The Effects of TNC Subsidiaries on National Innovation Systems: Technological Innovative Capabilities of Local Malaysian Suppliers

Abstract:

This research focuses on the organisational linkages between Transnational Corporations (TNCs) subsidiaries and local suppliers in the Malaysian electrical and electronics (EE) industry. Malaysia is an ideal country in which to study the factors causing and affecting the intensity of backward linkages, and the effect these linkages have on technological development and National Innovation Systems (NIS). TNC subsidiaries in the EE industry are major players in Malaysia's process of industrialisation. Local suppliers in Malaysia are involved in the process of manufacturing by subsidiaries either in terms of sourcing parts or components, or manufacturing under sub-contracting arrangements, depending on a supplier's technological capability. Although the weaknesses have been identified in various studies, there is also some evidence of significant linkages between subsidiaries and local suppliers in the Malaysian EE industry. Therefore, we try to explore evidence of significant inter-organisational linkages between TNC subsidiaries and local suppliers and to research backward linkages as critical factors affecting technological development of local suppliers.

Keywords;

Backward Linkages, Naitonal Innovation Systems (NIS), Transnational Corporations (TNCs), Subsidiaries, Local Suppliers, Malaysia.

1. Introduction

This research focuses on the organisational linkages between Transnational Corporations (TNCs) subsidiaries and local suppliers in the Malaysian electrical and electronics (EE) industry. It is commonly observed in EE industry that firms first conduct R&D, then develop products, then find resources in the host economy, and finally start manufacturing. Final products are usually refined and marketed in the home or host economy or in the international market. Local suppliers, especially in host developing countries like Malaysia, are involved in the process of manufacturing either in terms of sourcing parts or components, or manufacturing under sub-contracting arrangements, depending on a supplier's technological capability.

Malaysia is an ideal country in which to study the factors causing and affecting the intensity of backward linkages, and the effect these linkages have on technological development and National Innovation Systems (NIS). Specifically, the EE industry provides an opportunity for insight, given its importance in the Malaysian economy and the world in general. TNCs in the EE industry are major players in Malaysia's process of industrialisation. The presence of TNC subsidiaries in the EE industry has a long history which started in latter half of 1960s with export oriented strategies taken by TNC subsidiaries. Despite the significant contribution of TNCs, several weaknesses have been identified in inter-organisational relationships between TNC subsidiaries and local suppliers. Although the weaknesses have been identified in various studies, there is also some evidence of significant linkages between TNCs and local suppliers in the Malaysian EE industry. Therefore, we try to explore evidence of significant inter-organisational linkages between TNC subsidiaries and local suppliers and to research backward linkages as critical factors affecting technological development of local suppliers.

One of the factors affecting TNC motivations in providing backward linkages is local suppliers' technological capabilities, since TNCs pursue cost efficiency in procuring inputs in host countries. The technological level of a local supplier affects a subsidiary's motivation whether to source locally in the host economy, or to source regionally or internationally. Therefore, local suppliers have crucial roles in meeting subsidiaries' demands within the backward linkages. A supplier's technological capability to meet these demands contributes to the development of strong inter-organisational linkages between subsidiaries and local firms. Such interactions further benefit local suppliers in terms of exposure to the TNC's high standard of manufacturing operations in the global market. With the rapid global technological advancement in the EE industry and the ongoing process of globalisation, it is critical for local firms to be more technologically capable if they wish to participate in the industry, for it is very easy for TNCs to find other suppliers, or even other countries, with whom to interact. Lall and Narula (2004) suggest that the development of capacities and capabilities is a key to both attract Foreign Direct Investment (FDI) as well as to increase technological spillovers from TNCs.

We consider backward linkages as one of the interactions of organisations within the context of NIS. A NIS is defined as "the network of institutions in the public and private sectors whose activities and interactions initiate, import, and diffuse new technologies" (Freeman 1987: 1). Strong interaction between key actors in the NIS contributes flows of new technology between firms. Thus it can contribute to the technologically innovative activities of local suppliers. Recent studies on backward linkage creation showed a beneficial impact of TNC subsidiaries on local suppliers' capabilities (Halback, 1989; Fleury et al., 1994; and more specifically for Asia, Rasiah 1989, 1995; Wong 1991; O'Brien, 1993; IDE 2000; UNCTAD 2001, Giroud, 2003).

This article is organised as follows. Theoretical reviews on technologically innovative capabilities and the theory of NIS are first presented in section 2, followed by issues related to backward linkages within the framework of the NIS in section 3 and 4. In order to answer the research questions, this study utilised a comprehensive survey to gather detailed information on various aspects of firms' activities as well as their activities in providing or receiving backward linkages. A large number of direct interviews were conducted for the purpose of this study, and two sets of questionnaires were prepared, one each for TNC subsidiaries and local suppliers. The results of the survey and hypotheses analysis based on both qualitative and quantitative methods are provided in section 6, followed by concluding remarks.

