumi equity, which has limited the size of its potential market in Malaysia. JMINTEG is dependent on the joint venture for component sales, and, to a small extent, for dividends. JMINTEG has to meet its supply obligations to final customers in the Malaysian market. INTEGJV is heavily dependent upon JMINTEG for system sub-assembly design, capital equipment and engineering services, and totally dependent for specialist components. INTEGJV's capability in system sub-assembly design has increased over time,[3] and is able to do the designs for motorcycles and auto components. However, system sub-assembly design for Japanese cars is a highly complex computer-aided process, carried out in Japan. Moreover, model changes to Japanese cars were faster than for other cars, making the accumulation of local design capabilities more difficult. Raw material supplies and components have increasingly been sourced locally – a trend expected to continue.

Competition and ambiguity

Competition in both joint-venture arrangements is exogenous. However, ambiguities about future developments could introduce elements of endogenous competition and introduce instability into inter-organizational arrangements.

For COMPJV, a major source of instability is due to developments in AFTA, the ASEAN (Association of South East Asian Nations) Free Trade Area, which will cause import duties to be reduced over time and to be completely phased out by 2003. JMCOMP has a joint venture making the same product in another AFTA country. Elimination or reduction of duties would allow JMCOMP to reduce manufacturing costs by shifting production to the lower unit cost economy in the region, and thus also gaining from greater economies of scale. Labour costs in the other joint venture are lower than in Malaysia. In effect, conflict is likely to emerge between the two joint ventures. However, according to the Japanese MD of COMPJV, though future developments are unclear, this issue was the responsibility of JMCOMP, which was likely to be able to control, manage and limit potential conflict.

Potential instability in INTEGJV has arisen from pressures for the parents to expand operations overseas. This pressure is a result of the lack of Bumi investment in the joint venture, which has prevented sales to Proton, and thus severely limits the potential market in Malaysia. As a consequence, JMCOMP has set up a joint venture with local partners in another Asian economy, a course of action followed by CMINTEG a few years later. In effect, the two joint ventures in this third country could come into direct competition with each other, which – according to the Japanese general manager of INTEGJV – would damage the existing relationship between JMINTEG and CMINTEG. If such "face-to-face" competition develops, with the "top persons [in each organization constantly] fighting", there will inevitably be "cracks" in the relationship; these words were used by the Japanese GM, who hit one hand with his fist several times to help describe the situation of "face-to-face" competition. For him, this course of events had to be avoided as this would destroy a twelve-year relationship. At present, the joint ventures do not compete as they are in different parts of the country, and do not serve the same markets. However, both parents were engaged in discussions to avoid direct competition and to enable the relationship between the parents and INTEGJV to continue.

Joint-venture performance

Joint-venture performance has to be considered in terms of the objectives of the key stakeholders, who are, most obviously, the local and foreign parents, but also needs to include the policy objectives of the Malaysian government. The objectives of the local parents are financial, and can be considered in terms of the rates of return on their investments. The two Japanese parents had slightly different objectives in setting up manufacturing facilities in Malaysia. For JMCOMP, it was to avoid import duties, while for JMINTEG, it was to become a more international company and to enter an emerging market. These objectives have all been achieved. Other objectives arose once the joint ventures became operational. In the mid-1990s, the principal concerns of the Japanese parents in both joint ventures were sales levels, market shares and product quality, as well as sales from Japan of KD parts or other inputs to the joint ventures.

COMPJV has performed exceptionally well and occupies a dominant market position in Malaysia. This is positive from the perspective of the equity shareholders, but is also not unconnected with the joint venture aiming to meet Malaysian government objectives of localization, creating employment opportunities for Malays in the manufacturing sector and encouraging Bumi investment in such companies. Sales dipped in the mid-1980s during a period of recession which affected trust between the parents.

INTEGJV began production a year or so before the recession which led to a slight fall in sales in 1986. Turnover then increased very rapidly, though there was a slight downturn in 1992 and 1993, followed by a sharp increase. Initial production was for the motorcycle market, which has not grown much, and has been displaced by sub-systems for auto accessory manufacturers and the passenger and commercial market from 1987. Further success followed in the late 1980s, when exports to the Japanese market began.

Both joint ventures appear to have a very high degree of autonomy, but decision making with regard to strategic issues (i.e. formulation of joint-venture strategy, new product development and entry into new markets) has generally been dominated by the Japanese parent(s) – despite their minority equity position – with slightly less influence from the local partner. Operational and other issues (e.g. working environment and conditions) were largely controlled by the joint-venture management.

Trust

Trust has been regarded as important, both between the parents and with the joint venture, and seen in impersonal as well as personal terms. Japanese senior managers in both joint ventures explicitly expressed trust largely in terms of each party being willing to compromise their own interests and/or providing help to the other party when needed. For the Japanese manager of COMPJV, this meant the parents had to act in the interests of the joint venture even if it disadvantaged them. For example, yen revaluation had meant that COMPJVs prices had to go up substantially due to its reliance on imports of parts from Japan, though this would undermine its competitiveness and market position. Trust between the parents and the joint venture required JMCOMP to absorb part of the increased costs due to the yen revaluation. However, the degree of compromise depended on how well JMCOMP was doing. If JMCOMP was in a weak position, then most of the increase would be passed on, while being in a strong position would mean a much greater level of compromise. In effect, ensuring that the parents remained "strong" and "healthy" was of paramount importance for the joint venture. The Japanese general manager/technical director of JMINTEG similarly considered the importance of "give and take" and forbearance: "[when] one party [is] suffering, maybe the related party [should] help him, maybe the other way round . . . such an experience will . . . [strengthen] the relationship, if [we are] suffering . . . we ask them to help, they help us." A similar view was expressed by the Chinese-Malaysian general manager of INTEGJV, who saw trust largely in terms of support from the technologically competent Japanese parent for critical inputs: "if we have difficulty, they have to help us to get information, technology . . . if we are facing problems, they have to help."

Trust between the parents and the joint venture was considered to have increased over time in both cases. JMCOMP's trust in CMCOMP had been high when the joint venture was formed as the latter had been its importing agent in Malaysia. In effect, both shared a track record of interactions. JMCOMP had "trust" in both the top management of CMCOMP and the organization itself – which was important since it was the "partner company" – because of their "business style" (i.e. their way of doing business), in particular, their record of making prompt payments; suspicions would arise if payments to JMCOMP were late. If trust had not initially been high, then JMCOMP would have selected a different joint-venture partner. JMCOMP also trusted the Bumi group, which consisted of around twenty to thirty individuals; however, this was largely vested in the individual representing the group on the joint-venture board. In practical terms, this group was not so important because they only had minority equity and their interventions generally concerned minor issues. Over time, ambiguities over the different ways each parent operated – referred to as "their . . . ways of thinking" by JMCOMP – had been either reduced or accepted with the different perspectives seen as "reasonable". Trust had also increased because the joint venture had performed well. However, the Japanese general manager of COMPJV thought that both JMCOMP's and CMCOMP's trust in the joint venture had declined slightly during the mid-1980s, when its financial performance declined as a result of the economic recession in Malaysia during the period. For CMCOMP, there was a dip in its trust in the competence of the Japanese personnel seconded to the joint venture, the input from JMCOMP crucial to performance. However, trust had recovered as CMCOMP experienced similar downturns in its other businesses and so realized that the source of the problems was not the joint venture. From the point of view of the Japanese parent, there was concern as to why joint-venture performance (i.e. sales and market share) was declining. However, this did not change the basic relationship with the joint venture since trusted Japanese personnel had been seconded to it. Their response was therefore to get a better understanding of the environment in which the joint venture was operating which involved gathering information on the local market, changes in competition, import duties and so on.

Trust between the parents and the INTEGJV joint venture increased over time. JMINTEG's trust in the MD of INTEGJV has developed to such an extent that it had asked him to become a shareholder in a company it had set up in Hong Kong. Moreover, the fact that the joint venture began exports to Japan suggests a high degree of competence-based trust in the joint venture by JMINTEG. However, two dips occurred in JMINTEG's trust in INTEGJV, though it recovered each time. The first involved promissory trust and was due to INTEGJV not making a financial payment to JMINTEG within the time period stipulated in a contractual agreement. This failure was accidental as no one in the joint venture was aware that this particular payment was due. Eventually, one of INTEGJVs financial directors found out from JMINTEG that there had been a delay in payment, and action was immediately taken to rectify the situation by establishing a time frame to make payments and to monitor the outstanding balance every few months. This prompt action restored JMINTEG's trust.

The second dip was associated with INTEGJV setting up a joint venture in another Asian economy with a local partner in the third country which involved all three trust components (i.e. promissory, goodwill and competence). This joint venture was to supply sub-system assemblies to JMINTEG in Japan with the management to be handled by INTEGJV The local partner did not have any experience in sub-system assembly manufacture, but had been chosen because of government connections. The Chinese-Malaysian management of INTEGJV was responsible for the new joint venture and had stated that it would be operational by a particular date. However, staff from INTEGJV were reluctant to go to the new joint venture, leading to a number of adverse effects. First, there were problems in controlling the local management team; second, JMINTEG was forced to send technical support staff which it had not intended to do; third, the joint-venture performance was very poor and production was severely delayed, which led to financial losses to JMINTEG and damaged its reputation with final customers. This had a negative impact on JMINTEG's trust in INTEGJV – affecting the promissory component, since the new joint venture was not operational when it was supposed to be; the goodwill component because of the negative financial and reputation effects on JMINTEG; and competence-based trust, since there was a failure to manage the new joint venture effectively. However, trust recovered when INTEGJV took action to rectify the situation by sending two of their staff to the new joint venture, supplemented by long-term visits by senior Chinese-Malaysian staff.

Conclusions

This chapter has outlined a conceptual framework for understanding the dynamics of joint-venture formation and operation. Trust is postulated to be a central mediating variable between the context of the joint-venture arrangement and the outcome variables. Three factors were used to define this context: namely interdependencies, competition and ambiguities between the various parties. Feedback loops were introduced to capture some of the dynamics that might be expected to occur between the various factors involved in the model.

Caution is required in generalizing from two case studies about policy implications for the management of joint ventures. This chapter has stressed the inadequacy of a rational economic framework for understanding the dynamics of joint-venture performance and the need to place greater emphasis on the three-way processes between the parent companies and the joint venture. The central position of trust in the model presented here highlights the importance of personal relationships in sustaining joint-venture performance. This is an emphasis which may not always fit well with, on the one hand, a model of business performance which stresses short-term returns to capital and profitability or, on the other hand, a model of economic development giving primacy to short-term political goals.

These joint ventures were established because of government regulations on imports and manufacturing licence conditionalities which appear to have been successful in attracting these Japanese companies to Malaysia. The case studies suggest that joint ventures provide greater commitment from the Japanese partner, and may therefore be a more effective mechanism for technology transfer than technical assistance and licensing agreements. If this is generally the case, then there is cause for concern, given that the single largest category of technology agreements in Malaysia over the period 1980–90 were technical assistance/ know-how agreements rather than joint ventures. However, if agreements and joint ventures are complementary mechanisms for technology transfer, there is less cause for concern, but further research is required to determine whether this is the case.

Technology appears to have been successfully transferred since one joint venture (COMPJV) has a dominant market position, while the other (INTEGJV) was considered to produce a better quality product than its non-joint venture competitor in Malaysia, was exporting to Japan and had design capabilities on a dynamic path. Both joint-ventures had a very small number of Japanese personnel, suggesting that technical skills and other capabilities had been successfully absorbed by locals. The joint-venture form is more likely to be better suited to the transfer of the high tacit component of knowledge. However, further research is required: first, to test the general validity of this initial finding, suggesting higher degrees of commitment and technology transfer in joint ventures vis-à-vis other contractual forms of organizational collaboration for Japanese companies; second, to ascertain whether the level of commitment varies with the nationality of the foreign multinational; third, to determine whether there is any variation in the effectiveness and speed of technology transfer (especially that concerned with knowledge which has a high tacit component) depending on the institutional mode of transfer (e.g. joint venture, licence, patent agreement, and so on).

The two main sources of stability in the joint ventures were government conditions imposed on FDI and trust. Foreign multinationals cannot establish manufacturing facilities in Malaysia without a licence, which requires them to take a local partner. In effect, multinationals are "locked" into the joint venture until there is a change of policy, or they opt for exit. Moreover, the requirement that supplier firms to Proton have Bumi equity has provided significant market advantages to one of the joint ventures. In this case, the objectives of the Bumi investors appear to have been primarily financially, rather than technologically, oriented.

Both case studies show that trust has been an important factor in partner selection and joint-venture survival. In terms of the former, JMCOMP chose a partner with whom it already had an established relationship and had a "track record" of trustworthy behaviour, at least in terms of financial payments. While JMINTEG was most favourable to the individual from MIDA, to which it ascribed high trust by virtue of MIDA being a government agency. If other Japanese companies, and perhaps even Western multinationals, share this view, then this suggests that government agencies would be more favourably viewed as potential joint-venture partners, and can play a positive role as matchmakers in the joint-venture formation process. Further research is required to determine the extent to which this perception is shared by others. Of course, one government agency, HICOM, has been active in forming joint ventures. Other possibilities include the role of government agencies in catalysing interaction between various players, as for example in setting up networks which allow flows of information on issues such as organizational reputation, "trustworthiness" and so on, to be more widely disseminated.

Trust appears to be much simpler than commonly portrayed in the literature. Trust is multidimensional, with impersonal and personal elements providing the basis for its understanding, though these may be also merged, as individuals are embedded in organizations and societies. Personal and impersonal trust can be seen, in turn, to consist of promissory, goodwill and competence components. The promissory component concerns written or declared actions made by an individual or organization. This component of trust increases, usually slowly, if individuals or organizations carry out written or verbal promises. Conversely, not keeping promises leads to more dramatic falls. It would be expected that the larger the problems created by failing to carry out particular actions, the bigger the fall in trust. Thus, JMINTEG's trust in the joint venture fell due to the failure of INTEGJV to make a financial payment within a contractually specified time period, but slowly recovered as action was taken to deal with this problem.

The goodwill component of trust is where an individual or organization is expected to take action which will benefit the other parties and not take action which could cause them harm. The competence component of trust is where an individual or organization has the skills, knowledge or capabilities required to meet successfully the objectives of the various parties in the joint venture. For INTEGJV, this related to the ambiguities associated with expansion of the Chinese-Malaysian partner into another country where it could potentially come into direct competition with the Japanese parent's joint venture. Discussions were ongoing between the parents to avoid such conflict.

Since Japanese and western multinationals are technologically more advanced than the local partner in industrializing economies, the primary concerns of the foreign parent will be with the promissory and goodwill dimensions of trust, with competence elements on local knowledge/management provided by the local partner in areas such as finance, regulatory knowledge, cultural sensitivities and so on. From the perspective of the local partners, trust in the technological competence of the Japanese parents was a crucial partner selection criterion, which later shifted to a goodwill component concerned with the transfer of technology to the joint venture, leading to greater depth of knowledge, in terms of both organizational routines and human resources.

Instability in the joint ventures would arise from changes in personnel and the environment. Owing to the importance of trust relations between management personnel built over time, new personnel may remove previous certainties, commitments and understandings between the various parties. This may be a particularly pressing problem in a rapidly growing economy characterized by high labour turnover such as Malaysia. One practical option (used by a UK multinational in response to these issues) is to maximize interactions between the various firms in a joint venture arrangement at a variety of levels, to weave a dense web of connections, so that the loss of one individual had less impact.

Changes in the environment contributed to potential instability in both joint ventures. For COMPJV, developments in AFTA might lead to competition with another of the Japanese parent's Asian joint ventures. For INTEGJV, there was the possibility of competition between joint ventures formed separately by each of the partners in another Asian country.

In sum though, industrialization strategies have generally focused on macro aspects of technology transfer, where the crucial choices are the transfer mechanisms (e.g. licensing, joint ventures, technical assistance), rather than inter-organizational dynamics and trust. The framework and findings presented here suggest that much greater attention is required to understand the processes underlying the transfer of knowledge, skill and technology between organizations. Micro-level factors are likely to be crucially important in determining the rate and direction of technology acquisition and development by organizations which are central to the success of any industrialization strategy.

Notes

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1 Killing (1983) therefore recommends forming joint ventures in which one partner has dominant equity control.

2 The following draws largely on this source unless otherwise stated.

3 According to the Chinese-Malaysian general manager of INTEGJV, "the Japanese side helps us, but now we are slowly taking over ourselves".

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13

RENTS, TECHNOLOGICAL INNOVATION AND FIRM COMPETITIVENESS IN A *BUMIPUTERA* MALAYSIAN FIRM*

Rokiah Alavi

In recent years, the factors underlying East and South-east Asian economic growth have been increasingly discussed in the development economics literature, with economists offering various reasons for this success. Amsden (1989) argues that Korea's spectacular industrial achievement can be explained by government subsidies, tariff and non-tariff incentives, financial credit facilities, a highly educated and trained workforce, firm capabilities to learn and adapt foreign technology, and the government role in linking incentives to exports. Even the World Bank (1993) now recognizes the role of government intervention in spurring industries to export. The successes of local companies in South-east Asian countries have been attributed to technical tie-ups with multinational companies (MNCs).

Amsden suggests that firms in late industrializing countries go through four stages in becoming successful learners. First, they compete to get industrial licences and contracts from the government. Second, they compete to get foreign technical licences from international firms on the best available terms. Third, they compete in the labour market for the best recruits, supervisors, managers, and engineers, in terms of experience and skills. Fourth, they compete in the marketplace on the basis of cost, quality and reliability.

Doner (1992), however, claims that entrepreneurship has also been important in making local companies internationally competitive. In stressing the importance of institutional factors in the development and success of many local business groups, he argues that many writers have neglected the role of non-governmental institutional factors such as business groups, business-interest associations, networking systems and the relationship between the government and the private sector. Suehiro (1996) adds that political connections alone cannot always determine or guarantee the success of a firm, and therefore the rapid expansion and growth of specific business groups cannot be simply attributed to connections with the government or collaboration with foreign firms alone. Other factors have helped many domestic private firms to advance and develop, e.g. managerial skills, technological innovation, marketing and other capabilities.

In contrast, Jones and Sakong (1980:81) see a successful entrepreneur as one able to become competitive as a consequence of government intervention. The factors behind a firm's success are thus complex and manifold while the tasks of an entrepreneur, according to them, include the following:

1 perception of a new economic opportunity, including a new product, a new production process and new markets;
2 evaluation of the profitability of a new opportunity;
3 gaining command of financial resources;
4 supervision of plant design, technology and construction;
5 recruitment and training of new personnel;
6 good relations with government;
7 good relations with suppliers and purchasers.

This chapter studies some factors behind Sapura's apparent success in establishing a strong reputation for technological development among private Malaysian manufacturing firms. Sapura is a young company that has grown in size and scope within a short period of time. Presently, the company is involved in three main business areas: telecommunications, information technology and metals-based industries. The core competence of the firm has been in producing telephone equipment. One of the major factors cited for Sapura's success has been its good connections with key Malaysian government officials. The main objective of this chapter is to evaluate the extent to which institutional factors have nurtured this *Bumiputera* (indigenous) Malaysian firm in becoming a successful telephone equipment producer. As Sapura initially depended on foreign technology and joint-venture arrangements, we are also interested in assessing how learning by doing developed from simple reliance on foreign technology. We will also examine the role of entrepreneurial capabilities in company performance.

Company history

Sapura started operations in 1975, during a decade in which the Malaysian economy was growing rapidly. One of the many objectives of Malaysia's New Economic Policy (NEP)[1] introduced in 1970 was to promote *Bumiputera* involvement in business. Shamsuddin Abdul Kadir, the founder of the company, was among the earliest *Bumiputeras* to capitalize on such government policies. Previously an engineer in the Malaysian Telecommunications Department (JTM, now corporatized as Syarikat Telekom Malaysia, STM), Shamsudddin has had the relevant technical knowledge, experience and contacts in government, particularly in JTM. Like many big businessmen, Shamsuddin is said to have been close to some politicians, notably Prime Minister Mahathir Mohamad. He once served as director of

Permodalan Bersatu Berhad, the holding company of the ruling party UMNO's co-operative, Koperasi Usaha Bersatu (KUB).