2. Technology and Technological Innovative Capabilities

Technological Capability and Technological Learning

Technological capability is the knowledge, skills and experience necessary in firms to produce, innovate, and organise marketing functions (Lall and Wignaraja, 1998; Ernst, Ganiatsos and Mytelka, 1998). Technological capability is an especially crucial factor in developing countries. For instance, Kokko et al (2001) highlight the role of a country's past industrialisation experience as a precondition for technology transfer. The absence of such experience results in a lack of local absorptive capacity (Radosevic, 1999). Lall and Narula (2004) suggest that the development of capacities and capabilities is a key to both attracting FDI as well as in increasing technological spillovers[1] from TNCs. If local technological capacities and capabilities are weak, industrialisation has to be more dependent on the activity of TNCs; however, TNCs

[1] Spillovers occur when local firms benefit from the TNC subsidiary's superior knowledge of product or process technologies or markets, without incurring a cost that exhausts the whole gain from the improvement (Blomström et all, 2000).

cannot drive industrial growth without local technological capabilities (Lall and Narula, 2004).

Technological learning is the way organisations accumulate or acquire technological capability (Malerba, 1992). Learning refers to the mechanisms and processes by which technological progress is carried out. Learning enables firms to build up their technological knowledge about products and manufacturing processes, and to develop, deploy and improve the skills of their workforces, and continually transform knowledge assets to foster higher orders of operation (Dodgson, 1991; Lundvall et al, 2002; Malerba, 1992). As Malerba (1992) shows, learning is central to productivity growth and also to different types of product and process improvement. Technological learning is a dynamic, difficult and costly process, since it involves substantial and deliberate effort and investment by firms. In addition, technological learning itself or learning process is not easy to observe or measure. The learning process usually involves both knowledge and experience, encompassing formal methods such as training and informal activity such as imitation. Although technological learning is usually costly and is often difficult to undertake, it is central to incremental technical change and corporate progress as well as productivity growth.

Technological Innovation, Product and Process Innovation

"Innovation" is traditionally divided into product innovation and process innovation (Schumpeter, 1926). Product innovations are new or better material goods as well as new intangible services, and involve the development of a new good or improved goods. Process innovation is defined as a technological change which reduces the cost of making an existing product or enhances the quality or performance of existing products. Process innovations are new ways of producing goods and services. Firms do not normally innovate in isolation, but in collaboration and interdependence with other organisations such as suppliers, universities, research institutes and the government (Fagerberg and Godinho, 2004).

Although, the successful introduction of a new or improved product to the marketplace is crucial for TNC groups (Dorfman, 1987; SPRU, 1972; Kamien and Schwartz, 1982), SMEs or firms in developing countries function from behind the technology frontier. Therefore, it is important to add to the definition that innovation as a product or process which is new to the firm, rather than to the world or marketplace (Myers and Marquis, 1969; Schmookler, 1966; Gerstenfeld and Wortzel, 1977: 59-60). Thus, when a company produces a new good or service or applies a new method or material, it makes a technical change and an innovation can be said to have occurred, even if the technology itself is not new. As Myers and Marquis argue, many firms have been profoundly altered by innovations new to the company, although not new to the world (cited in Gerstenfeld and Wortzel, 1977: 60).

Another lesson from the Japanese experience is the importance of minor, continuous improvements (Kaizen) and the contrast between radical and incremental innovation. A radical product innovation in electronics would be the introduction of a brand new, successful product. By contrast, an incremental innovation would be a minor improvement to the design of a product already on the market. Innovation is not an easy task, and often takes long-term, continuous change rather than a short-term, once-and-for-all change. Learning to innovate is therefore a long-term process which can not be captured solely by counting discrete innovations. Within the long-term process, learning and innovation involve complex interaction between firms and their environment. Therefore, we need to look at the systems approach to technological learning and technological innovation for local suppliers in developing countries.

Technologically Innovative Capabilities and Technological Learning of Local Suppliers