All these contacts and experiences helped Shamsuddin start his business with a contract to lay cables for JTM in 1975 worth RM2.3 million. With this, he became the first such Malaysian turnkey contractor in Malaysia. This opportunity was almost certainly obtained through his strong government connections. However, the company failed to obtain loans from local financial institutions due to lack of collateral. Sapura would not have fulfilled the tender requirement if not for support from foreign financial sources, particularly 3M Malaysia.

Sapura has also depended on its foreign partners for much of its subsequent expansion. In 1983, Sapura got a share of the RM2.5 billion cable laying contract, one of the biggest government jobs before the RM3.4 billion North–South Highway project was awarded in 1987. This contract was divided regionally among four *Bumiputera* contractors: Shamsuddin's Uniphone, Binafon, Electroscon and Sri Communications. Sapura again faced funding problems and needed specialized expertise to handle the contract. Shareholder funds were depleted, and the company plunged into the red because of the huge start-up costs. Again, external financial support helped to pull it through. Sapura brought in two giant Japanese corporations – Sumitomo and Marubeni – as joint-venture partners. The two Japanese companies guaranteed the much needed bank loans amounting to RM70 million.

Sapura has joint ventures with large and established multinationals for most of its other projects. This has given the company the ability to take up projects much larger than its resources might otherwise allow. For example, Sapura is the sole agent for Macintosh personal computers, ancillaries and software, and NEC portable telephones and facsimiles, while Fujitsu is Sapura's joint-venture partner in fibre optics, and Mitsui supplies Sapura with telecommunications equipment for government projects such as earth satellite stations. Sapura has also joined forces with Hewlett-Packard of the USA and Nokia of Finland in other telecommunications activities.

Sapura won a contract from the JTM to supply telephone sets during the years 1977 to 1979. Subsequently, the company supplied telephones and payphones for fifteen years under three five-year contracts with JTM. When the second contract ended in 1989, the payphones contract was renewed for another fifteen years. The tender to supply telephone sets, however, was awarded on a two-yearly basis (as a result of the corporatization of JTM in 1987), and Sapura's contract to supply phones to STM was not renewed. Instead, the contract was given to a Taiwanese company operating from the Prai Free Trade Zone (FTZ) which offered a much lower price for telephone sets. This resulted in criticisms, which caused the government to intervene. When the contract with the Taiwanese supplier finally ended in 1991, Sapura and another local company, Asteria, obtained the contract.

Sapura also operates paging services. These services, which started in Malaysia in 1974, were once a monopoly of JTM, but were liberalized in 1985, with licences issued to *Bumiputera* companies to provide paging services in various localities in Malaysia. Sapura was one such beneficiary. Other important contracts obtained through government connections have been tenders to supply twelve critical component parts for the national car, Proton Saga, since 1990. The contract was awarded to Sapura Machining Corporation to supply two brake parts (brake disc and rear hub), three engine parts (water pump pulley, left and right rocker shaft assemblies), seven transmission parts (reverse shift hug, clutch, release fork shaft assembly, control shaft, stopper body) and three shift rail sub-assembly systems. Kyoto Engineering Incorporated, a consortium of six major suppliers to Mitsubishi of Japan, provides technical assistance to Sapura for producing those parts. Sapura obtained this contract – and associated rents – under the local vendor development programme (VDP), launched through and managed by Proton, which is thus required to share some of its rents (from Proton sales in the heavily protected Malaysian market) with the vendors, who are expected to eventually involve majority *Bumiputera* ownership.

In general, state connections have benefited Sapura significantly through acquisition of various government tenders and contracts. As a company, Sapura – which began operations with a staff of six in a one-room office in Wisma Central, Kuala Lumpur – has grown in scale and scope. The company has expanded its business activities from telecommunications into information technology, metals-based industries and automotive parts sector. The overall structure of Sapura's activities is shown in Appendix 13.2. Telecommunications products and services are the core business of the company, contributing more than 80 per cent of earnings. Table 13.1 indicates the importance of telecommunications to Sapura, with its business interests managed by two listed subsidiaries, i.e. Uniphone Telecommunications Berhad (UTB) and Sapura Telecommunications Berhad (STB). Telecommunications contributed 71 per cent of turnover and 82 per cent of pre-tax profits to UTB, while the sub-sector was also the major contributor to both revenue and profits for STB in 1995.

Uniphone Telecommunications Berhad was formerly called Malayan Cables

Table 13.1 Detailed activities of Uniphone and Sapura Telecommunications, 1995 (RM million)

Activities	*Uniphone Telecommunications*		*Sapura Telecommunications*	
	Turnover	*Pre-tax profits*	*Turnover*	*Pre-tax profits*
Manufacturing	113.2	10.4	–	–
Telecommunications	386.0	41.3	408.9	40.3
Investment	1.0	–0.3	–	0.3
Trading	45.0	–0.6	–	–
Property investment	0.9	0.1	2.6	0.6

Source: Company annual reports.

Berhad.[2] Sapura acquired a majority interest in the company in 1984, a year after Sapura was awarded the big cable networking contract; Malayan Cables was one of the leading cable manufacturers in the country at that time. In 1988, the company's name was changed to Uniphone Telecommunications Berhad (UTB) after some restructuring. Currently, UTB and its companies are involved in the manufacture of copper rods and communications cables, cable network installation, the manufacture and supply of push-button subscriber phones, and the manufacture, supply and maintenance of public payphones. Three subsidiaries specialize in digital services and pagers, namely Komtel Sdn Bhd, Sija Sdn Bhd and Komtel Farahat Sdn Bhd.[3] Installation of fibre optic cables has become increasingly important for Sapura, especially with the improvements taking place in telecommunications digital technology. While Uniphone Sdn Bhd is involved in the installation of fibre optic cables, Uniphone Fibre Optic Sdn Bhd provides fibre optic transmission systems.

Sapura's ventures into information technology involve software development and system integration; distribution of Apple Computers, peripherals and software; and integrated surveys of resources and environmental management. In addition to these activities, the company also supplies PABX[4] systems, sales and technical services for radio equipment, besides marketing and servicing heavy electrical engineering for sub-station projects. The company also offers consultancy and system integration services for computers and networking. There are ten subsidiaries that specialize in information technology which are largely linked to the core business of the industry, namely telecommunications.

Sapura's automobile parts manufacturing has been managed by Sapura Motors Berhad, a publicly listed subsidiary. Table 13.5 shows the increasing importance of the automotive parts sub-sector in the company's total profits. Currently, 75 per cent of the company's production is supplied to the national car manufacturer, Proton (Perusahaan Otomobil Nasional Bhd). Its other customers include Perodua, Mercedes Benz, Volvo, Ford, Suzuki and Mazda. It has recently signed a MOU to supply the Indonesian national car, Timor (*New Straits Times*, 3 Jan. 1997). There are a few subsidiaries which produce manhole covers, mail boxes, and cast iron bars.

Economies of scale, growth and profits

These contracts – particularly for telephones, payphones and cable laying – took Sapura into the big league, and have undoubtedly contributed to Sapura's growth and profits. Sapura was the only private company providing telephone sets and payphones in urban areas via long-term contracts with JTM, and then STM. JTM/STM has been the main service operator, providing the core network,[5] virtual monopoly in the telephone and urban payphone markets. while telephone equipment is supplied by Sapura which gave Sapura a

Sapura has enjoyed an additional advantage with telephone sets, because Malaysians are provided with telephones supplied by JTM/STM when they subscribe for a telephone line, unlike subscribers in many other countries who can buy telephones off the shelf. Furthermore, the market for telephones in Malaysia has been large and growing substantially over the years as a result of the greater affluence of the population, increased business activities and other developments in the telecommunications network. The number of telephone subscribers has increased from about 0.2 million in 1975 to 2.4 million in 1993, equivalent to an increase in telephone penetration rate (telephone lines per 100 population) from 1 per cent to 13 per cent over the same period (*Bank Bumiputera Berhad Economic Review*, Jan.-March 1995; also see Table 13.2). Although this is lower than the average penetration rate of 49 per cent in developed countries, the country's telephone density is among the highest in developing countries (Rais 1995). Being the sole supplier of telephone sets to Telekom Malaysia, the rapid expansion of demand for telephones has ensured rapid growth for Sapura. For example, due to increasing demand, production of telephone sets tripled from 134,521 in 1994 to 382,767 units in 1995 (see Table 13.3).

Between 1977 and 1996, Sapura produced four telephone models. The S2000A is the simple push-button subscriber telephone which has mainly been supplied to STM and increasingly to countries like Bangladesh, Mauritius and Papua New Guinea. Other models are more high tech with more sophisticated features, and are mostly exported to developed countries and sold locally at Sapura outlets (known as *Kedai Sapura*). Table 13.3 shows that production of the S2000HF decreased from 119,858 units in 1994 to 9,702 units in 1995, because as a new model is introduced, production of the earlier models falls. The latest model is the S3000. Production of this model has increased substantially from 2,650 units worth RM146,000 in 1994 to 368,123 units worth RM9.7 million in 1995. Meanwhile, total production rose from 134,521 units costing RM6.9 million to 382,767 units worth RM10.3 million.

On the other hand, payphones in Kuala Lumpur and Petaling Jaya have long been associated with Uniphone, and by 1996, there were 70,000 Sapura payphones (both pre-paid telephone card and coin-operated payphones) operating in Malaysia. Sapura was able to reach such a scale because, as mentioned earlier, a licence was issued in 1977 to Uniphone Telecommunications Bhd (a Sapura subsidiary) to operate payphones in urban areas, while Telekom Malaysia was left to serve the less lucrative rural areas.

Production of payphones has also been very impressive. In 1994 and 1995, Sapura produced between 20,000 to 22,000 units of payphones annually. Payphones' contribution to total telephone manufacturing has also been substantial, worth more than RM100 million in both 1994 and 1995. Thus, payphones have been Uniphone's core business, accounting about 70 per cent of revenue (*New Straits Times*, 21 Feb. 1996). The substantial share from payphones has been due to its virtual monopoly of the lucrative urban market. Such special privileges have given Sapura economies of scale in production, reflected in increasing turnover over the years. Figure 13.1 shows company turnover from 1978 to 1995. Sapura's

Table 13.2 Malaysia: number of subscribers for selected telecommunications services, 1985–95 ('000)

Services	*1985*	*1986*	*1987*	*1988*	*1989*	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*2000 (projected)*	*Average annual growth, 1984–95 (%)*
Telephones	950	1,050	1,115	1,300	1,450	1,555	1,850	2,100	2,397	2,847	3,371	7,855	13.0
Facsimiles	0.5	1.0	4.0	11.5	25	34	41	45	86	163	–	–	90.2
Telexes	9.5	10	9.5	8.5	7.9	7.5	7.9	7.6	7.3	7.0	6.7	–	4.3
Pagers	4	6	12	18	31	39	40	110	130	200	250	500	54.4

Sources: Rais (1995) and Telekom Malaysia Berhad, *Annual Report*, 1995.

Table 13.3 Production and export of payphones and telephones, 1994, 1995

Production item	*Production*				*Export ratio*		*Major export destination*
	Units		*Value (RM '000)*		*1994*	*1995*	
Year	*1994*	*1995*	*1994*	*1995*			
Payphones							
Prepaid cardphones	6,350	6,000	33,655	31,800	5	10	
Coinphones	13,360	15,773	69,472	82,019			Vietnam
Indoor payphones	194	128	275	243			
Total	19,904	21,901	103,402	114,062			
Telephones							
S2000A	8,174	4,407	879	141			Middle East,
S2000HF	119,858	9,702	4,925	378	7.5	9.0	ASEAN,
S2000 Classic	3,839	535	902	97			U.S., Germany,
S3000	2,650	368,123	146	9,663			Bangladesh,
Total	134,521	382,767	6,852	10,279			Mauritius, etc.

Source: Interviews.

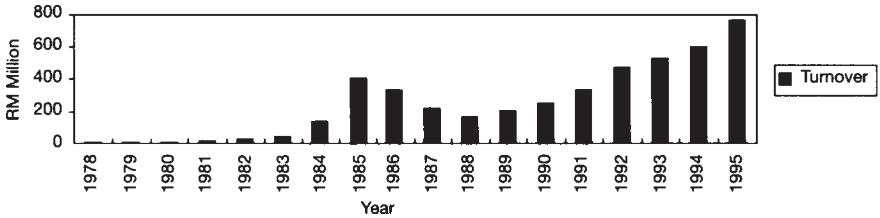

Figure 13.1 Total turnover of Sapura Group, 1978–95
Source: Company files at the Registrar of Companies.

sales increased tremendously from RM9.7 million in 1978 to RM162.8 million in 1988 and RM768.7 million in 1995.

Profits of the company have also increased steadily over the years. Table 13.4 shows Sapura's pre-tax profits and turnover since 1978. In the early stage, pre-tax profits of the firm were small, but increasing over the years (Mansor 1993). In this period, Sapura received two major contracts: RM2.3 million in 1976 to lay cables in the Kuala Lumpur area, and to become a telephone supplier to JTM from 1977.

Table 13.4 Sapura Holdings Sdn Bhd: turnover and pre-tax profit, 1975–95 (RM million)

Year	*Turnover*	*Pre-tax profit*
1975	n.a.	–0.001
1976	n.a.	–0.3
1977	n.a.	n.a.
1978	9.7	0.2
1979	10.9	0.7
1980	11.1	0.8
1981	16.3	1.8
1982	30.1	1.9
1983	45.6	–1.3
1984	137.7	–27.8
1985	400.0	n.a.
1986	332.0	40.9
1987	227.2	–0.9
1988	162.8	8.8
1989	204.4	13.1
1990	254.4	18.6
1991	337.1	26.8
1992	475.2	32.5
1993	526.4	53.1
1994	604.6	58.8
1995	768.7	40.6

Source: Company files at the Registrar of Companies.
Note n.a. = not available.

Sapura's growth stage (1983–9) began with the contract worth more than RM600 million in 1983 to lay cables. The Malaysian economy witnessed a short economic recession in the years 1985–6 (Jomo 1990), during which many companies suffered losses and were forced to retrench employees to cut costs. For Sapura, too, this was a turbulent phase. Although turnover suddenly jumped to RM138 million in 1984, and increased rapidly to more than RM400 million in 1985, it suddenly dropped to RM163 million in 1988. The company also suffered losses during some years in this period, particularly in 1984, largely due to the heavy start-up costs for the big cable laying contract (Mansor 1993). However, profits began to show in 1988, and increased to RM13 million in 1989. Sapura obtained other local and overseas contracts during this period, including (i) a telephone contract in Bangladesh; (ii) the contract to install a system for supervisory control and data acquisition (SCADA) for Lembaga Letrik Negara (LLN – the National Electricity Board); (iii) a licence to manufacture phones in Jordan; and (iv) a tender to supply telephones in Thailand and Mauritius.

The mature stage began in the year 1990, when turnover rose to RM254 million from around RM200 million in 1989, as pre-tax profits rose to RM18.6 million from RM13.1 million. Pre-tax profits peaked at RM58.8 million in 1994. Turnover, on the other hand, peaked in 1995 at RM768.7 million, though pre-tax profits declined to RM40.6 million. In the 1990s, Sapura was successful in getting many more contracts (see Appendix 13.1). In addition, there were many developments in the company's activities such as the launch of flexible card phones, introduction of a new generation of electronic payphones, diversification into the automotive sector, launch of the hands-free voice-activated telephone, etc.

The two listed companies in the group – Sapura Telecommunications Berhad (producing telephones) and Uniphone Telecommunications Berhad (operating payphones) – contribute about 23 per cent and 38 per cent, respectively, to the group's turnover in 1990 (Mansor 1993), rising to a total of 86 per cent in 1996. The biggest source of profits in 1992–5 was Uniphone Sdn Bhd, a company mainly involved in telecommunications-based activities, such as manufacturing modern push-button subscriber phones; manufacture, installation and maintenance of a public payphone network; and installation of fibre optic cables. Teledata Sdn Bhd was the second largest contributor to Sapura's profits. Manufacture, installation and maintenance of payphones has been the most profitable business for both Uniphone Sdn Bhd and Teledata Sdn Bhd. For example, Table 13.6 shows that profits from manufacturing payphones accounted for almost 50 per cent of Teledata's total pre-tax profits. This activity has "saved" the company because there are a few other divisions suffering huge losses.

It is clear that the manufacture, installation and maintenance of payphones and telephone sets have been the major contributor to Sapura's growth. Thus, Sapura's large profits can be mainly attributed to government intervention by limiting and eliminating competition in the payphone and telephone set markets.

Table 13.5 Pre-tax profits of selected Sapura subsidiaries, 1992–5 (RM million)

Year	*Sapura Group*	*Telecommunications-based companies*			*Metals-based companies*		*Others*
		Teledata	*Uniphone*	*Uniphone Cable*	*Sapura Automotive*	*SMC*	
1992	32.5	4.611	24.208	0.634	−1.43	−2.6	7.077
1993	53.1	4.35	26.828	12.93	−0.717	−1.38	11.089
1994	58.8	19.32	36.87	9.32	0.735	1.83	−9.275
1995	40.6	30.39	30.128	10.44	1.47	2.44	−34.268

Sources: Company files at the Registrar of Companies.

Notes SMC = Sapura Machining Corporation Sdn Bhd. Only five companies are included here. Three are in the telecommunications sub-sector and two in the metals-based sub-sector, producing parts for the automotive sector.

Table 13.6 Teledata Sdn Bhd: detailed profit and loss, 1992, 1993

Division	*Profit and loss (RM Million)*	
	1992	*1993*
Manufacturing, payphone division	11.33	11.46
Manufacturing, PABX division	–0.917	–3.29
Product department, marketing division	–2.97	–1.57
Product department, international division	–0.12	0.89
Racal radio project	–	0.13
Business system division	1.17	1.19
Common management division	–3.04	–3.48

Source: Company files at the Registrar of Companies.
Note PABXs = private automatic branch exchanges.

The protected domestic market has been crucial for Sapura in strengthening its position in the telecommunications industry in Malaysia.

Rents and technological change

It is obvious that Sapura has made sizeable profits from various contracts it has received via the company's chairman's contacts with the relevant government authorities in the past two decades. In economic theory, such a super-normal profit is also known as a "rent", which is deemed to exist in all kinds of situations of imperfect competition. If the government has discretion in the allocation of such rents, profit-seekers will be induced to capture such rents by lobbying government decision makers to allocate these rents in their favour. Krueger (1974) has termed such activities as "rent-seeking". It has been argued that in these circumstances, government intervention distorts market processes, undermining competition and causing wastage.

However, while there is a tendency for rent-seeking to result in unproductive, corrupt and wasteful activities in politically modified markets, state intervention can also reshape growth and accumulation processes to facilitate the emergence and development of new economic activities (see Schumpeter 1975:78, Chang 1994, Jomo 1996:5, Khan 1996). Schumpeter has argued that various restrictive practices may increase profits and reduce the risks faced by firms that undertake the costly investments required for innovation. Schumpeter (1975:102) explained that "a monopoly position is in general no cushion to sleep on. As it be gained, so it can be retained only by alertness and energy." Ekelund and Tollison (1981:18–19) acknowledge that rents provide the incentive for resource owners to seek out more profitable (and, presumably, more economically efficient) allocation of their resources.

Hence, the prospect of capturing rents stimulates entrepreneurial decisions, e.g. to invest in research and development to bring about technological change in the Schumpeterian sense, and can also be presumed to bring about an efficient allocation of resources. Even rent-seeking welfare losses may well be more than offset by the dynamic gains of productivity growth which the rent facilitates: for example, by increasing opportunities for learning by doing, as in the case of infant industry protection; or by encouraging firms to spend more on research and development. Hence, while rent-seeking may be directly unproductive, such activities may well constitute transaction costs which indirectly facilitate productivity gains (Chang 1994). Such distortions are recognized, for example, to have been important in facilitating late industrialization in continental Europe, the US and Japan in the nineteenth century.

Rents created and secured through government intervention seem to have been utilized more productively by Sapura than most other *Bumiputera* rentiers, as evidenced by its heavy investment in R&D to develop technical capabilities and to improve product quality and design. For example, Sapura has succeeded in manufacturing its own locally developed telephone sets by investing in foreign licences and technical assistance, i.e. through learning by doing. It took them eight years to reach this point. Initially, Sapura made telephones under licence from Siemens of Germany from 1980. In 1983, the company obtained a licence to manufacture Bell telephones.

Amsden and Kim (1985) have suggested that the forms of technological acquisition have changed over time, from the earlier tendency to absorb foreign technology, through copying and learning on their own, to adapting foreign technology after investing in foreign licences and technical assistance. The former mode of technology acquisition may be called imitation, and the latter, apprenticeship, i.e. learning by doing. Sapura has followed the apprenticeship mode of technological acquisition.

Over the years, Sapura has accumulated considerable experience in manufacturing telephones. To securely establish itself in the telecommunications industry, Sapura sought to manufacture its own telephone from early on. By 1984, with five years of experience in telephone manufacturing under licence, the company had already produced over one million telephone units. Although the company had acquired enough technology and experience to stand on its own feet, it was still constrained from making the required modifications and improvements. For even the simplest circuitry changes, it had to refer to the parent company, and bear all the expenses of related “expert visits”. The company set up an R&D department in 1984 to make its own telephone. A year later, in 1985, the first home-grown Malaysian telephone, of the S2000 series, was born. Using proprietary technology, the first model was the S2000A, which involved almost RM1 million in development funds. A year later, the first locally manufactured mini-PABX telephone system was launched. This was followed by the second version of Sapura’s telephone, the intelligent S2000B, with about RM500,000 spent on its development. This telephone was displayed at the Telecom ’87 exhibition in Geneva in October 1987, where it won favourable reviews for its computer-control features, that include a memory bank which stores and recalls, within a second, over 200 alphabetically-ordered numbers, and other features such as automatic dialling and call barring. This telephone has been exported to Japan, the USA, Germany and many other countries. The telephone also won first prize in the utility innovation section in the Malaysian Invention and Design Exhibition. Meanwhile, the company also successfully developed its own direct paging software programme. Sapura has increased its budget for R&D over the years, and also aims to produce its own brand of mobile telephones.

Sapura's R&D efforts have mainly been in product technology, improving products and conducting research for new products in the future, and not in process technology. Sapura mainly does designing and prototyping of in-house products, e.g. telephones and PABXs. Sixty per cent of Sapura's input is procured from local sources (*Business Times*, 4 Dec. 1989). In order to improve capacity to face future challenges, and to further emphasize its role, the board of directors of Sapura Holdings agreed to incorporate the R&D department as a corporate subsidiary. Hence, Sapura Research Sdn Bhd was formed in February 1991, with a paid-up capital of RM2 million. The rationale for setting up the company was also to gain greater operational autonomy. Shortly after its incorporation, Sapura Research announced another achievement – development of a hands-free, voice-activated telephone, the S2000HF, with home-grown technology. In the first year of operations (1989), the R&D unit was allocated RM2.8 million, with the amount increasing steadily to about RM5–6 million in 1990/1. This amounted to about 1 per cent of the group's turnover during those years. In 1992, R&D expenditure was estimated to be around RM10 million, which was about 2 per cent of turnover. However, due to the diversified nature of the company, measuring R&D expenses against turnover may be misleading (Mansor 1993). The proportion of R&D expenditure against telephone sales has been about 10 per cent – quite comparable with established multinational companies like IBM, Matsushita, Philips, Xerox and Ericsson, for whom the proportion ranges from 8 to 15 per cent.

Only printed circuit boards (PCBs) and chassis/mould are self-produced (PCBs are bought from local vendors, while the service-mounting of PCBs is done by Sapura). Metals, plastic, as well as some of the chassis and moulds are supplied by local manufacturers (see Table 13.7). Other inputs – such as test instruments, metals, plastics and IC chips – are imported, with the most important import being integrated circuits (ICs)/specialized chips. This is because, although there are many semiconductor manufacturers in Malaysia, most of their production is for export. In addition, Malaysian companies are still producing application-specific ICs.

The telecommunications sector is one area where the development and application of new technologies is very active. Progress in new electronic-based technologies during the 1980s has made large MNCs adopt computer-integrated designing and manufacturing systems. While this permits new products to be commercialized very quickly once they have been designed – i.e. shortening the lead-time from the product conception stage to the design stage – it also allows manufacturers to respond rapidly and flexibly to customers' specifications and to

Table 13.7 Components and raw materials, 1995

Major components and raw materials	*Supplied by*		
	Import	*In-house production*	*Local manufacturer*
PCBs	*	*	*
ICs/chips	*		
Test instruments	*		
Metals/plastic			*
Chassis/mould		*	*

Source: Interviews.

Notes PCBs = printed circuit boards.
ICs = integrated circuits.

changing market tastes. Consequently, there is a perceptible trend for manufacturing enterprises to emphasize product diversification, design, and servicing of their products, apart from production itself (Anuwar Ali 1992: 66).

MNCs – such as Siemens, Thompson, Hitachi, NEC, Ericsson, Toshiba and Philips – obviously dominate industrial R&D and technological innovation in the international telecommunications industry. These giant corporations set the pace and direction of R&D, and thus define the technological frontier. Catching up with these giants, particularly in technology, is not easy for a latecomer like Sapura. Furthermore, technological advancement in Sapura seems to be incremental, gradual and achievable through many small modifications, rather than being based on major breakthroughs. In addition, products or processes developed through Sapura's R&D efforts that are regarded as new for Sapura may not be very new in the world. Apparently, Sapura's R&D efforts have not helped production costs to fall, and have thus not helped much to improve international competitiveness. For example, in 1989, a Taiwanese company, Formula Electronics, was selling telephone sets for RM37.20 a set, compared to Sapura's RM54 per set. This means that Sapura's price was 45 per cent higher than that of the Taiwanese supplier. Sapura's officials admit that it has not achieved international competitiveness in terms of price, and that Korean and Taiwanese producers are generally much more competitive in the world market.

One of the major reasons why the results of Sapura's research and development efforts have not been at par with its international competitors is due to lack of skilled and educated manpower. The process of learning-by-doing invariably takes place in manufacturing industries, although it may not necessarily be found at all levels of the occupational hierarchy (Anuwar Ali 1992:129). The process is generally restricted to those who are considered technically skilled, including the managerial and professional, technical and supervisory, and skilled worker categories. However, as indicated in Table 13.8, these groups accounted for about 30 per cent of the total workforce in Sapura on average. On the other hand, the semi-skilled accounted

Table 13.8 Sapura Holdings: types of workers, 1995

Type of worker	*Percentage of total workforce*
Simple	30
Semi-skilled	40
Skilled	15
Foreman/inspector	3
Engineer	5
Clerical staff	7
Manager	1

Source: Interviews.

for 40 per cent, and the unskilled for 30 per cent. Sapura currently employs a workforce of about 3,800.

Technological learning also requires the industrial workforce to be well equipped to acquire technical skills, while shop-floor technicians, engineers, and technically trained managers are required in increasing numbers. This means that secondary and technical education has become more important. However, in Sapura, most of the workers are not highly educated. Eighty-five per cent of Sapura's factory workers only have upper secondary school, lower secondary or elementary school qualifications, while 15 per cent of the employees have university and technical institute training (see Figure 13.2).

This suggests that Sapura is essentially an assembly-type production company that largely employs cheap and unskilled workers with low levels of education which in turn limits the capacity for rapid technological change. Shop-floor workers are crucial for solving many problems and, together with engineers, they can

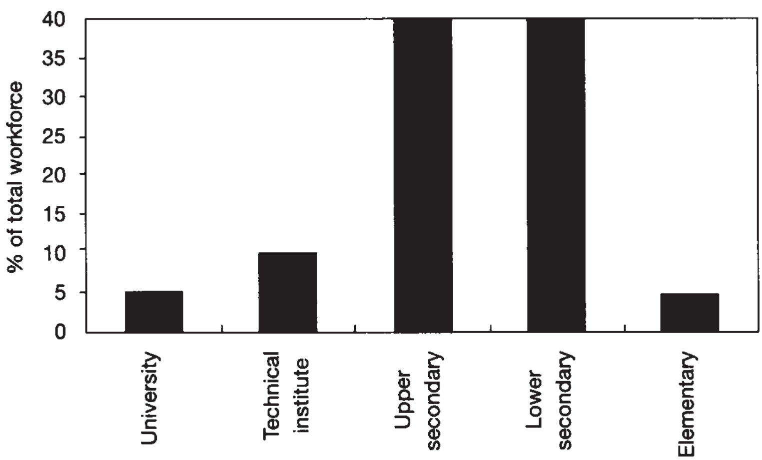

Figure 13.2 Sapura: education level of factory workers
Source: Interviews.

produce innovative results. Many innovative ideas have actually originated from the shop floor (Ozaki 1991: 60–1). In Korea, salaried engineers have been the key to late industrialization because they are considered to be the gatekeepers of foreign technology (Amsden 1989: 9). Amsden found that private firms employed and relied on university graduates, who replaced foreign experts at the earliest possible opportunity. Across the spectrum of company sizes, Korea's managers generally hold advanced degrees. In Japan, the university-trained engineer-manager has been identified as the key means for catching up with established firms abroad. According to Daito (1986), engineers in Japan took over several functions from foremen, and tried to control factors such as manufacturing, costs, product quality, inventory levels, work intensity and so on.

Given the employment structure and education level of its employees, Sapura is obviously far behind the standard and quality achieved by its competitors in East Asia. Therefore, it is questionable whether Sapura will ever be able to compete successfully with its competitors in the world market in terms of price and quality. Rapid progress in new electronic-based technologies in the industry makes the catching-up process even more difficult for Sapura. But, catching-up with the world technological leaders may not be the main priority for Sapura. This is because it relies mainly on the protected markets and, hence, export sales are not vulnerable to price competitiveness. Furthermore, Sapura mainly sells the simple push-button model to developing countries, because the tenders it has received so far have been from the government-owned Telecommunications Department, where cheap and easy-to-use telephone sets for the general public are preferred.

The majority of export sales has been to Bangladesh, Vietnam, Thailand, the Philippines and Jordan. Table 13.9 shows the list of Sapura business activities overseas. It is clear that Sapura has concentrated its business interests in developing countries, where price competitiveness has generally been the secondary concern in getting contracts, particularly government tenders. Markets in developing countries have generally been obtained through contacts with foreign business partners, and also through connections with relevant government officials.

For example, Sapura's success in getting a contract to supply 10,400 simple S2000A telephone sets to Bangladesh in 1989 would not have been possible without the involvement of the Sumitomo Corporation of Japan.[6] The main contract for the installation of telephone exchanges and for the supply of telephone sets was awarded to Sumitomo by the Bangladesh Telegraph and Telecommunication Board. Sumitomo, in turn, awarded Uniphone the contract to supply the telephone sets, while NEC of Japan got the contract to supply telephone exchanges. Similar collaboration with Sumitomo has enabled Sapura to obtain a small order from El Salvador for telephone-testing equipment. In July 1996, with another partner, Sumitomo Electric Industries of Japan, Sapura ventured into the payphone business in the Philippines through a joint-venture project with a local operator, the Philippines Long Distance Telephone Company, for the management of all payphones in the country.

Table 13.9 List of Sapura's overseas activities, 1986–96

Date	*Country*	*Items*	*Value*	*Joint-venture partner*
July 1996	Philippines	Payphones	–	Joint venture with Sumitomo and Philippines Long Distance Telephone Company
July 1994	Brunei	Cable network installation	RM54mn	Telecoms Department of Brunei
July 1994	Indonesia	Cable laying	RM50mn	PT Telekomunikasi Indonesia
February 1993	Mauritius	Telephones, paging, answering machines and services	–	–
April 1993	Indonesia	Telephones	RM150mn	–
Nov. 1992	India	Paging services	–	–
1991	Vietnam	Payphones	RM15mn	–
1990	Jordan	Telephones/payphones	–	Jordanian Company Petra Electronics Pte. Ltd
1989	India	R&D and management of tel. equip.	–	E.M. Electronics Co. of India
1989	Bangladesh	Telephones	–	Bangladesh Telegraph and Tel. Board
1989	Thailand	Payphones	–	Ruam Thai Pattana Pte. Ltd
1989	Jordan	Telephones	–	–
1986	Singapore/Hong Kong	Supply of cables	RM110mn	–

Sources: New Straits Times, The Star, Malaysian Business, Business Times, Asian Wall Street Journal.

Markets in less developed Asian countries like Bangladesh, India, Sri Lanka, Pakistan, Myanmar, Mauritius, Thailand, Indonesia, Vietnam, Cambodia and Laos have been penetrated by Sapura, not only through contacts with foreign business partners, but also thanks to government-to-government agreements. Asian developing countries, Muslim countries and also some African and Latin American countries admire Malaysia's rapid development. In addition, the Malaysian government's championing of South–South economic co-operation has also strengthened the chances of doing business in these countries. Malaysia's membership in the Organization of Islamic Countries (OIC) has also provided some leverage for telecommunications investments abroad (Rais 1995). Malaysian private firms often participate in government-led missions abroad to potential markets to build contacts with government help. The private sector refers to this phenomenon as the "Mahathir factor". It provides many local companies with better opportunities to capture overseas markets even when they lack a price advantage.

Sapura gets special treatment from the government's business missions abroad, where Telekom Malaysia and Sapura Holdings usually team up as a group representing the telecommunications industry in Malaysia. This gives both Telekom Malaysia and Sapura Holdings a competitive edge when bidding for international tenders because it enables them to offer a comprehensive package of services and expertise. A recent success in penetrating overseas markets has involved Sapura's investment in Vietnam. The country's ambitious expansion and modernization plans have provided many opportunities for Sapura. Vietnam's entry into ASEAN has reinforced the existing close co-operation between the Vietnamese Directorate General of Posts and Telecommunications (DGPT) and Telekom Malaysia, with the signing of a Memorandum of Understanding. Initially, in 1991, Sapura won the rights to operate payphones in Ho Chi Minh City, Vietnam. In 1995, Sapura succeeded in obtaining the licence to provide a pre-paid public telephone service throughout Vietnam; 600 cardphones had been installed by 1995, compared to 200 units in 1993.

Sapura's high costs of production and slow technological change have made exports to developed countries difficult, with sales to such countries still modest. Such foreign sales have mainly been to other industrialized countries such as Singapore, the Netherlands, Germany, Iceland and Japan. Sapura exports sophisticated top-of-the-line telephones such as the S2000HF and S3000 models to Japan, the US, Canada, Germany, Austria, France and Belgium. The US market has been one of the most difficult to penetrate. In 1989, Sapura appointed a California telecommunications-based company, Landsperger and Associates, as its representative to co-ordinate its North American sales and marketing. The arrangement, however, did not materialize, and Sapura tried to have another such arrangement in 1991 but without much success.

The last two decades have seen some liberalization of the telecommunications industry world-wide. New market forces, unleashed by these changes, have replaced or restructured old structures, requiring new strategies to succeed in the international and domestic markets. The next section analyses Sapura's strategy in facing the tremendous changes that have taken place in the telecommunications industry as a result of the corporatization of JTM and the increasing trend towards deregulation that has given rise to some competition in an industry that has traditionally been monopolistic.

Increasing domestic competition and diversification in the automotive industry

Sapura has faced increasing competition in the domestic market, which was once its monopoly, since JTM was corporatized in 1987. These became more serious as the telecommunications sector has been partially liberalized in the 1990s. The first big problem involved the supply of telephone sets. When the agreement to procure telephone sets from Sapura ended in 1989, STM awarded a two-year phone supply contract to Formula Electronics, a pioneer status company operating in the Prai FTZ. The tender was given to E-Ritek, Formula Electronics' local agent, to supply 600,000 telephone units worth RM23 million. However, STM currently procures telephone sets from two local companies, Uniphone and Asteria; despite corporatization and privatization, STM's supply procurement is still determined by the government. Despite losing its monopoly in the domestic telephone sets market, Sapura is still profitably operating in a captive market with two suppliers.

Liberalization of the telecommunication sector in the 1990s has significantly affected Sapura. In 1994, the Ministry of Energy, Telecommunications, and Posts awarded licences to Sapura and STM, allowing them to operate their payphone businesses anywhere in Malaysia. This means that Sapura no longer has a monopoly to operate payphones in the urban areas. Consequently, Telekom Malaysia has begun to capture a slice of the lucrative urban payphone market. In the prepaid phone card market, Telekom Malaysia has set up a network of about 1,000 Citifon payphones (operated by Mobicity Sdn Bhd, an associate company of Telekom Malaysia) in the city, competing directly with Uniphone. Telekom Malaysia also operates its own network of payphones using pre-paid cards, but mostly in outlying semi-urban and rural areas. In 1996, Telekom Malaysia was operating 64,000 payphone units throughout Malaysia. Competition in the payphone market became more intense with the entry of Mobicity Sdn Bhd, and the blurring of the boundary between urban and non-urban areas, following liberalization of the telecommunications industry. This has clearly had a big impact on Uniphone given its large payphone income base. In addition, Sapura now has to pay interconnection and line rentals charges to Telekom Malaysia which effectively limits its profits. In response to this increased competition, Sapura has installed more payphones at a rate of a thousand units per month. Installing new payphones is expensive as they cost RM8,000 each. By flooding the market, revenue per payphone has been reduced as utilization is not keeping pace with the growth of payphone facilities. By 1996, Sapura was really feeling the heat of liberalization when its revenue from payphone operations fell, as reflected in the reduction of Uniphone profits by 37 per cent from RM51 million in 1995 to RM 32 million in 1996.

At the same time, Sapura's cellular phone services also faced problems. In June 1995, it was reported that Sapura Digital (which runs the ADAM digital cellular network) did not meet certain requirements to draw down money from its loan facility (*Business Times*, 14 June 1995). Although the company has extended its coverage to all the major urban centres, it is unable to proceed with Phase Two of the Plan, to increase coverage along the highways for which it would need some RM300 to RM400 million.

Consequently, in July 1996, Sapura sold 75 per cent of its cellular and payphone business for RM1.2 billion to Time Engineering Berhad, an engineering and telecommunications concern controlled by Renong Berhad. By doing this, it is clear that Sapura is trying to shift from the payphone business as competition in the industry has become more acute. Some claim that this is partly due to the less cosy relationship between Sapura and STM and growing competition. All these changes led to a major restructuring in the company's structure in early 1997, with diversification into the even more lucrative automotive industry the apparent priority. In January 1997, Sapura confirmed that the group proposed to acquire a stake in heavy vehicles and automotive company, UMW Holdings Berhad (*New Straits Times*, 3 Jan. 1997), by trying to take over Permodalan Nasional Berhad's (PNB)[7] entire stake in UMW. As of 30 April 1996, PNB had a 5.68 per cent share in UMW and another 38.47 per cent through Amanah Raya Berhad, for Amanah Saham *Bumiputera* (ASB, known previously as Amanah Saham Nasional).[8] The proposed take over, however, was aborted as it created uneasiness among many Malays who felt it unfair to transfer yet another profit-making asset of PNB to an influential Malay individual.

Conclusion

Sapura's success can be traced, in large part, to successful medium-term identification and pursuit of lucrative engineering-based business opportunities, initially in telecommunications and, more recently, in the automotive industry. Sapura has gone through various challenging stages of development, in which it has managed to acquire and build new capacities from various favours (rents), e.g. the relevant business licences and contracts which have enabled it to develop resources and capabilities to become more profitable.