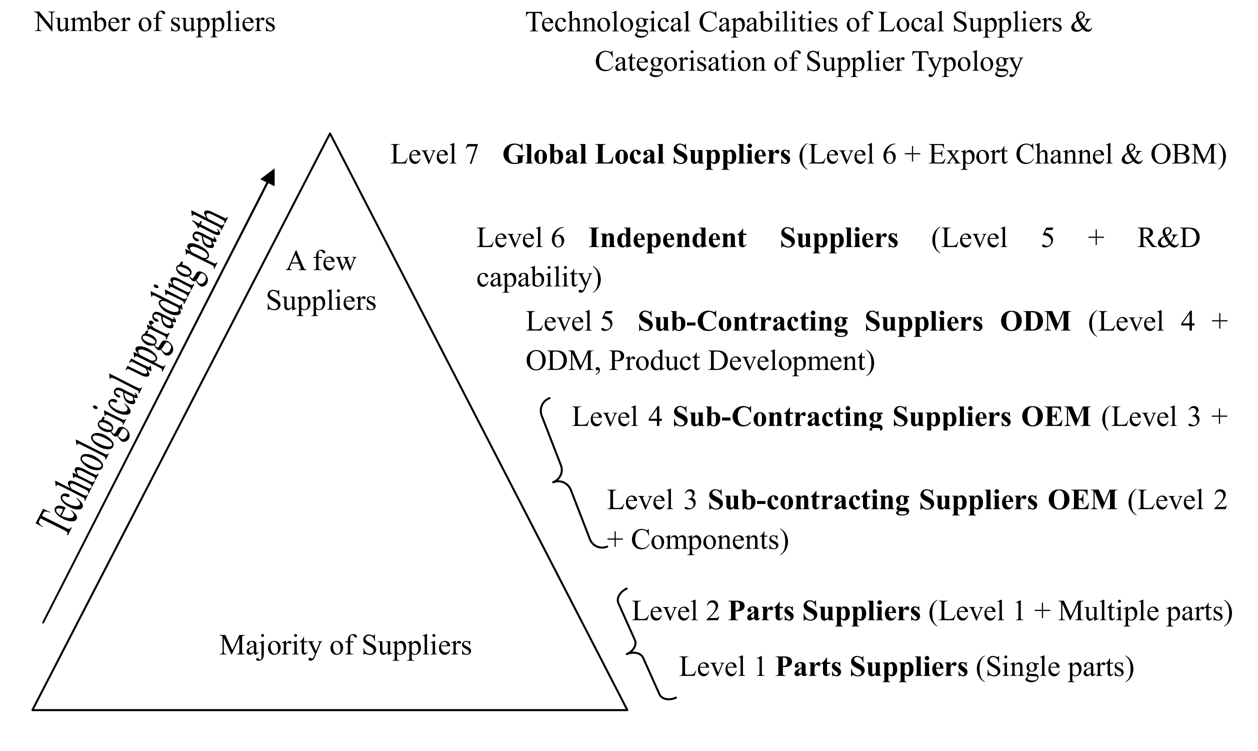
It is commonly observed in the EE industry that firms first conduct R&D, then develop products, then find resources in the host economy, and finally start manufacturing. Final products are usually refined and marketed in the home or host economy or in the international market. Local suppliers, especially in host developing countries like Malaysia, are involved in the process of manufacturing in terms of either sourcing parts or components, or manufacturing under sub-contracting arrangements, depending on a supplier's technological capability. The technological capability of a local supplier affects a subsidiary's motivation whether to source locally in the host country, or to source regionally or internationally. With the rapid global technological advancement in the EE industry and the ongoing process of globalisation, it is critical for local firms to be more technologically capable if they wish to participate in the industry, for it is very easy for TNCs to find other suppliers, or even other countries, with whom to interact (Lall and Narula, 2004).

Development of the Analytical Framework: Local Supplier Typology, Technological Capabilities and Technological Levels (Abilities) of Local Suppliers

In order to examine to what extent local SMEs' level of technological capabilities or technological knowledge have been upgraded, we need to define different levels of technological capabilities of local suppliers. The technological level of the supplier is first developed and defined as level 1 to 7. Based on the 7 levels, we divide the supplier typology into Parts suppliers (level 1 and 2), Sub-contracting suppliers (OEM) (level 3 and 4), Sub-contracting suppliers (ODM) (level 5), Independent suppliers (level 6), and Global suppliers (level 7). Depending on a supplier's technological capability, we assign a technological level and supplier typology which best fits to the supplier. We assume that each supplier upgrades its status to the higher one as it successfully accumulates technological ability. Therefore, suppliers' development paths are defined using factors affecting their development, and the length of time that they stay at a given status. We also look at dynamics (speed) of suppliers' development paths so that we can later focus on factors affecting these dynamics.

Contractual arrangements between TNC subsidiaries and local suppliers include technological learning activities of suppliers. A variety of interaction (backward linkages) between them can be observed, depending on the basis of a supplier's technological ability to meet the TNC subsidiaries' demand. Therefore defining the levels of technology which suppliers possess is necessary to assess local suppliers' technological level as well as technological development paths. In the conventional supplier-oriented model of industrialisation and economic development observed in East Asian NIEs and elsewhere, local suppliers continuously upgrade their technological capabilities either by serving the needs of the TNC subsidiaries in host economies or by supplying TNCs outside host countries. In both cases, the technological upgrading process can proceed in stepwise fashion, beginning with simple parts or components manufacturing for subsidiaries, followed by the supply of complete products to the specification of subsidiaries (so called original equipment manufacturing, or OEM), followed by the addition of design serviced to the manufacturing of complete products, known as own design manufacturing (ODM). Once design competencies are well established, suppliers can design, develop and manufacture whole products for sale under the subsidiaries' brand name, and later their own brand name, known as original brand manufacturer (OBM). If a supplier becomes an OBM, it has reached at the top of the supplier's upgrading path. Firms like Samsung in South Korea or Acer in Taiwan, as well as others, have successfully made the shift from OEM to ODM status, and through time, from ODM to OBM status. However, in this research, OBM status is omitted in the Malaysian case since none of the suppliers had reached at OBM status yet at the year of 2002, and the OEM to ODM and ODM to OBM upgrading path had stalled at the ODM phase in Asian NIEs (Sturgeon and Lester; 2003). The figure below shows different technological levels and status of the supplier typology developed through interview process.

Figure 1 Technological Positioning of Local Suppliers and Local Supplier Typology



Source: Derived from research

Level 1 is defined as the capability of manufacturing parts with a single structure, such as plastic parts by injection or metal parts by single stamping. The suppliers who produce single parts are usually not required to undertake technologically innovative activity, and are only engaged in ongoing production. At level 2, the number of manufacturing parts increases to more than one. Suppliers are required to have the capability of producing some parts in addition to the technology discussed at level 1. Thus they have to acquire additional technological activity beyond level 1 so that they can produce multiple parts. Still, design and specification are all supplied by subsidiaries, and innovative activity is not required. Those who are at level 1 in the previous period may need to invest in additional facilities or equipment to become achieved level 2 ability. These level 1 and level 2 suppliers are assumed to be the majority of Malaysian suppliers, and will be categorised as “parts suppliers”.