Sapura's R&D effort is commendable, especially considering its size and experience compared to bigger local and multinational companies. However, Sapura's R&D efforts have not yet enabled the company to become truly competitive internationally in terms of price. Therefore, for example, Sapura phones still cannot compete with its competitors from Taiwan and Korea, who are the least cost telephone producers in the world. The high costs of production mainly stem from its dependency on foreign technology and imported inputs.

Even though Sapura exports its production to foreign countries, much of such sales were not attained due to cost competitiveness but through the company's foreign partners and Malaysian government influence abroad. The possibility of Sapura achieving international competitiveness through technological advancement seems remote as the company's R&D efforts largely involve upgrading its main products, i.e. telephones, software, etc., which are highly competitive in the world market. In addition, the company also lacks skilled and trained staff to keep up with the fast-changing international telecommunications technology. Realizing this, Sapura has concentrated on getting contracts in developing countries, where there is extensive government intervention in the procurement policies of big local companies, particularly in the telecommunications sectors.

The sale of 75 per cent shares of Uniphone Sdn Bhd and Sapura Digital Sdn Bhd, two important Sapura subsidiaries making substantial profits, indicates the company's shift of emphasis to another even more lucrative sub-sector offering higher rents, i.e. automotive parts, as rents in Malaysian telecommunications have been eroded by various changes in the industry. The automotive industry is still highly protected, and there are significant rents to be captured with the vendor development programme. There also appear to be some lucrative opportunities to be tapped in multimedia information technology (IT), with the recent launching of the Multimedia Super Corridor (MSC) by the Malaysian prime minister, though it is also feared the big foreign transnational will capture most of the special privileges being offered.

Noes

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1 When Malaysia became independent from Britain in 1957, the ethnic composition of the 6.28 million population was 50 per cent Malay, 37 per cent Chinese and 11 per cent Indian. The numerically dominant Malays, who considered themselves indigenous, were the paramount group controlling the political sphere and the bureaucracy, while the Chinese were essentially the domestic capitalist class. This traditional ethnic split between the public and private sectors is politically sensitive (Jesudason 1989:1). Many Malays have felt that there has been an unequal distribution of income in the country and that the wealth of the country has been exploited and dominated by "immigrant" Chinese. The business opportunities created by the industrialization programme in the country after independence was said to have benefited the Chinese more, and many Malays have maintained that the new government has failed to improve their economic and social status. Racial tensions intensified and, in 1969, they exploded into bloody riots. As a result of this incident, the New Economic Policy (NEP) was announced in 1970. The Malays wanted greater control over the nation's economic resources, both to increase Malay economic power as well as to expand their political base. Targets were set so that by 1990, Malay corporate ownership would be 30 per cent, non-Malay 40 per cent, and foreign 30 per cent, in contrast to 1.9 per cent, 37.4 per cent, and 60.7 per cent in 1970 (*Mid-Term Review of the Second Malaysia Plan*, 1973: 86–7).

2 Berhad means Limited.

3 Sdn Bhd is an abbreviation for Sendirian Berhad which means Private Limited.

4 Private automatic branch exchanges.

5 However, as the demand for telecommunications services began to escalate rapidly, especially in recent years, STM's monopoly has been undermined, ostensibly because it could no longer cope with the rapid expansion. Following the liberalization of the industry, four more licences have been awarded to other companies, namely Binariang, Celcom, Time Engineering and Syarikat Wireless.

6 The Sumitomo group is one of Japan's top four trading houses, with diverse interests in banking, shipping, construction, manufacturing and trading. Sumitomo Electric Industries, a subsidiary of the Sumitomo group, has been Sapura's business partner in many Malaysian government contracts awarded to Sapura, and has acquired a 5.73 per cent stake in Uniphone Telecommunications in 1989.

7 The Permodalan Nasional Berhad (National Equity Corporation), PNB, was established in 1978 to speed up the acquisition of corporate assets on behalf of the Malays. In 1975, Malay (individual and state) corporate ownership fell short of target – with 7.8 per cent instead of 9.0 per cent. A serious shortfall of the 16 per cent target for 1980 seemed imminent if the same rate continued. The government therefore provided enormous funds to PNB to accelerate the purchase of shares in non-Malay and foreign companies. PNB was supposed to buy the shares of established companies with good track records, including the shares of other state companies which performed well (Jesudason 1989:86).

8 The Amanah Saham Nasional (ASN), or National Unit Trust scheme, was launched in 1981. ASN's mandate was to buy, at cost, PNB's assets and sell shares to the wider Malay community. The maximum an individual could purchase was RM50,000, while the minimum could be as small as RM10. To make the scheme attractive, a minimum 10 per cent return was virtually guaranteed, and banks were instructed to lend money for buying these shares.

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Appendix 13.1 Main developments of the Sapura Group, 1975–96

Year	*Important events*
1975	• Incorporation of Sapura Holdings Sendirian Berhad
1976	• Awarded payphone contract (joint venture with 3M Malaysia)
1977	• Awarded contract to supply telephones to Telecoms Department, over the period 1977–89
1978	• Installed 38,000 payphones all over the country
1980	• Manufacturing, under licence, of Siemens telephones
1983	• Inauguration of Bangunan Sapura, the corporate headquarters, at Jalan Enggang, Ulu Kelang
	• Manufacturing, under licence, of Bell telephone
	• Awarded big cable laying contract worth RM 600+ million (joint venture with Sumitomo and Marubeni)
1985	• Acquired controlling stake in Malayan Cables (which became Uniphone Telecommunications Berhad)
1987	• Launch of first locally manufactured mini-PABX telephone system
1988	• Launch of first made-in-Malaysia telephones, S2000A and S2000B
1989	• Development of software program for direct paging system
	• Awarded phone contract in Bangladesh (10,400 units)
	• Awarded contract to install supervisory control and data acquisition (SCADA) system for LLN
	• Telephone manufacturing joint venture in Jordan; operation starts in 1990
	• Deal with E.M. Electronics of India for a joint effort in research, development and manufacturing of telecommunications equipment
	• Deal with Telephone Organisation of Thailand
	• Awarded tender to supply telephone sets to the Mauritius Government
1990	• Launch of the flexible card phone system
	• Manufacture of card payphones under licence from GEC Plessey Telecommunications (GPT)
	• Agreement with Siemens Plessey Defence Systems of the UK to co-operate in communications for the defence sector
	• Diversification into manufacturing of automobile parts
	• Technical assistance agreement with Kyoto Engineering Incorporated, a consortium of six major suppliers to Mitsubishi of Japan
	• Awarded a contract to supply twelve critical components for the Proton Saga
	• Formation and listing of Sapura Telecommunications Berhad
	• Launch of hand-free voice-activated telephone, S2000HF
1991	• Won rights to operate payphones in Vietnam
	• Awarded RM20 million contract by the Defence Ministry. Signed agreement with Britain's Racal Radio Ltd
1992	• Launch of credit card telephones
	• Joint-venture with Hewlett-Packard to provide computerized communications services for local telecommunications needs
	• Awarded contract by STM, worth RM414 million, for training and engineering services, and to supply digital switches, DX200 (joint venture with Nokia of Finland)
	• Signalling contract with Keretapi Tanah Melayu (KTM) or Malaysian Railway

[*continued on p. 354*]

Appendix 13.1 Main developments of the Sapura Group, 1975–96

Year	*Important events*
	• Cable plant specializing in higher voltage cables of the XLPE (cross-link polyethylene)
	• Five-year contract agreement with GEC Plessey Telecom to assemble and sell payphones
	• Award of contracts for laying fibre optic cables for Petronas and Esso's off-shore stations (RM200 million), Tenaga Nasional (RM148 million) and Sarawak Electrical Corporation (RM40 million)
	• RM28 million sub-contracting work on STM's Kuantan-Kota Kinabalu sub-marine cable projects (joint venture with Sumitomo and Marubeni)
	• Assured licence by Indian government to operate paging services in at least six major cities in India
1993	• Signed MOU with Mauritius Government for assembling Sapura telecommunication products such as cordless telephones, answering machines, accessories and services, as well as the possibility of setting up local area networks and paging services in the region
	• RM60 million turnkey project in Indonesia
	• Awarded contract worth RM150 million by KTM Berhad
1994	• Cable laying contract in Medan, Indonesia worth RM50 million
	• Uniphone cable plant in Bangi started production
	• Secured second installation cable contract in Indonesia, worth RM15 million; project involves installation of 94,200 lines in Northern Sumatra and Acheh provinces
	• Joint venture with Sarawak SEDC, PPES Pinnacle Sdn Bhd, an IT-based company
	• Business ranges from sale of computers, peripherals and accessories to providing consultancy services, application software development, maintenance and support, training services
	• RM53 million project for cable network installation in Brunei
	• Installation of full turnkey project through Jadual Kadar Harga (JKH) scheme set up by STM
1996	• Awarded contract to manage payphones in the Philippines (joint venture with Sumitomo of Japan and the Philippines Long Distance Telephone Co.)
	• Sold 75 per cent of cellular and payphones business for RM1.2 billion to Time Engineering
	• RM10 million contract to supply computer system to Johore Port Berhad

Sources: Mansor (1993), *New Straits Times, Business Times, Star, Asian Wall Street Journal* and *Malaysian Business.*

Appendix 13.2 Subsidiaries of Sapura Holdings and their products

Name of company	*Products*	*Capitalization (1994)*	
		Effective interest (%)	*Issued and paid share of capital (RM million)*
	Telecommunications		
Komtel Sdn Bhd	Markets digital paging services and pagers	45	1,600
Sija Sdn Bhd	Markets digital paging services and pagers	25	50
Komtel Farahat Sdn Bhd	Markets digital paging services and pagers	23	100
Teledata Sdn Bhd	Sales and marketing of telecommunications equipment	45	14,980
Sapura Electronics Ind. Sdn Bhd	Line card manufacturing	23	2,000
Uniphone Sdn Bhd	– Manufacture and supply of modern push-button subscriber phones – Manufacture, installation and maintenance of public payphones network – Installation of fibre optic cables		5,000
Uniphone Cables Sdn Bhd	Cable manufacturing and cable network installation	30	20,000
Uniphone Usahasama Sdn Bhd	Engaged in planning, designing, installation, jointing and testing telephone cables	38	5,000
Sapura Business Systems Sdn Bhd	Sale and marketing of Alcatel products	n.a.	n.a.
Uniphone Fibre Optic Sdn Bhd	– Provides engineering services for transmission and signalling in the telecommunications industry – Transmission – leader in digital micro-wave market in Malaysia – Provides use of fibre optic transmission system – Signalling – provides modern signalling and communication to the railway industry	n.a.	n.a.
Sapura Nokia Telecommunications S/B	Manufacture of digital switching equipment	30	n.a.
Sapura Digital Sdn Bhd	Provides ADAM (Advanced Digital Access for Communication Network (PCN) Technology in Malaysia)	n.a.	n.a.

[*continued on p. 356*]

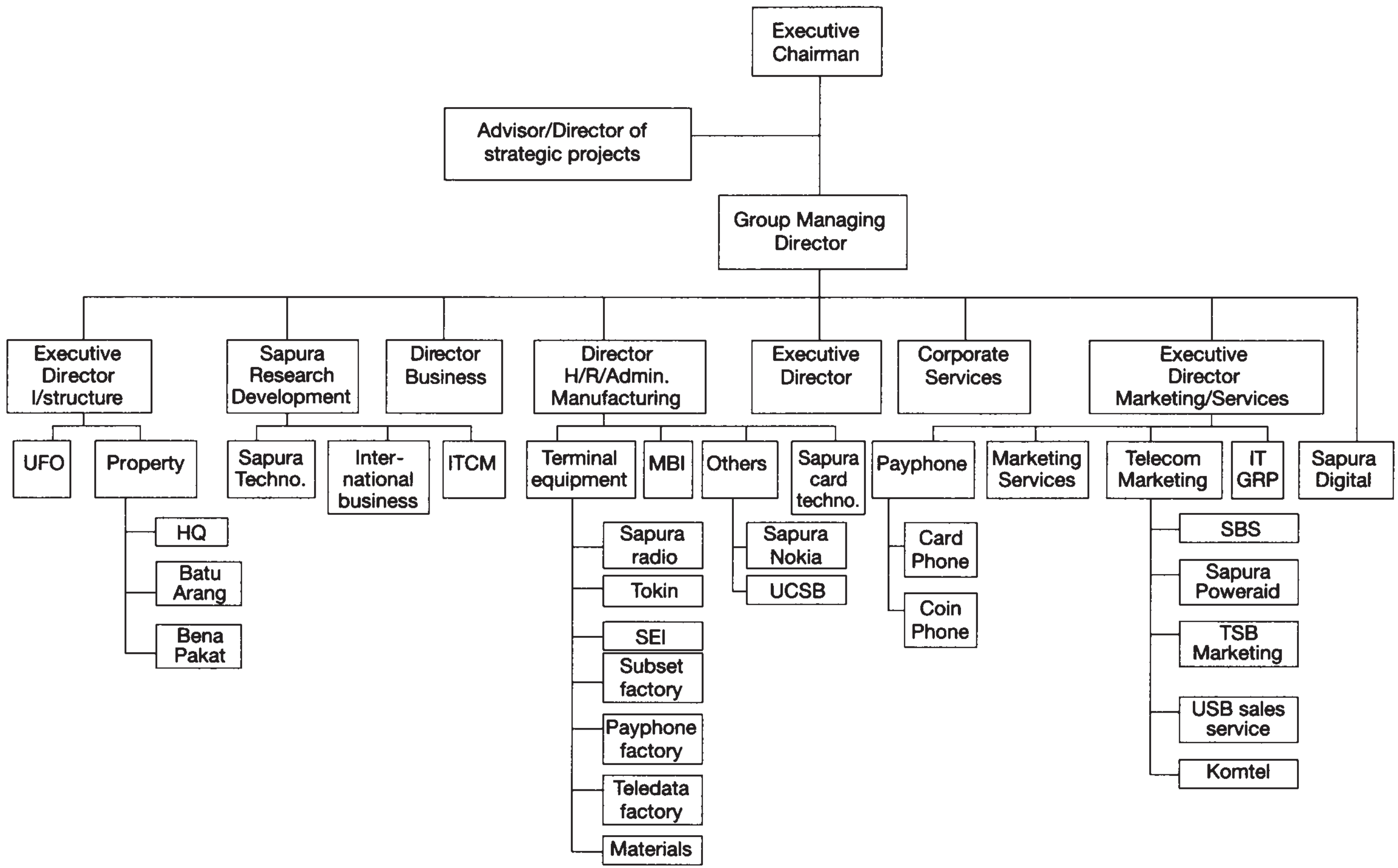
Appendix 13.2 Subsidiaries of Sapura Holdings and their products (continued)

Name of company	*Products*	*Capitalization (1994)*	
		Effective interest (%)	*Issued and paid share of capital (RM million)*
	Information Technology		
Asia Pacific Institute of Information Technology (APIIT)	Specialized training institute providing for information technology industry	n.a.	n.a.
AXIS Computer Sdn Bhd	Marketing personal computers and peripherals, providing technical consultancy services	28	30
Diversitec Distributors Pte Ltd	Authorized distributor of Apple computers and allied products	n.a.	n.a.
Jurudata Sdn Bhd	– Provides total computer solutions, including hardware, software and peripherals – Specialized equipment and application packages for data processing, networking and 50250 CAD/CAM system	51	50
Micro Express Sales (M) Sdn Bhd	Provides services and distribution of third party information-based products for Micro Express	76	250
Sapura Advanced Systems Sdn Bhd	Software development and system integration	62	750
Sapura System (M) Sdn Bhd	Provides consultancy and system integration services in computers and networking	100	–
Terra Control Tecchnologies Snd Bhd	– Provides products and services in geomatics and applications in interactive computer graphics – Specializes in integrated surveys of resources and environmental management utilizing remote sensing, image processing related techniques in the acquisition, processing, interpretation, and presentation of data – Data acquisitions Spot Satellite, Landsat Series SAR and SLAR Radars – Provision of turnkey and tabletop image processing equipment and system	63	1,053
Uniphone Sdn Bhd (Apple Division)	Distributor of Apple computers, software and peripherals	38	5,000

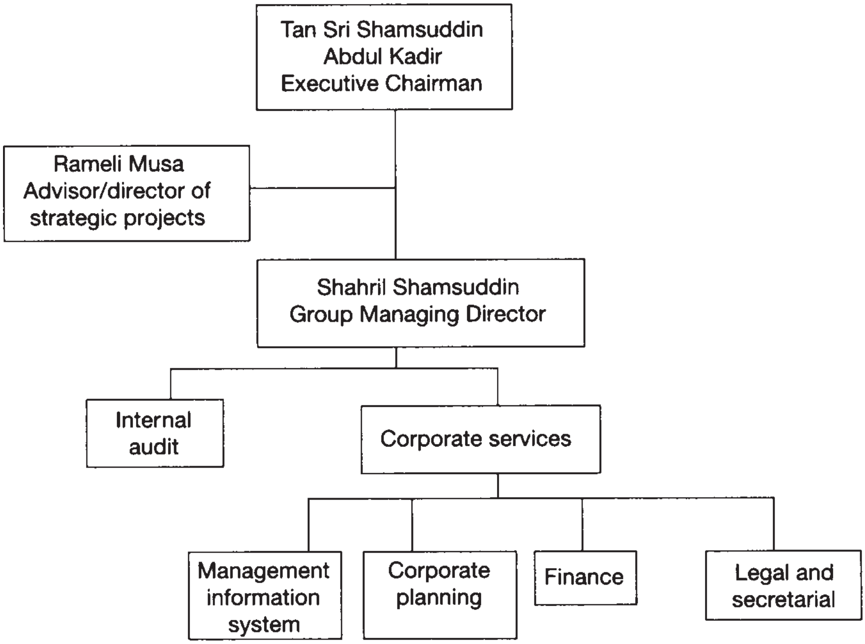
Sapura Network Integration Sdn Bhd	– Provides total Networking and Data Communications solutions with comprehensive range of offerings – Specialist in the area of networking solutions – UB Networks	n.a.	n.a.
Ascom Timeplex, Hewlett-Packard, Farallon and Cosmos Technology	– Offers solutions in the areas of local area network and wide area networking (LAN and WAN), cabling, networking training and consultancy		
	Metals-based Industries		
Metal Formers Sdn Bhd	Manufacture and supply of galvanized steel hardware and general steel, metal stamping and fabrication	100	2,400
Sapura Automotive Industries S/B	Manufacture of automotive coil-springs and stabilizer bars for the auto industry	100	6,130
Sapura Foundry Sdn Bhd	Manufacture of manhole covers, mail boxes and cast iron frames	n.a.	n.a.
Sapura Machining Corporation S/B	Manufacture of automobile components, e.g. water pump pulley, shift rail, rocker shaft, stopper body, clutch release fork shaft, control shaft and reverse shift lug	70	10,000
Sapura Motor Industry Sdn Bhd	Investment holding company for the development of the new business	100	100
	Others		
Sapura Technology	– Marketing, sales, business development and support of defence-related technologies, products and services – Technology transfer of defence capital procurement	n.a.	n.a.
Sapura Poweraid Sdn Bhd	Sales and technical services of radio-related equipment, e.g. mobile radio walkie-talkie, transmitter and security system	100	200
Sapura Radio Sdn Bhd	Joint venture with RACAL UK in manufacturing VHF transceiver, personal radio manpack 4700A	60	240
ITCM Sdn Bhd	Travel agency	90	250
Merapi Sdn Bhd	Property management and building maintenance	45	7,115
ABB Sapura Sdn Bhd	Marketing and servicing heavy electrical engineering for sub-station projects	51	50
Syarikat Benapakat Sdn Bhd	– Sales and service of all types of electronic and mechanical weighing machines – Types of machines include weigh-bridges, platform and scale bench analytical and precision	100	600

Source: Sapura Telecommunications Bhd, *Annual Report*, 1995.

Appendix 13.3 **Sapura Holdings Sdn Bhd: group organizational structure**



Appendix 13.4 **Sapura Group: organizational structure**



14

MALAYSIA'S PALM OIL REFINING INDUSTRY

Policy, growth, technical change and competitiveness*

Jaya Gopal

The emergence and dramatic growth of the palm oil refining industry has been a remarkable achievement in the industrial development of Malaysia. Exports of processed palm oil (PPO) products from the industry grew at a compounded rate of about 25 per cent per annum over the last two decades. Currently, the industry, with an estimated annual refining capacity of about 11–12 million tonnes of feedstock, processes about 8–9 million tonnes of crude palm oil (CPO) and crude palm kernel oil (CPKO) yearly. This is an estimated 60 per cent share of world refined palm oil products and about 10 per cent of the major refined oils and fats.

The most important policy instrument used to promote the growth of this export-oriented industry was duty exemptions for the export of higher value-added processed palm oil products. Besides export duty exemptions, other tax incentives were also given to encourage the growth of the industry as part of a broader strategy of promoting resource-based industrialization. Such provision of incentives was viewed by many in industrialized countries as subsidies to the industry, without which rapid growth in processing capacity and exports, its financial profitability and ability to compete in the world market could not have been sustained.

Todd (1978) found palm oil refining and fractionation in Malaysia socially and economically unprofitable during 1975–7. He argued that "the rapid growth of the Malaysian processing industry and the somewhat disappointing returns on processed palm exports can be explained as effects of Malaysian Government subsidies". Todd implied that the "subsidies", in the form of export duty exemptions on PPO products and investment tax incentives, contributed to the high domestic financial profitability and attractiveness of investment in the industry. However, he argued that this was, on the whole, socially unprofitable given the export prices of palm oil products. He suggested that the rate of capacity expansion be slowed down and that more resources be put instead into marketing processed products. Since then, there has been no other study examining the social and economic profitability and international competitiveness of the Malaysian palm oil refining industry.

In contrast to the 1960s and 1970s, there have been several published case studies of firms/industries in the "more advanced" developing countries that have undergone processes of technological learning and change in the 1980s and 1990s. These processes have led to higher productivities and improved levels of competitiveness in these firms/industries.[1] Citing empirical evidence, Fransman (1986), Nelson (1987), Lall (1992), Katz (1984) and others criticized the static neo-classical framework and argued that a more dynamic approach is necessary for analysing the comparative advantage of industrial projects and industries in developing countries. Others also argued for the need to consider technical change and technological capacity in industrial project evaluation (Weiss 1989: 496–505, 1986: 173–4, Fransman 1982: 1008–9, Bell *et al.* 1984: 102–3) and of the positive role of intervention in achieving technological learning and competence (Lall 1992, 1995, 1996). However, outside the East Asian NICs, there has been limited evidence of the firms/industries achieving international competitiveness (Herbert-Copley 1990: 1463, Weiss 1986: 172, Bell *et al.* 1984: 111–14, 123). Furthermore, with increasing globalization and trade liberalization, achieving international competitiveness has gained considerable significance and attention in both developing and developed countries (UNIDO 1995, Porter 1990).

Considering the importance of the palm oil refining industry in the Malaysian manufacturing sector,[2] these issues raise several pertinent questions. Was the industry subsidized and socially unprofitable, as claimed by Todd? While Todd's analysis was not static, it only covered a period of less than three years, which is too brief to adequately capture any technological and industrial learning processes, and resulting changes in technology and competitiveness that may have occurred in the Malaysian palm oil refining industry. This raises the question of whether the industry has made much progress in terms of competitiveness in the longer term. Have there been significant technological learning and change? If so, have these processes resulted in the industry's capacity to compete in the world market, i.e. has the industry achieved international competitiveness? To answer some of these questions, this chapter examines the competitiveness of the industry over a much longer time period than Todd, and attempts to identify various factors underlying the changes that have taken place.

This chapter begins by examining the rapid expansion of the palm oil refining industry[3] in Malaysia over the last two decades, and the policy environment in which this rapid expansion took place. It then examines, in the light of Todd's analysis, how competitive the refining industry has been during the 1980–94 period, using the concepts of "gross refining margin" and "competitiveness ratio". Finally, it looks at the impact of policy incentives, growth, competition and other factors on the technical and structural changes in the industry and on its competitiveness.

Growth of the industry

The palm oil refining industry emerged as a significant industrial sector in Malaysia in the late 1970s. Prior to 1975, there were only a few factories refining and fractionating palm oil, palm kernel oil and coconut oil, mainly for the manufacture of cooking oil, margarine, vegetable ghee and soap products for the domestic market. In 1974, for instance, these factories were refining and fractionating about 90,000 tonnes of CPO, or less than 10 per cent of total CPO production. By 1976, 15 refineries – with an estimated capacity of 800,000 tonnes – were in operation, processing about 580,000 tonnes of crude palm oil, making Malaysia the country with the largest palm oil refining industry in the world. By 1977, the industry had a refining capacity of about one million tonnes and processed about 890,000 tonnes of crude palm oil. This also involved a new structural feature in the refining of oils and fats and their trade – the large-scale bulk refining of a single crude oil feedstock and large-scale bulk shipment of its refined products for export.

Growth in refining capacity

Total approved capacity[4] of operating refineries increased from 2.879 million tonnes of CPO feedstock in 1980 to a peak of 10.515 million tonnes in 1991, decreasing to 8.879 million tonnes in 1993, but increasing again to 10.013 million tonnes in 1994. This does not include the capacities of refineries that had ceased operation for one reason or another. Idle capacity of non-operating refineries has fluctuated but been persistent since the early 1980s. The total approved (operating and non-operating) capacity of such refineries increased from 2.879 million tonnes of CPO feedstock in 1980 to a peak of 11.753 million tonnes in 1986. Since then, it has fluctuated between 10 to 12 million tonnes of CPO feedstock (Figure 14.1). The expansion of fractionation capacity has also exhibited trends similar to those for refining.

The total number of (operating and non-operating) refineries increased from forty-five in 1980 to peak at fifty-seven in 1986, before declining to forty-six in 1989 (as the licences of obsolete refineries were withdrawn), before increasing to fifty-four in 1992 (as new refineries were established).

The number of operating refineries peaked at fifty-one in 1982, having risen from forty-five in 1980, but declined drastically to thirty-five in 1984. Since then, operating refineries have numbered between thirty-seven and forty-one. While operating capacities were increasing in the 1980s, the decreasing number of operating refineries is indicative of the increasing scale of refining operations in Malaysia and of the economies of scale in bulk refining CPO. In the 1990s, however, smaller refineries were successfully established to process crude palm oil and kernel oil into specialty fat products.

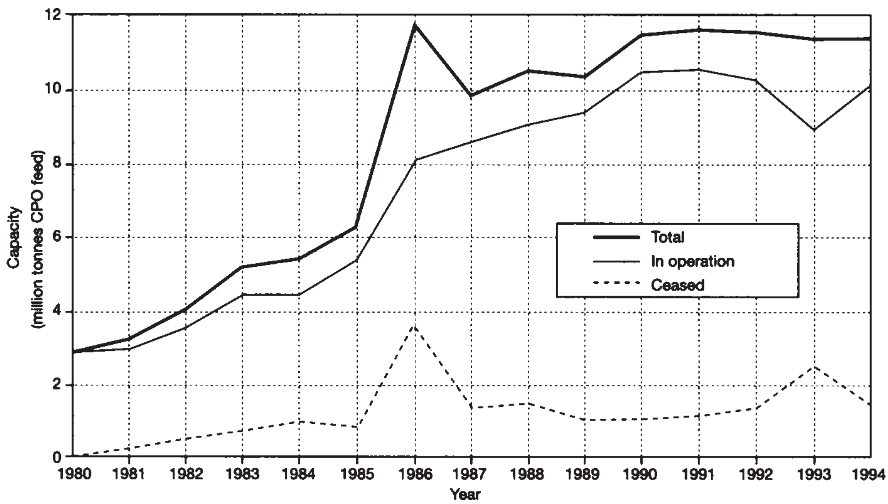


Figure 14.1 Malaysia: approved refining capacity, 1980–94
Source: Malaysian Industrial Development Agency (MIDA), unpublished statistics.

Exports of processed products

Concomitant with the increase in refining and fractionation capacity, exports of processed (refined and/or fractionated) palm oil products (including palm fatty acid distillate) increased from 0.215 million tonnes in 1975 (when they were first exported in significant quantities) to 2.074 million tonnes in 1980 (Figure 14.2). The volume of PPO exports increased further to 5.634 million tonnes in 1990 and to 6.595 million tonnes in 1994.

Processed palm oil (PPO) exports grew at a compounded annual rate of 19.7 per cent over the 20-year period. The share of PPO exports in total palm oil product exports increased rapidly from nil in 1974 to 18.4 per cent in 1975 and 91.3 per cent in 1980, 98.4 per cent in 1990 and 99.2 per cent in 1994. Total palm oil exports grew at compounded annual rates of 15.2 per cent, 18.9 per cent, 9.7 per cent and 3.8 per cent in the 1960s, 1970s, 1980s and 1990s (up to 1994), respectively. Exports of processed palm kernel oil also increased rapidly – from 38,971 tonnes in 1984 to 411,046 tonnes in 1994, increasing the export share from 10.0 per cent to 89.1 per cent of total palm kernel oil exports.

There has been a distinct change in the pattern of trade in palm oil products over the years. Traditionally, when exports from Malaysia were in the form of CPO, the major markets were the developed countries, particularly in Europe. With expansion of PPO product exports from Malaysia in the 1970s and 1980s, exports shifted to developing countries, particularly China, India, Pakistan and West Asia.

In summary, the domestic-oriented refining industry, with a capacity of less

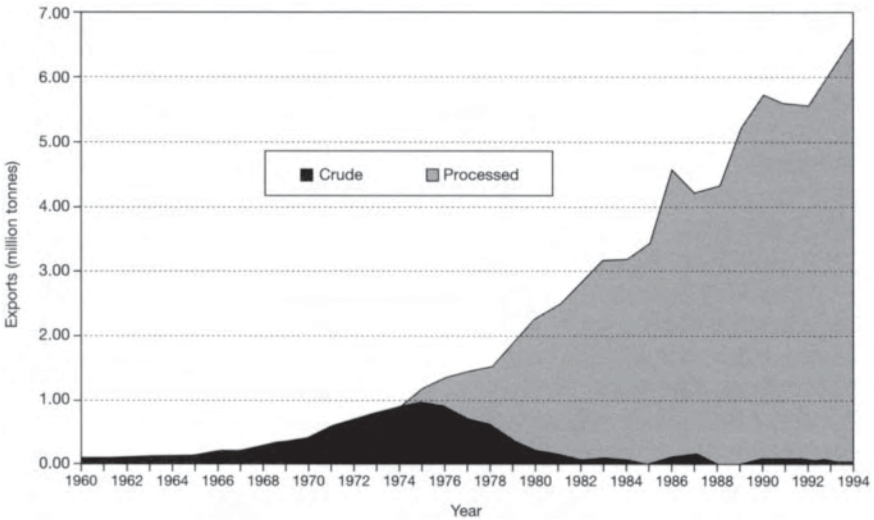


Figure 14.2 Malaysia: exports of palm oil products, 1960–94
Source: Palm Oil Registration and Licensing Authority (PORLA), *Palm Oil Update,* various issues.

than 40,000 tonnes of crude oil feedstock in the early 1970s, grew into a large export-oriented industry with a capacity of about 12 million tonnes within a period of less than two decades. The industry currently processes about 8–9 million tonnes of crude palm oil (CPO) and crude palm kernel oil (CPKO) yearly, or 99 per cent of domestic production. This is an estimated 60 per cent share of world refined palm oil products and about 10 per cent of the major refined oils and fats.

What were the factors that contributed to this rapid expansion in palm oil refining capacity and exports in the 1970s and 1980s? Was this expansion achieved at the expense of economic welfare due to protectionist policies and subsidies, as claimed by Todd (1978)? Or was it a consequence of the inherent international competitiveness of the refining industry? In the next section, we examine the policy environment in which this rapid expansion took place for some of the answers.

Policy environment

In the 1960s, industrial policies and incentives were mainly geared towards import-substitution industries. Thus, during this period, the refining industry was mainly oriented to meeting domestic consumption. This outlook changed after the country adopted a more export-oriented industrialization strategy from the late 1960s with various new policies and incentives introduced to promote such investments.[5] Resource-based industrialization was an important component of this strategy. Incentives were given for the establishment of industrial plants to further process domestically produced raw materials – rubber, palm oil, timber and petroleum – and to increase domestic value added in these export commodities (Jan. 1982).

Prior to 1974, there were few attempts to undertake refining and fractionation of palm oil and palm kernel oil for the export market. The largely foreign- (mainly British) controlled plantation companies preferred to maintain the exports of CPO produced on their oil palm estates. Similarly, multinationals (from Western countries) did not see many gains in (re-)locating their vegetable oil processing facilities in Malaysia. As late as 1978, the refining and fractionation of CPO in Malaysia for export was, on balance, seen as having limited potential (Dunn 1978, Todd 1978, Khera 1978). Many reasons were advanced for the limited viability of local processing of CPO and the export of PPO products to major importing countries, such as in Europe:

- Malaysian refiners would be less efficient in processing CPO and manufacturing fat products because they had very little experience compared to refiners in industrialized countries in sourcing and processing crude oils and fats, and in blending, manufacturing and marketing fat products.
- Transportation, handling and shipping facilities and procedures in Malaysia were designed for the bulk movement of CPO for export. Modifications and additional facilities would be needed to handle and transport processed palm oil products and to prevent quality deterioration as well as to meet standards. These would increase the cost of transporting of (processed) palm oil products from Malaysia to the importing countries.
- Processed products shipped from Malaysia to importing countries would be less acceptable because of quality deterioration due to transport and handling over long distances and periods. On arrival, the processed palm oil products would be of poorer quality and would require re-refining before being further processed into consumer products.
- High import duties on processed palm oil products in industrialized countries, especially in Western Europe, shaped the global oils and fats market, discouraging the import of processed palm oil products. These duties protected the local refining industry in importing countries in order to capture the higher margins derived from producing and marketing higher value-added consumer products for their domestic markets and for export to third countries.
- The supply and availability of processed palm oil products of specific qualities as raw materials for a variety of blends and products would be adversely affected by the long distance and reduced interaction between suppliers and purchasers.
- The marketing of processed palm oil products in a highly substitutable oils and fats market was quite sophisticated. Only industrialized countries importing and processing CPO had the experience to market refined and fractionated palm oil products domestically and to third countries importing oil and fat products from these developed countries.

Whatever the truth of these arguments at that time, they suggest that there were major barriers and obstacles to establishing an export-oriented palm oil refining industry in Malaysia. In such a scenario, policy incentives not only were necessary but had to be sufficient to attract the investment to develop such an industry.[6]

The most important policy instrument used to promote the growth of an export-oriented palm oil refining industry in Malaysia was duty exemptions on exports of higher value-added processed palm oil products. Initially, the export duty structure was simple. From 1968, all PPO product exports were free of duty while a duty was imposed on CPO exports. In 1976, a graduated export duty structure was formulated to encourage more than the first stage of CPO processing. This was followed by a complex export duty formula in 1978 which was primarily designed for the same purpose.[7] In essence, high export duties were imposed on CPO and PPO based on their respective average export prices.[8] However, processed palm oil products, which fell into five categories depending on the degree of processing undergone, were allowed varying levels of export duty exemption. The amount of duty exemption increased (and hence, the export duty payable decreased) as the degree of processing and the value of the processed product increased. The export duty payable decreased to nil for the final fully refined and fractionated product category (MIDA 1985). The intended effect of the export duty structure was to reduce the domestic prices of the crude and the less processed palm oil categories further away from their world prices while maintaining the prices of the more processed palm oil products nearer or at world prices, encouraging a greater degree of CPO processing by increasing domestic processing margins (above "world" margins) down the processing chain. The net effect of this would be processing subsidies from the CPO producers to domestic refiners.[9]

Other incentives used to promote the industry have been tax relief and allowances for investment and export. The more important of these have included pioneer status, investment tax credits, export allowances, overseas promotion, training, research and development incentives involving various kinds of tax exemptions. There have also been pre- and post-shipment export credit refinancing assistance programmes (MIDA 1985).

By the mid-1980s, most of the investment tax incentives for basic refining and fractionation operations were withdrawn or had lapsed. The major incentives that remained were the export duty exemptions on refined and fractionated palm oil and palm kernel oil products. Investment tax incentives were increasingly only provided for activities further downstream, such as the manufacture of consumer and specialty fat products and oleo-chemicals (MIDA 1985). Export credit refinancing assistance programmes were expanded in the 1990s, while tax deductions for overseas promotion, training and R&D activities have been continued.

Besides these direct incentives for investment in and export of PPO products, legislation was also introduced for the creation of institutions to assist the industry in R&D, training and market promotion. In the late 1970s, the Palm Oil Research

Institute (PORIM) and the Palm Oil Registration and Licensing Authority (PORLA) were established. PORIM has been responsible for research on all palm oil-related activities, including the chemistry and technology of processing. PORIM has also been involved with PORLA and the Ministry of Primary Industries in technical and market promotion of processed palm oil products. In the mid-1980s, to counter the US soybean lobby against palm oil, the Malaysian Palm Oil Promotion Council (MPOPC) was also established to assist the industry in consumer-oriented promotional campaigns world-wide. All these organizations were largely supported by cesses imposed on oil production and, as such, were not dependent on government subsidies.[10]

Besides incentives, there have also been important regulatory elements in the policy environment. The most important have involved the monitoring and control of investments and capacities in the industry via conditions attached to the issue of manufacturing licences under the 1975 Industrial Co-ordination Act (ICA). The most important of these conditions have been the (approved) maximum capacity and export limits, while less important conditions have involved local content/material utilization, employment, location and equity structure. Implicit in this regulatory framework is the monitoring and control of total installed refining and fractionation capacities to ensure that refiners have adequate CPO supply. In 1986, however, approved maximum annual capacity conditions on refining and fractionation licences were relaxed, which led to a surge in capacity expansion among existing plants. Conditions for the issue of new licences for refining and fractionation plants were also relaxed. This relaxation in policy on the issue of new licences did not last as refiners clamoured for greater controls as capacities greatly exceeded supply of CPO and capacity utilization rates declined in the late 1980s.

In the late 1980s, public policy making was strengthened and policies were better co-ordinated, as shown in Figure 14.3.[11] In practice, the major incentives have been for capital flows (investments) and export growth, while incentives and institutional assistance for R&D, manpower training and joint ventures have been less significant and focused.

It is clear from the above that the Malaysian government has provided a policy environment and substantial incentives conducive to the growth of the palm oil refining industry. These imply that there has been a welfare loss as a consequence for CPO producers and that the refining industry would not have been able to compete in the world markets without such intervention. In the next section, we examine the international competitiveness of the palm oil refining industry in the 1980s and 1990s by introducing the concepts of "gross refining margin" and "competitiveness ratios".

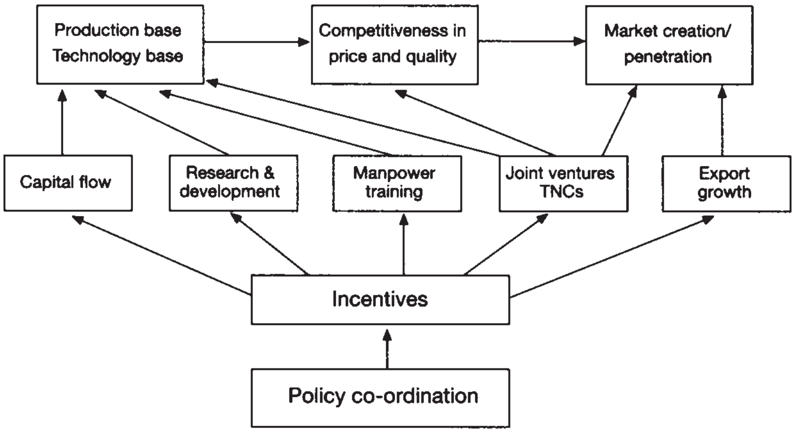


Figure 14.3 Relationship of promotion strategy
Source: Yakin (1991).