Level 3 is defined as the technological ability to manufacture components with a variety of parts, either locally sourced or manufactured in-house. Since their required tasks are specific to the subsidiary and components consist of major parts of finished products which are commonly assembled in the subsidiary’s site, suppliers act a as sub-contractor to the subsidiary. Again, the subsidiary supplies designs and specifications. Especially for suppliers at level 3, subsidiaries are important technological sources who require them to be capable of technological innovative activities to meet designs and specifications of the subsidiary, and who sometimes supply training of the local suppliers' engineers and technicians.

When suppliers are capable of manufacturing complete products as an OEM (a specific form of sub-contracting[2]), with either locally-sourced components or components produced in-house with offered designs and specification from the subsidiary, a suppliers' technological level is defined as level 4. Under OEM, suppliers manufacture products which are designed and specified by subsidiaries, and purchased by suppliers. The subsidiary markets the product under its own brand name, through its own distribution channels; thus, it accumulates the value-added activity of finished products under OEM. Suppliers are not required to invest in marketing and distribution channels, but are required to manufacture with the appropriate quality, delivery, and price so that the subsidiary can depend on their technological level and manufacturing of products. The OEM supplier often involves subsidiaries in the selection of capital equipment and the training of managers, engineers and technicians, as well as receiving advice on production processes, financing and management. Suppliers in Level 3 and 4 are categorised as OEM sub-contracting suppliers. Sub-contracting suppliers, depending on the number of components they assemble or manufacture and the level of technology used, can be divided into either intermediate sub-contracting or advanced sub-contracting, the latter which requires rather sophisticated technology.

Some suppliers upgrade their capability to not only manufacture specified products given by subsidiaries, but also to develop designs and product definitions to meet their own demand as well as that of subsidiaries. This level of technology is defined as level 5. Under ODM, detailed designs and specifications are not offered by subsidiaries, thus higher technology is required for suppliers to carry out some or all of the product design and process tasks needed to make a product according to a general design layout supplied by the subsidiaries. In some cases the subsidiaries cooperate with the suppliers on the design. In other cases the subsidiary is presented with a range of finished products to choose from, defined and designed by the suppliers with their own knowledge of international market demand. The products are then sold under the TNC's brand name as in OEM. ODM signifies the internalisation of system design skills, and sometimes complex production technologies and component design abilities on the part of the suppliers. Although in Malaysia some suppliers function as ODM for subsidiaries, evidence suggests that majority of Malaysian suppliers have not reached the ODM level.

[2] In some countries, like South Korea, OEMs are sometimes linked to licensing deals. Under licensing arrangement, suppliers pay for the right to manufacture products usually for the local market, and the TNC transfers the necessary technology for manufacture.

Suppliers who have succeeded in investing in R&D facilities, and who are capable of implementing innovative activity, which is not limited to design but applies to R&D based production innovation, are categorised as level 6 and independent suppliers of the supplier typology. In the Malaysian case, the establishment or introduction of R&D facilities and willingness to adopt R&D to their products and processes are commonly observed at this stage, rather than fully utilising R&D capabilities for new products.

Suppliers who have successfully accumulated their own global or regional marketing channels and networks, and who export their products directly to TNCs or customers outside the host country, are categorised as Level 7 and global local suppliers[3]. At this level, suppliers have to overcome their barriers to entry to the international/export market, and they are required to progress simultaneously on technological upgrading and export marketing. For local suppliers, especially for SMEs, entering export markets is the most demanding task, which requires acquiring product and process capabilities enabling them to sell higher quality products to a larger base of TNCs in exporting countries, where the advantages of low-cost engineering and management to the market are significant. The technological role of exports is to progressively pull the learning of suppliers forward by stimulating technological change (Hobday; 1995). Through linkages with export buyers and export demand act as a focusing device for technological investments.

3. National Innovation Systems (NIS)

Innovation, Institutions, and Systems of Innovation

As discussed, technological innovation is considered to be either product innovation or process innovation, and which is narrower definition of innovation. Firms do not normally innovate in isolation, but in collaboration and interdependence with other organisations such as other firms (suppliers or buyers), universities, research institutes and government organisations (Fagerberg and Godinho, 2004). The behaviour of these organisations is influenced by institutions that constitute incentives and obstacles for innovation. Edquist (2004) argues that systems of innovation have a function to pursue innovation processes, i.e. to develop, diffuse and use innovations. The activities by main actors in systems of innovation are the same as the determinants of the main function, thus influence the innovation processes. Activities in an innovation system, such as R&D, implementation, end-use, education and linkages (Johnson and Jacobsson, 2003) are, in turn, focused on creating new knowledge, guiding the direction of the search process, supplying resources, creating positive external economies, and facilitating the formation of a market (Johnson and Jacobsson, 2003: 3-4). The following activities can be expected to be important examples in