Competitiveness analysis: concepts and method

Several methodologies have been used for analysing competitiveness. The suitability of any particular method partly depends on whether the analysis is at the level of the country, industry or firm.[12] The appropriateness of a methodology also depends on the purpose for which the analysis is intended and data availability. Our purpose here is to show trends and changes in the competitiveness of the Malaysian palm oil refining industry over a period of more than a decade.[13] The simpler, common methods used for analysing the competitiveness of an industry have involved comparing its market share, profitability, productivity or costs with those of its competitors.[14] The major problem in using these methods is the lack of reliable data for comparing several countries over several years.[15]

CMS, RCA and DRC analysis

Two simple and commonly used cross-sectional analytical methods are the economic concepts of constant market share (CMS) and revealed comparative advantage (RCA).[16] CMS is geared to a dynamic analysis of competitiveness using time-series data, while RCA has been commonly used (but not necessarily restricted) to indicate static comparative advantage. However, the application of CMS or RCA to analyse the competitiveness of the refining industry has a major limitation. Palm oil refining and fractionation are essentially processing activities, constituting a small fraction of the total value of the refined and/or fractionated product. CMS and RCA analyses normally use market shares of products produced or exported – rather than the market shares of economic activities – as the basis for analysing competitiveness. In this sense, CMS or RCA analysis of a product is a measure of the competitiveness of all the economic activities involved in adding value and producing a product in a country under free market conditions.[17] Hence, CMS or RCA analysis of refined palm oil would be more indicative of the competitiveness of fresh fruit bunch (FFB) or CPO production, which constitutes the major part of the total value added of the refined product.

A nation's competitiveness in refining and fractionating palm oil can be more satisfactorily analysed by domestic resource cost (DRC) analysis.[18] However, one major problem is the relatively higher data demands of the DRC method. A good proxy for the DRC method, which is easier to measure, based on concepts of the effective exchange rate and effective rate of protection, would be to compare domestic value added to world (border) value added in refining and fractionating palm oil.[19] The analysis can be further simplified by substituting the estimation of value added with an estimation of the gross margin for refining and fractionation.

Value addition and the competitiveness ratio

The level of competitiveness in refining palm oil in a country can be expressed by the ratio of (actual) domestic value added in refining (within country) to world (border) value added under conditions of free trade:

$$\text{Competitiveness Ratio} = \frac{\text{refining value added at domestic prices}}{\text{refining value added at world (border) prices}}.$$

Value added in this case can be defined as receipts from the sale of refined products less the cost of the material and service inputs used in refining, including the crude raw material, CPO:

$$VA_j = \Sigma\ (P_j.Y_j) - \Sigma\ (a_i.\ P_i)$$

where

VA_j = Value added in activity j, producing j products using i material inputs
P_j = Price of product j
Y_j = Yield of product j
a_i = Input coefficient i
P_i = Price of input i.

Border prices of a commodity are the prices at a country's border under free trade conditions and reflect world or shadow prices for the commodity. Domestic prices of a commodity are actual market prices in the domestic market irrespective of market intervention.

A competitiveness ratio of one implies that the country can profitably undertake the refining activity at the same cost-margin as the "world", i.e. the country's refining industry is as competitive as any in the world. A competitiveness ratio of less than one implies that the country is more competitive and can profitably undertake the refining activity at a lower cost-margin than the "world", while a ratio of more than one implies the converse.

Gross margin and value added

Gross refining margin can be defined as the gross margin (gross profit) from refining one tonne of CPO into refined, bleached and deodorized palm oil (RBDPO) and palm fatty acid distillate (PFAD). This is termed the "gross margin" because it is not net of costs for refining, packaging, marketing and distribution.

Gross Refining Margin (GRM):

$$GRM = Y_{rbdpo}.\ P_{rbdpo} + Y_{pfad}.\ P_{pfad} - P_{cpo}$$

or

Gross Refining and Fractionation Margin (GRFM):

$$GRFM = Y_{rbdpol}.\ P_{rbdpol} + Y_{rbdpst}.\ P_{rbdpst} + Y_{pfad}.\ P_{pfad} - P_{cpo}$$

where

Y_{rbdpo}	=	Yield of refined bleached deodorized (RBD) Palm Oil
Y_{pfad}	=	Yield of palm fatty acid distillate (PFAD)
Y_{rbdpol}	=	Yield of refined bleached deodorized (RBD) Palm Olein
Y_{rbdpst}	=	Yield of refined bleached deodorized (RBD) Palm Stearin
P_{rbdpo}	=	Price of refined bleached deodorized (RBD) Palm Oil
P_{pfad}	=	Price of palm fatty acid distillate (PFAD)
P_{rbdpol}	=	Price of refined bleached deodorized (RBD) Palm Olein
P_{rbdpst}	=	Price of refined bleached deodorized (RBD) Palm Stearin
P_{cpo}	=	Price of crude palm oil (CPO).

The value added in the refining activity can be approximated to the gross refining margin since the major material input for refining and fractionation is CPO, which constitutes, in most instances, more than 90 per cent of total material and services input costs. The impact of the remaining major intermediate input costs – bleaching earth, fuel oil, electricity, maintenance and f.o.b. (free on board) transport costs – on value added would be considerably less, and can be qualitatively evaluated based on their cost trends.[20] Hence, the competitiveness ratio can be simplified to:

$$\text{Competitiveness Ratio} = \frac{\text{gross refining margin in country (domestic prices)}}{\text{gross refining margin outside country (border prices)}}.$$

The use of gross margins to compute the competitiveness ratio of palm oil refining is far easier than using value added, as data for domestic (actual) market prices and world border prices of PPO products and CPO are relatively more easily available or are easier to estimate using scheduled tariff rates.[21] This simplification also allows the analysis of trends and changes in competitiveness over time. Such trends would provide more reliable comparative results than point data and would yield useful background information for analysing developments in the industry.

Competitiveness analysis of the refining industry

To analyse the competitiveness of the Malaysian palm oil refining industry, the following gross margin estimations were made:

- monthly domestic gross refining and fractionation margin
- monthly border gross refining and fractionation margin.

As there was some doubt as to the extent to which prices at the Malaysian border reflect world prices under free trade, we also substituted them with price estimates at the European border from a different source of data.[22] We thus estimated gross margins for refining and fractionating palm oil at the European border in order to compute the competitiveness ratio of Malaysian refiners in relation to border prices in Europe. Since this too may not be satisfactory, we also compared the gross margins for refining and fractionating palm oil within two major borders, i.e. Malaysia and the European Union. This was done by estimating the gross margins the Malaysian refiners would have made if their refining and fractionation operations had been translocated to Europe. Owing to the limited data available, the period for the analysis was restricted to 1980–94. Data for the competitiveness ratio analysis using European border and domestic prices were limited to 1985–94.

Data sources and estimation

To analyse the competitiveness of the industry at the country level, gross refining and fractionation margin computations, aggregate price and product yield data were used. For comparison, a uniform boundary for determining the prices of products and raw materials was specified. Based on the availability of data, simplicity and comparability, we have defined prices to be on a "delivered" or "ex-" basis at refinery or port, depending on whether they represented domestic or border prices of CPO and PPO products.

Aggregate product yield data vary from country to country, and over time, depending on the technology employed in the refining industry and the quality of feedstock used at any particular time. Aggregate yields of PPO products can be estimated if data on CPO, processed and PPO products produced are collated and published on a regular basis. As such data were not available, case studies were used to estimate the yields of refined and fractionated products from CPO.

Prices

There are two major sources of price distortions in the international market for CPO and PPO products. The first is the export duty structure in major exporting countries, such as Malaysia, which have a decreasing export duty on PPO products as more value is added to CPO. The second is the import duty structure in major importing countries, such as the European Union (EU), which have a higher import duty on PPO products than on crude oil, i.e. through import tariffs which escalate with processing. These tariffs distort the prices of crude and processed products in exporting and importing countries, as well as world (border) prices.

The removal of tariffs would result in new equilibrium relationships, particularly in the price spread between CPO and PPO products.[23] However, because of difficulties in estimating them, we assume that border prices for palm oil products, as expressed by tariff-ridden equilibrium relationships, generally reflect world prices (or at least their trends) under free trade conditions. This, however, remains the major weakness of the analysis. Additional comparison using European domestic prices compensates for this weakness, to some extent, as world shadow prices are likely to lie somewhere between European border and domestic prices.

The data for actual transacted domestic (delivered) prices and border (f.o.b.) prices for palm oil products in Malaysia were from the Palm Oil Registration and Licensing Authority (PORLA) and the Palm Oil Refiners' Association of Malaysia (PORAM). Where such data were not available, prices were estimated from c.i.f. prices in North-West Europe[24] and appropriate freight, insurance and other handling costs and/or scheduled tariff rates. Border prices for palm oil products in Europe were the representative lowest asking (c.i.f.) prices in North-West Europe collated by Oil World. Where such data were not available, prices were estimated from Malaysian (f.o.b.) prices and appropriate freight, insurance and other handling costs. Domestic prices for palm oil products in the EU were estimated from c.i.f. (border) prices plus the scheduled import duties.

Product yields

Product yields from refining and fractionation are functions of the technology employed for the purpose. The quality of the CPO feedstock is also an important variable determining the yield of refined and fractionated palm oil products. The refined and fractionated product yields of Malaysian refineries have improved over the period analysed. The major sources of improvements in refining yields have been optimization in pre-bleaching, de-acidification and de-odorization unit operations, and improved bleaching earth quality in the 1980s. With the introduction of high pressure membrane filtration – replacing vacuum filtration –

in dry fractionation, the product yield of the higher value olein fraction improved significantly.

The yield data for refined palm oil products were based on physical refining, the most common refining process since the late 1970s. The yield data for fractionated palm oil products were based on dry membrane fractionation, also the most common process since the mid-1980s. Product yields were estimated from regression analysis of actual production and quality data from several refineries in 1985 (Gopal 1988). From the data, the following product yields[25] (based on CPO feedstock) were used in gross refining and fractionation margin computations:

RBD palm oil:	94.7%
RBD palm olein:	71.0%
RBD palm stearin:	23.7%
Palm fatty acid distillate:	4.3%

Improvements in product yields, resulting from the technical changes in refining and fractionation over the years, were not considered in the computation of gross margins. Product yield improvements have a significant effect on absolute gross margins. However, the impact of product yield improvements can be qualitatively assessed and would not have affected trends in gross margins.[26] More importantly, it would have had a similar effect across all gross margin estimations and, hence, its impact on (comparative) competitiveness analysis is minimized.

The product yields used in the estimation of refining and fractionation margins at all the four "locations" were the same as those estimated for Malaysian refiners. This was because the competitiveness analysis compares the gross margins Malaysian refiners would have obtained from their refining and fractionation plants (technology) and from CPO feedstock if they had been translocated to the "border" on another country, but at the prices of the PPO products and CPO feedstock at these locations.[27] However, the quality of the CPO feedstock and PPO products to and from these "translocated" plants and product markets can be different, depending on the origin of the CPO feedstock and the markets for the PPO products. This would affect product yields and prices to some extent and, hence, gross margins.

Gross margins and competitiveness ratios

Figures 14.4 and 14.5 show the gross margins for the refining and fractionation of palm oil in Malaysia and at the Malaysian border during 1980–94, on a monthly-average and a six-month moving-average basis, respectively. The figures show that both margins fluctuated widely as the price spreads between PPO products and CPO varied. However, a general downtrend in domestic margins and an uptrend in border margins can be discerned.

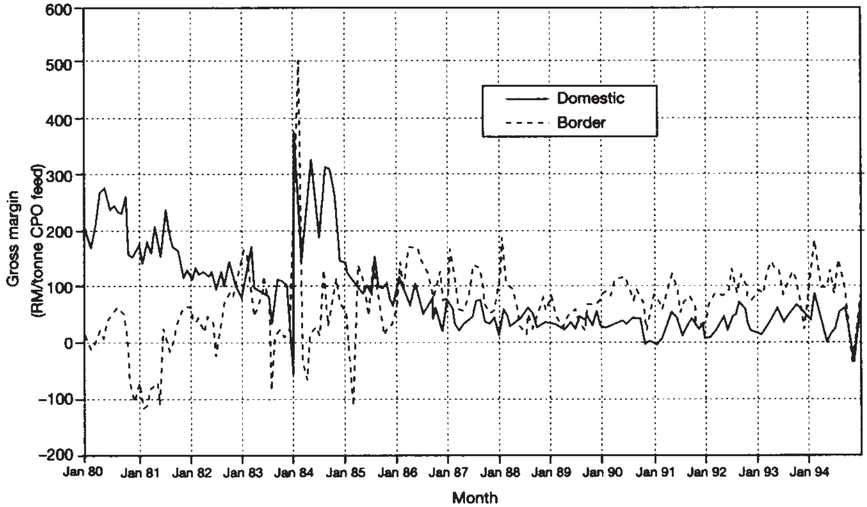


Figure 14.4 Malaysia: gross refining and fractionation margin, 1980–94 (monthly average)
Source: Gopal (1995).

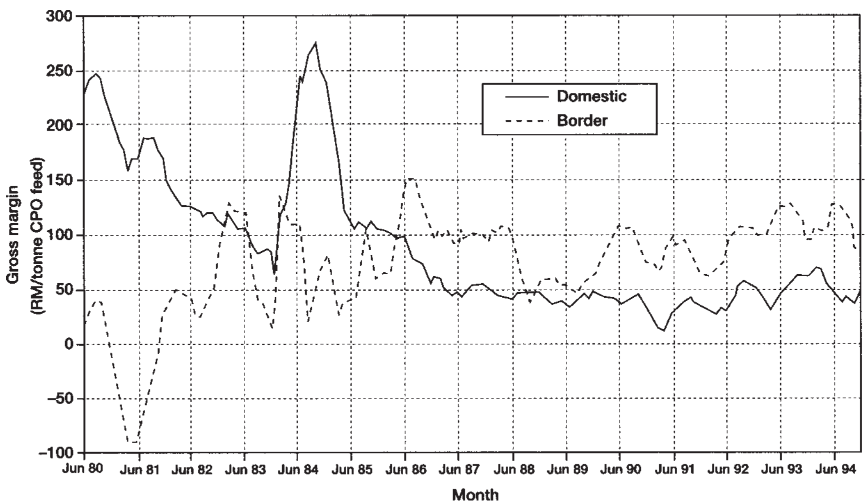


Figure 14.5 Malaysia: gross refining and fractionation margin, 1980–94 (six-month moving average)
Source: Gopal (1995).

The twelve-month-moving-averages, shown in Figure 14.6, eliminated the wide fluctuations, and clearly shows the downtrend in domestic margins and the uptrend in border margins. On closer scrutiny, a slight uptrend in domestic margins between 1991 and 1993 can be discerned.[28] It is also interesting to note that border

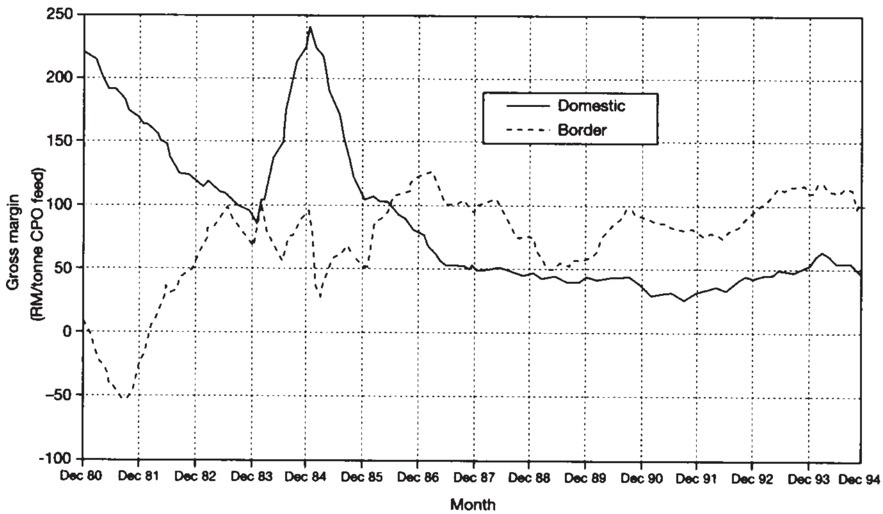


Figure 14.6 Malaysia: gross refining and fractionation margin, 1980–94 (twelve-month moving average)
Source: Gopal (1995).

margins have been less stable than domestic margins. This can be attributed to the import and export duty regimes in trading palm oil products, leading to the relatively high demand for, but uncertain supply of, CPO in the world market.

If we take into account product yield improvements over the years, the decline in domestic margins would have been more moderate, but the marginal increase in border margins would have been exacerbated. The net impact of this on competitiveness ratio trends would have been minimal.

Value added (i.e. the gross margins net of intermediate input costs) in refining and fractionation activities for both the domestic market and at the border would reflect trends similar to their respective gross margins, though more moderately. This is because material input costs for refining and fractionation declined during the 1980s (with much lower material input requirements per unit of processed CPO in the late 1980s) as a consequence of optimization and technical changes in palm oil processing. Using value added, instead of gross margins, would not have significantly altered the results of the competitiveness analysis.[29]

Table 14.1 shows the annual average gross margins for refining and fractionating palm oil at four locations using Malaysian technology and CPO feedstock. Some of the extreme values can be explained by prevailing market conditions. The high margin in 1984 was the result of unusually high and fluctuating prices in the year for CPO and PPO products. The negative and very low margins at the Malaysian and European borders in 1980–2, 1985 and 1988–9 can be attributed to the severe distortions of CPO and PPO product prices resulting from the

Table 14.1 Competitiveness of Malaysian palm oil refiners, 1980–94

Gross refining and fractionation margins					*Competitiveness ratios*			
Year	*Malaysia domestic prices US$/tonne*	*Malaysia border prices US$/tonne*	*Europe border prices US$/tonne*	*Europe domestic prices US$/tonne*	*Malaysian domestic/ Malaysian border*	*Malaysian domestic/ European border*	*Malaysian domestic/ European domestic*	*European domestic/ European border*
1980	101	5	n.a.	n.a.	21.19	n.a.	n.a.	n.a.
1981	73	−13	n.a.	n.a.	−5.49	n.a.	n.a.	n.a.
1982	51	22	n.a.	n.a.	2.34	n.a.	n.a.	n.a.
1983	41	29	n.a.	n.a.	1.39	n.a.	n.a.	n.a.
1984	95	38	n.a.	n.a.	2.52	n.a.	n.a.	n.a.
1985	44	22	4	43	1.97	11.13	1.01	11.02
1986	30	46	42	67	0.64	0.71	0.45	1.59
1987	20	37	29	59	0.54	0.69	0.34	2.01
1988	16	28	17	53	0.58	0.95	0.31	3.07
1989	15	21	10	38	0.71	1.48	0.39	3.76
1990	13	33	24	49	0.39	0.53	0.26	2.04
1991	11	28	20	49	0.39	0.55	0.23	2.41
1992	16	36	21	54	0.44	0.74	0.29	2.53
1993	20	42	31	63	0.47	0.65	0.31	2.07
1994	17	37	24	68	0.48	0.72	0.26	2.80

Source: Gopal (1995).

import and export duty regimes in palm oil product trading and the effects of the rapid expansion of Malaysian refining and fractionation capacities prior to these years. This led to the relatively high demand for but uncertain supply of CPO in the world market and the narrowing of the border price spread between PPO products and CPO. These extreme gross margin values distort the competitiveness ratio estimates. Nevertheless, the general trends in gross refining and fractionation margins as well as competitiveness ratios can be clearly discerned from the estimates.

Gross refining and fractionation margins in Malaysia declined tremendously during 1980–94. Although there were some fluctuations, the annual average domestic margins declined from about US$100/tonne CPO feedstock in 1980 to US$11 in 1991, but then increased slightly to about US$20 in 1993–4. In contrast, "world" margins for refining and fractionation were on an upward trend from about US$20/tonne for CPO feedstock at the Malaysian border in the early 1980s to about US$30 in the early 1990s. The competitiveness ratios for refining and fractionation of palm oil in Malaysia improved from more than 200 per cent of "world" gross margins in the early 1980s to less than 60 per cent in the 1990s (based on Malaysian border prices).

In comparing palm oil refining and fractionation in Malaysia with world border prices in Europe, there was no clear trend in the competitiveness ratios for the period for which data are available (1985–94). However, the analysis clearly supports the earlier finding that the Malaysian palm oil refining industry was highly competitive, with a lower gross refining and fractionation margin than the "world". From a comparison with the EU, which was protected by escalating import duties between crude and processed palm oil products, the ratios also suggest (although again no clear trend is discernible) that palm oil refining and fractionation activities in Malaysia were highly competitive, with a gross margin of less than 30 per cent of the gross margin using European domestic prices in the 1990s. This is a vivid indication of the efficiency, technological progress and high level of international competitiveness achieved by the Malaysian palm oil refining industry.

Despite the similarity, this analysis represents a more accurate reflection of gross margins, both in terms of methodology and data, compared to Todd's (1978) study.[30] However, Todd's analysis of border margins for refining and fractionation during 1975–7 appears to be comparable with our results for the early 1980s. Todd found that border margins of refined or fractionated palm oil were negative or very low, and in most instances, below the social cost of refining and fractionation.[31] This was very much in line with our figures for 1980–1. However, as domestic margins began to fall subsequently in the 1980s, border margins began to rise, in contrast to the trends for the period he analysed. These trends eventually resulted in border margins rising above the domestic margins in 1986. While we are in agreement with Todd's analysis that the industry was socially unprofitable and uncompetitive in the early years of its establishment, it did not remain so. Through processes of industrial growth, competition, entrepreneurship, technological learning as well as ensuing technical and structural changes over the years, the industry achieved a high level of international competitiveness in the late 1980s, which is the subject of examination in the next section.

Competitiveness: the key factors

This section attempts to examine the factors that contributed to the high level of competitiveness achieved by palm oil refining and fractionation activities in Malaysia.

Policy incentives and growth

As shown in the section on the policy environment, the Malaysian government has employed an array of policy instruments to promote an export-oriented palm oil refining industry. The primary objective of the policy incentives was to attract investments for processing CPO and exporting PPO products, by creating an environment in which the (private) financial profitability of such investments would be high. This was clearly achieved very successfully, as described in the section on growth of the industry. Malaysian refining capacity grew rapidly at a compounded rate of about 25 per cent per annum over the two decades from 1974, currently processing more than 8 million tonnes or 99 per cent of the CPO and CPKO produced.

The policy incentive mainly responsible for this rapid expansion was the duty exemptions on PPO exports. The high export duty on CPO ensured that the domestic prices of CPO were well below world prices. With lower or no export duties as a result of export duty exemptions, PPO products could be exported at or near world prices. With such relative prices for PPO products and CPO, refiners received higher domestic margins, and were guaranteed bigger profits for processing CPO and exporting PPO products. At this time, the main requirement for realizing huge profits from processing CPO was finding lucrative markets for PPO products. Tax relief and allowances for profits and exports further increased the private profitability of these processing activities.

The creation of a highly profitable environment by providing generous incentives has been crucial to the formation and growth of the palm oil refining industry in Malaysia. In the absence of these incentives, an export-oriented industry would not have been established because there were several major obstacles to its emergence. As argued by Todd (1978), Malaysia lacked (static) comparative advantage in palm oil refining and fractionation activities. Similarly, the industry lacked comparative advantage in marketing and distributing PPO products overseas (due to the lack of infrastructure, facilities and capabilities, resulting in high costs to undertake them). Further, there were trade (escalating tariff and non-tariff barriers), commercial (restrictive marketing and business practices) and technical (product, transportation and quality problems) barriers to imports of PPO products.[32] In the face of these obstacles, generous policy incentives have been necessary to ensure high financial profitability and reduced risks for investment. Even then, significant investment flows into CPO processing for export followed five years after the export incentives were introduced in 1968. Needless to say, the response of foreign direct investment has been far more muted throughout.[33]

As the pioneer investors began realizing huge profits at relatively low risk in CPO refining and fractionation activities by the mid-1970s, investments in the industry snowballed. Refining capacity and processed palm oil exports in the early period (1974–9) grew rapidly at more than 60 per cent per annum when the generous incentives maintained a highly profitable environment and CPO production (supply) increased and continued to be in excess of refining capacity. In this respect, the increase in CPO supply was an important factor in maintaining this rapid growth, as CPO production doubled during this period. Ironically, however, the generous incentives provided for investment were also the seeds for the erosion of high financial profitability. However, erosion of the high domestic margins and profitability was, in turn, a blessing in disguise, as it spawned a competitive environment that pushed the industry towards greater efficiency and productivity.

Growth, competition and gross margins

From our analysis in the earlier section, development of the competitiveness of the refining industry was a consequence of the ability to reduce gross domestic margins. As summarized in Figure 14.7, two key processes can be said to have contributed to this reduction in gross domestic margins in two more or less overlapping phases. The first phase (1977–83) can be characterized as the period when excess profits in refining and fractionation activities were eliminated. As investments rolled in, lured by the huge profits of the early and mid-1970s, increases in refining capacity greatly exceeded increases in CPO supply. This led to increasingly higher domestic demand for CPO and relatively higher CPO prices, nearer to world prices, thus reducing gross domestic margins, eliminating excess profits, and narrowing the large differences with border margins (see also Figures 14.4–6).[34]

Domestic demand for CPO was further exacerbated as total domestic refining capacity outstripped total domestic CPO supply at the turn of the decade. And as capacity continued to expand in this second phase (1980–8), it created intense competition for CPO supplies, pushing CPO prices closer to and then above world border prices by the mid-1980s. This resulted in the reduction of gross domestic margins below that of "world" margins. The most important feature of this phase – in comparison with the earlier phase – was that the reduction in gross domestic margins was largely made feasible by the technical, organizational and structural changes in the industry (see also Figures 14.4–6).

Evidence of both these processes and phases can be gleaned from Figure 14.8, which shows gross domestic margins in comparison with the export duty on

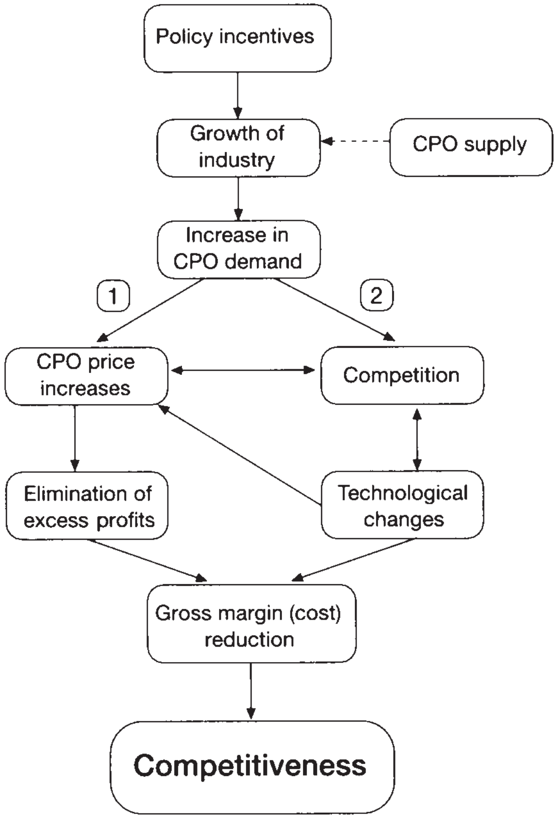


Figure 14.7 The Malaysian palm oil refining industry: the development of competitiveness

CPO and the total approved capacity of installed refining plants. The figure indicates that the export duty on CPO contributed to lower domestic prices for CPO than the world border price, and to higher domestic margins until around 1983 (also see Figures 14.4–6).[35] Based on theoretical calculations, the domestic margin should have been higher (in most instances) than the export duty payable on CPO (as the refined-fractionated products are duty free) by an amount equivalent to the border margin.[36] In practice, however, as shown in Figure 14.8, it was lower than the export duty on CPO. Hence, the effectiveness of the CPO export duty (in reducing domestic CPO prices by an equal amount below border prices) was already declining in the early 1980s (from which time data have been available) and, with that, domestic margins were also generally in decline compared to the early years of rapid growth of the refining industry in the mid-1970s.

Figure 14.8 also indicates that since 1986, the export duty has had no impact at all on gross domestic margins. Technological, organizational and structural changes thus became critical for the survival of firms and a significant number of

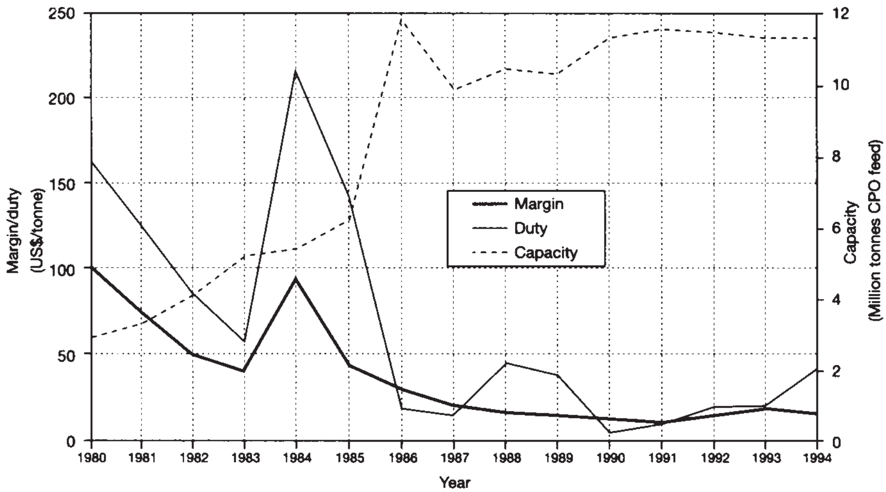


Figure 14.8 Domestic margin, export duty and refining capacity

inefficient firms had to cease operations (also see Figure 14.1). As capacity increased dramatically in 1986, the industry experienced lower capacity utilization and intense competition for CPO supplies. The CPO export duty became totally ineffective in lowering domestic prices for CPO (below the world border price), and in thus maintaining relatively higher domestic margins than at the border. Instead, the high domestic demand for CPO pushed domestic prices above world border prices, reducing domestic margins below border margins. These reductions in domestic margins, which were crucial for the industry achieving a high level of international competitiveness, were made feasible by the greater efficiency and productivity generated by investment and capacity expansion in the mid-1980s. By then, the industry had sufficiently accumulated the necessary entrepreneurial, marketing and technical skills to bring about major technical changes, improve efficiency and sustain profitability.[37] The next section examines, in more detail, this second process in the reduction of domestic gross margins in Malaysia.

Technical and structural changes

The second phase of reduction of domestic gross margins was the result of the technical and organizational changes in the refining, fractionation and export of palm oil products and the consequent changes in the industry's structure. The technical changes included: (i) the modification and optimization of refining and fractionation unit operations: the switch from chemical to physical refining, higher plant throughput (capacity stretching) and reduction in steam consumption by deacidifier–deodorizer modification, heat recovery and segregation of crude oil feed by quality, reduction in bleaching earth and phosphoric acid dosage with better knowledge of oil and earth quality and their interactions, higher fractionation yields at lower cost with the switch from solvent fractionation and dry vacuum filtration to high pressure membrane filtration; (ii) better control over the variability in product quality with better knowledge of the impacts of CPO quality, processing and transportation conditions on final delivered quality; (iii) economies of scale with bulk refining, fractionation and export; (iv) greater quality control and efficiencies in the bulk transport and handling of products for shipment; and (v) localization of equipment design and manufacture.

These changes have been driven by the rapid growth in capacity, the large size of the industry and competition (Figure 14.9). The huge expansion in capacity in the late 1970s and early 1980s resulted in intense competition for CPO, as capacity exceeded domestic CPO supply. Refining margins and profits were squeezed as a consequence of higher bids for CPO. With the erosion in (excess) profits in the 1980s, refiners had to improve efficiency to earn reasonable profits. With the successive installation and operation of an increasing number of refining and fractionation plants, the industry accumulated considerable experience, skills and knowledge in refining and fractionation technology and the processing of CPO.

At the same time, the large size of the industry, with more than US$500 million of investment, created the necessary economies and incentives for strong backward linkages to domestic engineering and technology-related activities (see the later section on technology imports and local capacity). Similarly, equipment vendors (mainly of foreign origin) also had an incentive to optimize refining and fractionation technology, considering the huge market potential since palm oil was the fastest growing edible oil in the world market. Local refiners collaborated with vendors to improve and optimize CPO refining and fractionation technology, also involving greater localization of equipment design, fabrication and installation.

Refining and fractionation technology was modified and optimized for continuous processing of a single oil feedstock, namely CPO. The major source for these technological improvements was the differences in the refining properties of CPO from those soft oils for which the technology was originally designed.[38] The changes were made possible by the accumulation of knowledge and skills on: (i) the physical and chemical properties of crude and processed palm oil products; (ii) the effects of crude palm oil quality and processing parameters on final product quality; and (iii) product specifications, product uses and market demand. This process of learning was assisted by public sector institutions (such as PORIM, the palm oil research institute) and private sector organizations (such as the refiners' association) which conducted technical and marketing research, promotion and extension activities.

With the liberalization of regulatory controls on capacity expansion in 1986, refineries competed to establish large-scale plants with the newly optimized technologies and significant economies of scale. The expansion in capacity also led to the closure of smaller, less efficient and unprofitable refineries under the low domestic refining and fractionation margin regime. This has been a persistent

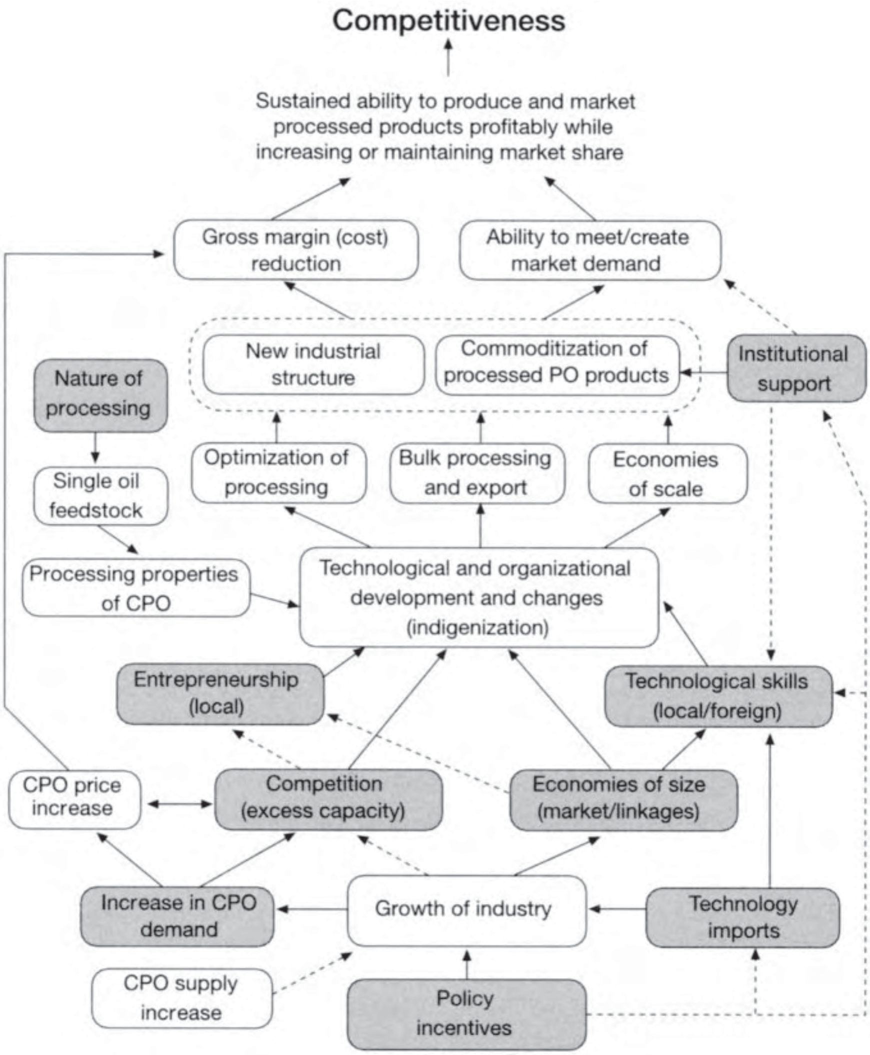


Figure 14.9 Malaysian palm oil refining industry: technical and structural changes and competitiveness

phenomenon since 1983, when capacity greatly exceeded CPO availability. In the 1980s and 1990s, there have also been take-overs of inefficient and non-operating refineries by plantation groups, investors with potential market niches and other more efficient refineries which have led to capacity upgrading and expansion.

These technical and structural changes created a new and unique industrial structure in the refining and fractionation of CPO in Malaysia – involving highly optimized, continuous large-scale bulk refining and fractionation of CPO, and the commoditization, bulk marketing and distribution (export) of PPO products – which resulted in the economies to competitively market refined and fractionated products world-wide.

Foreign direct investment and local entrepreneurs

Foreign direct investment (FDI) played a very minor role in terms of equity in the development of the palm oil refining industry. By 1987, when investments in refineries had already peaked, foreign equity accounted for about 17 per cent of total paid-up capital (MIER 1990:9). In contrast to the general flow of FDI from developed countries into developing countries, most FDI in the Malaysian palm oil refining industry was not from the "North", with most coming instead from India, Singapore and Hong Kong. The Indians have had a leading and key role in the Malaysian palm oil refining industry, with interests in as many as eight installed refineries in the 1980s.[39] The main reason has been the considerable imports of processed palm oil products to India from Malaysia from the late 1970s until the late 1980s. Another factor could be foreign exchange controls in India then which encouraged Indian capital overseas to continue investing profits abroad rather than be repatriated home.

From the developed countries, only the Japanese invested significantly in refining and fractionating palm oil for export in the 1970s and 1980s, when policy incentives encouraged rapid growth.[40] Despite the generous incentives, which resulted in high domestic financial profitability, Western companies generally showed no interest in investments in palm oil refining and fractionation for export in the 1970s and 1980s.[41] Their arguments against such investments have been described elsewhere in the section on policy environment. It was only two decades after policy incentives were first introduced that a large American multinational oils and fats company acquired two operating refineries, having recognized the need to have a stake in the highly efficient Malaysian palm oil processing industry to strengthen and boost their international oils and fats trading activities.[42]

Plantation groups producing large quantities of CPO in Malaysia were expected to lead investment in the Malaysian palm oil refining industry. However, because of the dominance of European (mainly British) interests in the major oil palm plantation groups and their negative view of the local potential for palm oil processing, the responses from these groups fell far short of expectations. (An exception to this was the Danish-controlled plantation group, United Plantations, which invested in a joint venture refinery with Tata, an Indian conglomerate in 1972.) The plantation firms that pioneered establishing local refining capacity in the 1970s were mainly controlled by local interests, from both the private sector as well as public-sector agencies. Others who invested significantly included the local refiners who had been processing CPO on a small scale for domestic consumption and independent investors who had knowledge of the industry and of the profits that the export incentives could generate or were generating for refineries already in operation.

However, in the early years, the high profits from local processing of CPO as a result of the generous incentives diminished the entrepreneurial element in these enterprises. The entrepreneurship in the industry grew with intense competition, lower margins and higher risk and the accumulation of processing and marketing experience in the eighties. This was manifested in the competitive search for processing efficiencies, product differentiation and markets. This process of renewal and change was not a uniform one, with the more enterprising refiners being technology and market leaders and the less enterprising laggards often ceasing operation in the low season when CPO supplies were tight. But with the diffusion of new technology there was a slow overall improvement in efficiencies and competitiveness in the industry as a whole.