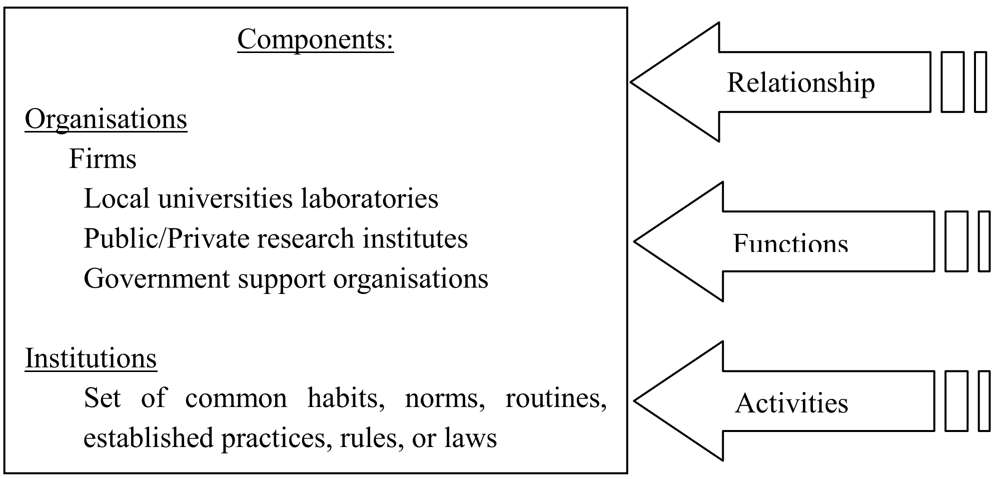
[3] It is important to note that "global local supplier" needs to be distinguished from recent studies of "global supplier" such as in Sturgeon and Lester(2003).

most systems of innovation (Edquist, 2004: 190-191); 1) provision of R&D, 2) creating new knowledge, 3) competence building, 4) formation of new product markets, 5) articulation of quality requirements from the demand side for new products, 6) creating and changing an organisation's need for the development of new fields of innovation, 7) networking through markets and other mechanisms including interactive learning between different organisations involved in the innovation processes, 8) creating and changing institutions, 9) incubating activities including providing access to facilities and administrative support, 10) financing of innovation processes and other activities that can facilitate commercialisation of knowledge and its adaptation, and 11) provision of consultancy services of relevance for innovation process.

National Innovation Systems (NIS)

Freeman (1987) defined NIS as "the network of institutions in the public and private sectors whose activities and interactions initiate, import, and diffuse new technologies" (Freeman, 1987: 1). Within NIS, components, relationships among them, functions and activities are all important constituents of the system. Organisations and institutions are considered to be the main components of systems of innovation as illustrated in figure 2. Organisations are defined as actors within the system such as firms, universities, public agencies responsible for innovation policy and competition policy, and formal structures that are consciously created and have an explicit purpose (Edquist and Johnson, 1997: 46-47). Institutions are defined as "sets of common habits, norms, routines, established practices, rules, or laws that regulate the relations and interaction between individuals, groups, and organisations" (Edquist and Johnson, 1997: 46), such as patent laws as well as rules and norms influencing the relations between firms and universities.

Figure 2 Main Actors in Conventional National Innovation Systems (NIS)



The NIS in a newly industrialised country like Malaysia should be examined in terms of two analytical frameworks (Kim, 1997): the global technology environment and the institutional environment. The global technology environment suggests that industries and firms in industrialised countries evolve along a technology trajectory with the following stages: fluid, transition, and specific (Utterback, 1994). Some studies (Kim, 1980, 1993, 1997; Lee et al, 1988) indicate that Korean firms entered the specific stage of the technology trajectory in the 1960s and 1970s, acquiring and assimilating labour intensive, mature foreign technologies. Imitation was the focus of industrial efforts during this period. After this, Korea progressed in the reverse direction towards the transition stage in the 1980s, acquiring and assimilating increasingly knowledge-intensive foreign technologies. Some selected industries even entered the fluid stage in the 1990s to compete neck-and-neck with leading advanced countries, which showed technological innovation is the centre of those industries. Therefore, the NIS must evolve in response to the changes that occur in technology trajectory (Kim, 2000). The institutional environment provides the various economic actors and other elements that influence technological learning in the NIS (Kim, 1997; Lundvall, 1992; Nelson, 1993). They include 1) the government and its policies, 2) the dynamics of the industrial structure, 3) the availability and quality of the educational system, 4) R&D infrastructure and its role, 5) the changing nature of socio-cultural factors, 6) buyers and suppliers in the international and domestic markets, 7) national R&D investment, 8) corporate management, and 9) the interactions among them. An analysis of the NIS must examine the effectiveness of these actors and elements and their interactions along the evolution of the technology trajectory. The literature on NIS emphasises the importance of strong linkages among these various institutional environment as well as organisations in improving national innovative and competitive performance, and this emphasis can apply in particular to the relationships between firms (TNC subsidiaries and local suppliers), universities and government institutes within NIS. The NIS are a complex combination of institutions that support learning processes and technological accumulation.