Technology imports and local capacity

Limited FDI and local experience encouraged investors in the 1970s to seek out for refining and fractionation technologies from foreign sources. Several foreign equipment designer–manufacturers also competed to market their wares to these investors. However, early technology selection and adoption was less discriminating because of the lack of experience.[43] The mainly foreign consultants and equipment vendors, selected by the investors, based their design of refining and fractionation plants on existing plants in the advanced countries, while adding the latest improvements.[44]

Technology imports in the 1970s were high, with all major plant equipment being imported. Local capital expenditures were mainly for civil and structural works, fabrication of simple vessels, tanks and piping and the erection of the plant. However, technology imports gradually declined, and by the late 1980s, foreign capital expenditures were limited to sophisticated and precision plant equipment such as separators, high pressure presses, chillers, filters, membranes, motors, engines, control devices, instrumentation, laboratory equipment and analytical instruments.[45]

How was the localization of technology achieved? For a developing country in the 1970s, Malaysia had a relatively high level of local skills in basic engineering.[46] For instance, in the early 1970s, engineering was a major industrial sector, accounting for over 13 per cent of manufacturing value added and growing at about 15 per cent per annum. Historically, agriculture and agro-based industries have had strong backward linkages to the local engineering industry.[47] Engineering output to the primary commodities export sector (tin, rubber, oil palm and timber) was large, but declining in the 1960s and 1970s, suggesting that engineering growth was increasingly driven by import substitution and then exportoriented manufacturing. The high level of vertical disintegration in refining and fractionation technology made local fabrication of less sophisticated equipment and components feasible. Such local fabrication was slowly upgraded to involve more complex equipment and components as more knowledge and skills were acquired through the processes of learning by doing. Technology search and import, equipment design and fabrication, project execution and erection of the pioneer refining plants and their subsequent commissioning, start-up, operation and maintenance provided the foundation for technological learning and training in a range of skills necessary for indigenous technological capability in refining and fractionation.[48] These processes of learning also contributed to the modification and optimization of palm oil refining and fractionation technology, with current technology quite different from that of the first refining plants installed in the 1970s (see the section on technical and structural changes). With the successive installation and operation of a greater number of refineries, local skills have reached a level where local consultants, contractors, operating staff and equipment have been exported to other Asian and African countries establishing local oils and fats-processing facilities since the 1980s.[49]

Conclusions

The emergence and rapid growth of an export-oriented palm oil refining industry in Malaysia has been a remarkable achievement in its industrial development. Processing capacities grew annually about 70 per cent in the 1970s and 15 per cent in the 1980s. In the 1990s, the industry processed 99 per cent of domestic CPO supply and produced 60 per cent of the world's refined palm oil products. As the industry initially lacked (static) comparative advantage and faced various barriers to its exports, generous policy incentives were crucial for the rapid expansion in palm oil refining and fractionation capacities in the 1970s and 1980s. The most important policy incentives were duty exemptions on exports of PPO products (while a high duty was imposed on CPO exports) and tax relief as well as allowances on profits and exports. However, the Malaysian refining industry did not languish in the high profit environment created by the generous incentives, as earlier studies have suggested. Instead, there were significant technical, organizational and structural changes in the 1980s, which created a highly competitive industry in Malaysia within a decade of its emergence.

To demonstrate the dynamism of the industry, changes in the level of international competitiveness during 1980–94 were measured using competitiveness ratios. Using the concept of effective exchange rate, the competitiveness ratio compared gross margins (or value added) for processing CPO at domestic market prices with world border prices. The analysis indicates that the Malaysian refining industry has improved dramatically from being internationally uncompetitive in the early 1980s to become highly competitive since. The gross margin for refining and fractionating palm oil in Malaysia decreased from more than 200 per cent of the "world" gross margin (based on Malaysian border prices) in the early 1980s to less than 60 per cent in the 1990s. Malaysian refiners in the 1990s competed internationally in spite of achieving only 30 per cent of the gross margin of their European counterparts.

The gains in international competitiveness were driven by the rapid growth in processing capacities, large size of the industry and domestic (inter-firm) competition. The rapid growth of the industry in a highly (private) profitable environment led to several developments. Ironically, one was the elimination of excess profits created by the policy incentives, as processing capacities increased faster than domestic CPO supply, leading to relatively higher CPO demand and prices. Competition for CPO supplies and price pressures intensified in the 1980s as domestic processing capacities outstripped CPO supplies. This led to the search for greater efficiency and productivity. Besides the intense competition, the effects of several other factors, as the industry grew, made the realization of a very high level of processing efficiency feasible. The growth and large size of the industry (as a consequence of policy incentives and increasing CPO supplies) generated significant economies and strong backward linkages to domestic engineering and technology-related activities and also led to the accumulation of experience, knowledge and skills in CPO processing techniques and technology. Refiners collaborated with equipment vendors and manufacturers to improve and optimize processing technology – building on differences in the physical properties of CPO compared to the soft oils on which the initial imported processing technologies were based – and to localize the fabrication of processing equipment to a greater extent. Eventually, domestic competition, technical changes and economies generated by the accumulation of experience, knowledge and skills and the growth of a large industry led to the development of a unique industrial structure: the highly optimized, continuous large-scale bulk processing of CPO and the commoditization, bulk marketing and export of PPO products. These factors gave rise to an industry with a competitive advantage in the world market for PPO products.

While policy interventions (incentives) were critical in overcoming political and economic obstacles to the establishment of an export-oriented refining industry, its direct impact on increasing the level of competitiveness was marginal. The most important policy intervention – the export duty structure – was effectively a "market-based" transfer pricing mechanism involving CPO, intended to favour CPO refiners over CPO producers. During the infant stage of the CPO refining industry (when processing capacities were less than domestic CPO supply) in the 1970s, this mechanism had the intended effect of providing favourable (lower) CPO transfer prices and higher profits for refiners. The unfavourable (lower) prices for CPO producers, however, did not affect the expansion in domestic CPO production and supply as it was highly profitable in the 1970s and could easily absorb the lower CPO prices. However, since the mid-1980s, with CPO profitability declining and expansion in CPO production slowing down, more intense competition for CPO supplies and improvements in CPO processing efficiency in refineries reduced the domestic–world price margin, increasing domestic CPO prices and thus providing favourable (higher) transfer prices to CPO producers. These shifts in CPO domestic prices, relative to world prices, enhanced the incomes and profits of both CPO refiners as well as CPO producers when they needed it most and helped sustain the growth of the palm oil industry (producers and processors) as a whole. The export duty interventions succeeded in expanding processing capacities and PPO exports, but did not contribute "actively" to achieving higher processing efficiencies and gaining international competitiveness. However, the growth of the refining industry, as a consequence of the policy incentives, contributed to the more "passive" processes of "learning by doing".

Other incentives meant to promote greater efficiency and competitiveness were found wanting. Double taxation relief for R&D and market promotion by themselves were insufficient incentives to encourage activities in market development, technology search, training, R&D in process and product development, and investments in improved technology. Similarly, institutional support largely served as avenues for technical and market information – on which the search for processing efficiencies and new markets could be based. Most of the gains in competitiveness were the result of pressures to survive and sustain or increase profits as well as the entrepreneurial and technological skills accumulated by individuals in progressive firms actively pursuing growth and greater efficiency. This was particularly so for firms which were not backward integrated and had to purchase CPO supplies in the open market. With hindsight, it is fortunate that regulatory controls over entry and capacity expansion were rather "flexible" and largely deregulated by the late 1980s. Strict regulation of entry and capacity expansion to levels lower than domestic CPO supply would have maintained relatively lower CPO demand and prices and higher profits for CPO processing. This would have limited competitive pressures to improve efficiency and competitiveness. Further, the rationalization of the industry – through the acquisition of inefficient firms or those that had ceased operating, by other refiners, plantation companies or investors with market niches – in the mid-1980s and after, was largely left to market forces.

The major costs of policy intervention, to the palm oil industry as a whole, were due to the less discriminating large-scale technology imports during the early years of an expanding refining industry. These costs, we believe, have been more than offset by the gains in international competitiveness and other positive externalities generated by backward linkages, technological accumulation and greater indigenous technological capacity. However, better planning and policy interventions, such as those promoting more active and effective processes for technological learning as well as development of indigenous technological capacity, would have reduced technology imports and learning costs, and enhanced the international competitiveness of the industry more rapidly. Similarly, while the lack of FDI and involvement of multinational corporations was a stumbling block to more rapid acquisition of technology, marketing skills and international levels of competitiveness, the flip-side was that there was a much more active search for technology imports and more effective processes of technology transfer and learning.

Notes

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1 For case studies, see the articles in the volumes by Stewart and James (1982), Fransman and King (1984), Teitel and Westphal (1984), Lall (1984) and Katz (1987). Other case studies are Lall (1987) and Teitel and Thoumi (1986). See also Herbert-Copley (1990) and Weiss (1986).

2 The importance of the palm oil processing industry in the manufacturing sector can be seen by the attention given to it in the first Industrial Master Plan (IMP) as one of the sectors selected for detailed study (MIDA/UNIDO 1985).

3 The palm oil refining industry refers to the core activities of refining and fractionating crude palm oil (CPO) products and crude palm kernel oil (CPKO) products and, to a lesser extent, the refining of other oils and fats, and the marketing (domestic and export) of a wide range of products from these activities. It also includes the blending and/or hydrogenation and/or inter-esterification of oils and fats (with palm oil and palm kernel oil as the main ingredient), the manufacture of cooking oils, margarines, vegetable ghee, baking, frying and specialty fats, and the packaging and marketing of these products world-wide. Broader (and vaguer) terms – such as palm oil processing industry, processed palm oil (PPO) and processed palm kernel oil (PPKO) products – are sometimes used to refer to this industry and its main products. In this chapter, we only analyse the core activities of refining and fractionating crude palm oil when we refer to the palm oil refining industry.

4 Approved capacity refers to licences issued by government authorities (especially the Ministry of Trade and Industry) to firms, which allow them to refine crude oils up to a maximum annual capacity (based on the daily maximum capacity of the approved refining plant multiplied by 300 days of operation a year). The approved capacity is not necessarily the same as the design or guaranteed installed capacity of equipment suppliers or the maximum attainable capacity of the refining plants installed.

5 For a review of Malaysia's industrialization strategies and performance, see Jomo and Edwards (1993) and Edwards (1992).

6 See the later section on policy incentives and growth.

7 See Stewart and Hj. Amiruddin (1983).

8 A system of monthly prices gazetted in advance was used in calculating export duties.

9 Todd's (1978) argument that the export duty exemption was a Malaysian Government subsidy to domestic refiners is inaccurate. Instead, the high export duty on CPO has involved transfers from the CPO producers to the refiners.

10 Cesses were levied on CPO and CPKO produced at palm oil and palm kernel mills respectively. Hence, the cesses were part of the costs of producing CPO and CPKO.

11 Policy making as a whole was strengthened as a consequence of the recession in the mid-1980s.

12 For a review of competitiveness analysis methodologies, see Coffin *et al.* (1993). In general, they argue that competitiveness is a vague concept whose measurement has been as diverse as its definition.

13 In the context of infant industry and learning arguments, we feel that any distinct change in competitiveness would be within a reasonable time span of two decades or less for most industries. See, for instance, Bell *et al.* (1984: 115–17) and Jacobsson (1993).

14 See, for instance, van Duren *et al.* (1991).

15 Another major problem is protection in various forms in many countries which invariably distorts profitability measures.
16 For RCA analysis, see Balassa (1979), Greenaway and Milner (1993) and Porter (1990), and for CMS analysis, see Richardson (1971), Arshad and Ghaffar (1989) and Basiron (1988).
17 Since CPO and PPO products have been subject to tariffs by both the major exporters and importers of these products, free trade conditions do not exist. Hence, any analysis using market shares would need to evaluate the impact of these tariffs.
18 This, for instance, was argued by Westphal (1981:9). See also Bell *et al.* (1984:102–3). For details of DRC analysis, see Bruno (1972), Towers (1992) and Greenaway and Milner (1993).
19 This is essentially the effective exchange rate method and is a simplification of the domestic resource cost method approach under ideal conditions. For an elaboration, see, for instance, Fong (1986: 211–18).
20 These inputs constitute more than 70 per cent of total non-CPO intermediate inputs. Price distortions on these inputs, except for bleaching earth, are small. Bleaching earth has been subject to a tariff and/or import quota in Malaysia since 1986, when import-substituting bleaching earth industries were established. However, price distortions on CPO would have a much greater impact on estimates of world border (shadow) values, and hence, on the competitiveness ratios, than the price distortions of these inputs.
21 The concepts of value added, gross margin and competitiveness ratio can be applied more generally to analyse the international competitiveness of processing industries which involve processing a small number of major raw materials into a small number of products, whose prices are well established and process input coefficients and output yields are easily determined.
22 Theoretically, there should only be small differences, as any price difference between the Malaysian and the European borders which is larger than the freight, insurance, financial and quality costs and transportation losses would be arbitraged. But since the methods used to collate the price data were different at the two borders, significant price differences may exist in the data used.
23 The spread between PPO products and CPO at world prices would have been wider under free trade than under the prevailing tariff-ridden conditions, especially from the mid-1970s till the mid-1980s.
24 As North-West Europe (Rotterdam) is the largest centre for trade in CPO, European c.i.f. (border) prices most closely reflect world prices under tariff-ridden equilibrium relationships in the supply and demand for palm oil products.
25 The following product yield equations were used for physical refining of crude palm oil:

$Y_{rbdpo} = 99.7 - 1.35$ (FFA%) and
$Y_{pfad} = 1.15$ (FFA%)

where the average FFA (free fatty acid) content of crude palm oil feedstock was estimated at 3.75 per cent.

The product yields for dry membrane fractionation used were:

$Y_{rbdpol} = 75\%$ and $Y_{rbdpst} = 25\%$

26 If prices of CPO and PPO products remain constant, then the product yield improvements, i.e. improved yields of refined palm oil and the higher valued olein fraction, over the years, would have improved gross margins.
27 In practice, product yields of refined palm oil and olein in Europe, for instance,

would have been lower than in Malaysia because many of their refining and fractionation plants use several oils as feedstock (and hence, are not optimized to process palm oil), and have smaller capacities and generally "older" technology. The actual gross margins obtained by refiners in the EU would have been lower than estimated here because of lower product yields. Also, a higher gross margin would have been necessary for economic viability than in Malaysia as a result of higher palm oil processing costs and differences in industrial and market structure (see the later section on technical and structural changes).

28 This was because of greater stability in available processing capacity and improving capacity utilization rates during these years.

29 The improved estimation of world border (shadow) prices of CPO would have resulted in a far more accurate measure of competitiveness than estimating and using value added. See also note 20.

30 Todd used the same basic formula for computing border gross margins. But he used different product yield coefficients and termed them gross value added in exports. He argued that for his computations, the product "yield coefficients used are feasible, but imply high yields of refined palm oil and olein, compared to figures actually reported in the Malaysian vegetable oil industry" at that time. The export (border) prices he used were f.o.b. unit values calculated from export statistics.

31 Besides the limited duration, the most significant shortcoming of Todd's analysis (as well as this study to some extent) is the failure to take into account border (export) price distortions, which resulted in the negative or low border gross margins from the mid-1970s till the early 1980s.

32 See also the sections on the policy environment and foreign direct investment.

33 The lack of FDI has probably also hampered local investors from taking the plunge in the early years into what would have largely been seen as a risky venture because of the lack of knowledge of refining and fractionation and of export markets for processed products.

34 As a consequence of rapid growth in domestic refining capacity in the 1970s and increased demand for CPO from both domestic refiners and the export market, the spread between the border prices of CPO and PPO products was very narrow or negative. This resulted in very low or even negative border margins. The impact of this on domestic margins depended on the amount and effect of CPO export duty on domestic CPO prices.

35 Unusually high palm oil prices occurred in 1984 and 1985. This resulted in unusually high CPO export duty, widening the spread between domestic and border CPO prices. This, in turn, resulted in unusually high gross domestic margins.

36 During highly distorted periods, when the border gross margins were negative, the theoretical gross domestic margins would have been lower than the export duty. For the period analysed, on an annual average basis, border gross margin was negative only in 1980.

37 Since then, annual average domestic margins, which have been in the region of US$10–20, have fluctuated somewhat inversely to capacity utilization rates. The relationship is complex and depends on the processing cost structure as well as the entry and exit costs for the installed refineries. But the lack of reliable data on installed capacity and actual capacity utilization rates prevents any meaningful analysis.

38 In many refineries, small amounts of crude palm kernel oil have also been refined using the same equipment. This changeover to crude palm kernel oil refining can be done with a high level of efficiency with minor changes to the processing parameters since crude palm kernel oil has many similar refining properties to CPO.

39 The refineries were Pan Century, Nalin, Kupak, Olinco, Geetha, Twenty-first Century, Unitata and Ballapur. The major Indian groups involved in these ventures

were Birla, Allana, Thapur and Tata. Most of these investments were in the form of joint ventures with local partners. The loans for these investments were largely financed by a previously Indian-controlled bank, United Asian Bank. According to Lall (1984: 548–51), 35 per cent of Indian FDI was invested in Malaysia as of 1980, with food and palm oil processing constituting as much as 20 per cent of Indian FDI ventures in overseas operations then. This suggests that a substantial amount of Indian FDI was invested in palm oil processing activities in Malaysia in the 1970s.

40 The Japanese companies involved in Malaysian operations were Mitsui, ADK (in Felda Oil Products) and Fuji Oils (in Palm Maju). Joint ventures between large oils and fats multinational companies and large local palm oil producing groups – like the joint venture in the mid-1970s between Mitsui and the largest Malaysian public sector palm oil group, FELDA – were not significant.

41 Unilever was the only western multinational company which had interests in processing CPO in Malaysia in the 1970s. However, its refinery had been established in the 1960s under the import substitution incentive programme to produce consumer oil and fat products for the domestic market.

42 This involved Cargill Inc. which took over two relatively successful Indian-controlled refineries, Kupak and Olinco, in the 1990s.

43 As a consequence, there were cases of installed refineries getting into difficulties after a few years, or even less, in operation during the early to mid-1980s.

44 Developed countries have had long experience in refining and fractionating all kinds of oils and fats, including palm oil, and have used the same equipment in refining by modifying operating conditions and processing inputs despite differences in physical properties. However, the processors of oils and fats were quite distinct from the process equipment designers and/or manufacturers. The process equipment designers/ manufacturers specialized in developing the technology and fabricating many of the key units for operations, often with the collaboration of oils and fats processors with operating experience. The improved processing of oils and fats tended to be based on experience and innovation and was often in the use of the technology rather than in the design of equipment, although all these are interrelated, and the interactions play an important role in technological development, process improvements and plant modifications.

45 Not only were advanced technological knowledge, skills and machinery necessary for the production of this equipment, but often, they were also subject to considerable economies of scale, and hence, required markets in several industries and countries.

46 With a good functional education system and considerable industrialization in the 1960s and 1970s, Malaysia had accumulated a relatively high level of basic engineering skills (for a developing country) in technology search and selection, simple process design, mechanical and electrical installations, civil and structural engineering and production and plant engineering. These skills facilitated the design and fabrication of basic processing equipment and erection of plants.

47 Thoburn (1977: chapter 8) provides an excellent study of the backward linkages from the tin, rubber and oil palm industries to the engineering sector in the 1960s and early 1970s in Malaysia. He quantifies these linkages and offers an economic analysis of the reasons for the development of engineering as a backward linkage. His study has provided invaluable insights for our analysis of the localization of the refining technology.

48 Importantly, a range of marketing and distribution (transportation) skills and technologies were acquired or developed to meet the new demands of the bulk export of high quality products.

49 One such local firm is Oiltek, which has undertaken several projects locally and overseas.

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