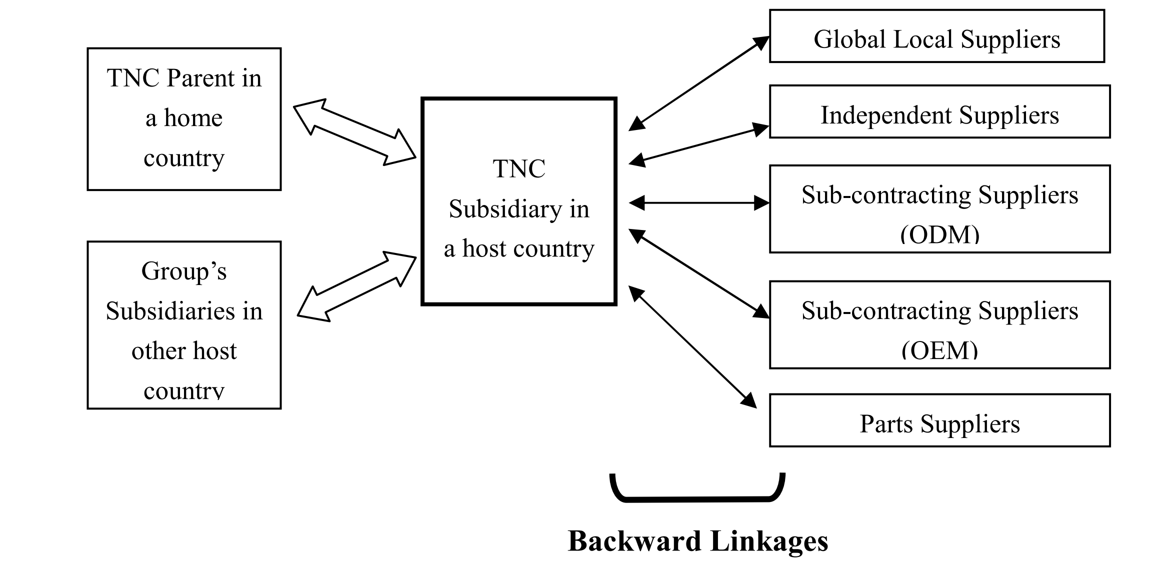
4. Backward Linkages within the National Innovation Systems

NIS are a complex combination of institutions that support learning processes and technological accumulation. Since interaction between firms is crucial institutional framework, this section presents issues of inter-organisational linkages, with particular attention to the relationships between TNC subsidiaries and local suppliers, called backward linkages, in host developing countries.

Key Concepts of Backward Linkages

When a TNC subsidiary proceeds to FDI and establishes a subsidiary in a host country, the latter creates inter-organisational linkages. Backward linkages refer to all the relations established with supplier firms, whereas forward linkages describe the relations established with the customers in the host country or in the global market. Therefore, backward linkages exist when TNC subsidiaries acquire goods or services from local suppliers. Lall (1980) defines linkages as "the direct relationships established by firms in complementary activities which are external to 'pure' market transactions (i.e. anonymous buyers and sellers exchanging goods in discrete transaction at prices determined in competitive markets.)"(204). Backward linkages are a channel by which TNC subsidiaries transfer their technology and knowledge, and create spillovers so that local suppliers can acquire modern technologies as well as new management or organisational practices from subsidiaries. Several works have treated backward linkages and resulting spillovers (O'Brien, 1993; Halbach, 1989; Fleury et al., 1994; Supapol, 1995; Rasiah, 1995; Wong, 1991; IDE, 1994; Capannelli, 1997; Ariffin, 2000; Giroud, 2001, 2003; UNCTAD, 2001). Through backward linkages, local firms can gain beneficial spillovers from subsidiaries. Figure 3 shows different organisational linkages, and focuses on backward linkages between TNC subsidiaries and different types of local suppliers discussed earlier, namely Parts Suppliers, Sub-contracting Suppliers (OEM), Sub-Contracting Suppliers (ODM), Independent Suppliers, and Global Local Suppliers.

Figure 3 Backward Linkages



Source: Adopted from UNCTAD(2001); derived from research

We assume that one of the most important forms of backward linkages between subsidiaries and local suppliers is the technological relationship since technological learning of local suppliers is a key issue in this research. TNC subsidiaries need to ensure that the parts, components or products procured meet their precise requirements and, therefore, they need to provide the necessary specifications to their local suppliers. In addition, they may transfer related technologies to the suppliers if the suppliers do not possess technologies which are necessary for subsidiaries. Such technologies are related to product and process know-how, including proprietary knowledge,[4] and organisational and managerial know-how as well as

[4] Proprietary knowledge refers to product and/or process know-how developed and owned by an affiliate and is

technical assistance of various kinds. Whether and to what extent such technology flows take place depends on the benefits perceived by a TNC subsidiary for its own operations, since they incur costs when providing linkages; subsidiaries weigh these costs against the benefits such as improved quality, reduced costs and/or improved delivery conditions of a supplier's products.

Important aspects of backward linkages for local suppliers are acquiring spillovers and gains through interaction with TNC subsidiaries. As suggested by Lundvall (1988) and Von Hippel (1988) the accumulation of knowledge takes place not only by developing and employing local suppliers' internal capabilities but through learning by interaction with a wide variety of sources, such that local suppliers interact with several external organisations such as technology producers and TNC subsidiaries. Backward linkages are particularly important for local suppliers in host developing countries because linkages provide opportunities for production and employment in local suppliers, and because they constitute a direct channel for knowledge diffusion. Backward linkages can become substantial channels for transferring knowledge and technological and other capabilities to local suppliers, with spillover effects on the rest of the economy (Giroud, 2003; UNCTAD, 2001). Hence, backward linkages lead to an upgraded technological level through accumulation of technological capability of local suppliers.

Determinants and Motivation of Backward Linkages

Although the existence of backward linkages is necessary for local suppliers' technological learning, we need to clarify mechanisms and forces behind the existence of backward linkages. To do so, the process through which TNC subsidiaries conduct backward linkages in host countries, and the motivation of backward linkages provide by TNC subsidiaries are discussed.

TNC subsidiaries' motivation for backward linkages is extended if and when they are expected to yield a positive (and competitive) gain, since we assume TNC subsidiaries are the ones who initiate backward linkages. The intensity of backward linkages depends on subsidiaries' motivations and their strategies on product range, market scope, and sourcing activities. If subsidiaries are targeting the local market, they generally employ lower technology than export-oriented subsidiaries because of lower quality requirements and technical specifications especially in host developing countries. Although scholars such as Ganiatsos (2000) and Carilo (2001) argue that TNC subsidiaries are more likely to be integrated with local suppliers and host countries where they source relatively simple inputs, some suppliers in host developing countries already possess technology to produce simple inputs which implies arms-length relationship rather than

---

usually protected through a patent, copyright, industrial design or trade secret.

backward linkages. On the other hand, Rodriguez-Clare (1996) argues that subsidiaries create more linkages when they use intermediate goods intensively, and the home and host markets are relatively similar in terms of intermediate products. It suggests that as technological level of suppliers upgraded and suppliers can produce relatively similar intermediate products, level of backward linkages is intensified.

In the EE industry, the potential for backward linkages is broad, depending on the extent of the type of manufacturing products, the type of production processes, and the type of intermediate inputs. The type of product is determined by either the parent TNC or subsidiaries in a host country depending on their strategy, and their product ranges change over time depending on the shift of their strategies. Traditionally, subsidiaries internalise their production process for products technologically similar to their main production, simple products, or similar but very capital-intensive products. These products will be outsourced as local suppliers' technological capabilities develop and the cost advantages of outsourcing become higher.

The characteristics of product components or inputs which are outsourced depend on the type of final products. If subsidiaries in host developing countries have experience with matured technology, there is less need for the subsidiary to provide assistance to its suppliers (Supapol, 1995). Primary attention by subsidiaries is typically given to a limited number of key suppliers which are provided the most complex and strategically important inputs, the production of which requires close interaction with subsidiaries. Highly ranked suppliers receive larger and higher value-added orders, along with greater technical assistance and know-how. Therefore, the intensity of backward linkages by TNC subsidiaries can be categorised according to the area of technology involved which results from ranges of final products produced by subsidiaries.

Once subsidiaries engage in backward linkages, the ultimate objective usually is to expand the number of suppliers that meet the requirements of subsidiaries in terms of cost, quality and timely delivery, and/or to help existing suppliers improve their capabilities in one or more areas. For some subsidiaries, efforts to upgrade supplier activities are part of a corporate strategy taking broader economic and social considerations into account.[5] The intensity of backward linkages also depends on the relative technological capabilities of TNC subsidiaries and local suppliers. Lall and Narula (2004) assume that the greater the gap between them, the lower the intensity of linkages. The extent of the intensity of backward linkages by subsidiaries to their local suppliers is likely to be greater the more they are committed to long-term relationships with their suppliers, the greater the technical complementarity between the activities of the subsidiaries and their

[5] From interviews in 2001 & 2002.

suppliers, and the more specialised or custom-made (rather than standardised) the components or products supplied are. The size of a foreign subsidiary, the type of products manufactured and procured, and the subsidiaries' strategy also positively influences the extent of backward linkages.[6] Other factors influencing the nature of backward linkages relating to technology transfer include factors related to host countries' level of development, support institutions and business environment, as well as factors related to suppliers' technological capabilities, and their willingness and ability to adopt new technologies. Linkages increase over time as the skill level of local entrepreneurs grows, new suppliers emerge and local content increases (Driffield and Noor, 1999; Noor 1999, Gorg and Ruane, 1998; Scott-Kennel and Enderwick, 2001).

The Impact of Backward Linkages on the Firms

Possible Gains and Benefits of Backward Linkages

Backward linkages are considered to be important for TNC subsidiaries, so that they can successfully procure parts and components locally in a host country in which production costs are likely to be lower than imports. Local suppliers can also benefit from linkages with TNC subsidiaries, as they can increase their production and technological capabilities, and maintain employment through relationships with subsidiaries. Strong linkages can promote production efficiency, productivity growth, technological and managerial capabilities and market diversification in local suppliers.[7] As local suppliers create linkages with TNCs subsidiaries, suppliers cannot only expand their marketing scope to foreign affiliates in the host country, but also promote the direct export of their products. Some suppliers successfully become global local suppliers after having linkages with subsidiaries for many years. The benefit for host countries is studied in UNCTAD (1995, 1999), ILO/UNCTC (1984, 1988) and Supapol (1995); broader benefit for host developing countries are explored in Lim and Pang (1991), and Fukushima and Kwan (1995).

Possible Benefits for Local Suppliers

Technology and knowledge transfer through backward linkages have long been known as beneficial to the host country (ILO/UNCTC, 1984, 1988; Supapol, 1995), especially in host developing countries. These transfers comprise transfer of technology and know-how from subsidiaries to suppliers, and also may benefit suppliers via long-term relationship building and the exchange of information. Supplier development activities improve suppliers' costs, quality, delivery performance and cycle time (Handfield et al., 2000).

Local suppliers, for their part, may also assist subsidiaries by suggesting technical improvements for

---

[6] See Giroud, 2000 and Halbach, 1989; Supapol, 1995; Gultom-Siregar, 1995; and Wong, 1991.

[7] UNCTAD (2001 p129) reports that most of interviewed local suppliers also mentioned the same benefit from linkages.

fine-tuning the latter's products or providing localised knowledge. Therefore, mutual interaction in technology involving two-way flows is likely to take place mainly in developed countries where subsidiaries and suppliers possess comparable levels of technological competence. In developing countries, given the existence of a technology gap between them, knowledge exchanges are expected to flow from the subsidiaries to local suppliers. To the extent that this happens, it can have a significant impact on the suppliers' operations in terms of improved productivity, lower costs of production and/or enhanced product quality. These effects may, in turn, enable supplier firms to expand their supply activities, including to other foreign affiliates located in the country or even to the export market.[8]

Possible Costs or Problems of the Linkages

Forming and maintaining backward linkages involve costs and risks for subsidiaries, which substantially vary according to local suppliers' capabilities and infrastructure. This is why a subsidiary making the same product in different host countries may have very different local sourcing patterns. Local linkages, especially with domestic firms, rise with the level of local development, particularly with complex technological activities. It is more likely that foreign affiliates source from local suppliers and engage in supplier development when the technological and managerial gaps between them and their local suppliers are not very wide. Furthermore, whether supplier development programmes are effective or not depends not only on efforts made by foreign subsidiaries, but on the efforts made by local suppliers. It is obvious that, in order for linkages to be favoured and for assistance through linkages to contribute to an improvement in the competitiveness of local suppliers in a host country, strong commitment on the part of the suppliers is required.

Subsidiaries' costs for establishing backward linkages arise from the launching, training and monitoring of small suppliers, and the monopolistic price advantage enjoyed by certain large suppliers. As far as society at large is concerned, if subsidiaries decide to import components or internalise component production rather than farming it out, employment and 'learning' opportunities would be lost to the economy. The social costs of linkage creation arise from the initial inefficiencies of forcing the pace of subcontracting, and from the risk of anti-competitive collusion by the linked enterprises.

Development of Analytical Framework: Forms of Backward Linkages

The upgrading technological level, knowledge level, and managerial skills can take a long time and are not easy to be achieved. There are various ways in which backward linkages between subsidiaries and

[8] One-way relationships, in which a foreign affiliate provides specifications to its suppliers without any "joint" research, planning or development on how to produce, tend to be more fragile compared with the more sophisticated two-way relationships that involve a more intense buyer and supplier interaction.

suppliers can be formed and strengthened. In order to assess the level of benefits realised, the level of technology acquired, and the level of capability absorbed, we examine the forms of linkages that can be taken between subsidiaries and suppliers.

We expect that tacit assets such as technology, knowledge, and managerial skills flow from a subsidiary to linking local suppliers through backward linkages of different qualities. Backward linkages take several different forms, namely 1) pure market transactions, 2) short-term linkages, and 3) long-term linkages (UNCTAD 2001, p131). Compared to pure market transactions and short-term linkages, long-term linkages are often preferred by local suppliers and beneficial for suppliers. Therefore, we focus on a form of long-term backward linkages which are assumed to influence the development paths of a supplier's technological activity. Long term linkages mean long-term buyer-supplier relationships, such as contractual arrangements for the procurement of inputs, and subcontracting of the production of intermediate or final products. Within long-term linkages, different types of linkages within the backward linkages exist. In order to assess the quality of backward linkages and how these assets flow from a subsidiary to suppliers, possible forms of linkages are divided into seven categories according to issues relating what a subsidiary can offer for local suppliers.[9] They are categorised into 1) Marketing/Purchasing linkages[10], 2) Product technology related linkages[11], 3) Process technology related linkages[12], 4) Training linkages[13], 5) Innovation/Collaborative linkages[14], 6) Managerial and Organisational linkages[15], and 7) Other linkages[16], as noted figure 4. In each form of linkage, a subset of categories relating technology or knowledge flows can be derived according to the areas of technology involved.

[9] Compiled and modified from Lall (1980), UNCTAD (2001), Arrifin (2001), and Giroud (2003)

[10] This is centred only on market transactions and considered with subsidiaries' purchases of parts or components through the existing market in the host economy.

[11] Items contain in the index are proprietary knowledge, product design and technical specifications, technical consultation, feedback

[12] Items contained in the index are machine-embodied process technology, technical support on process related activities, visits suppliers by subsidiaries to provide process related advice, subsidiaries send their engineers to suppliers

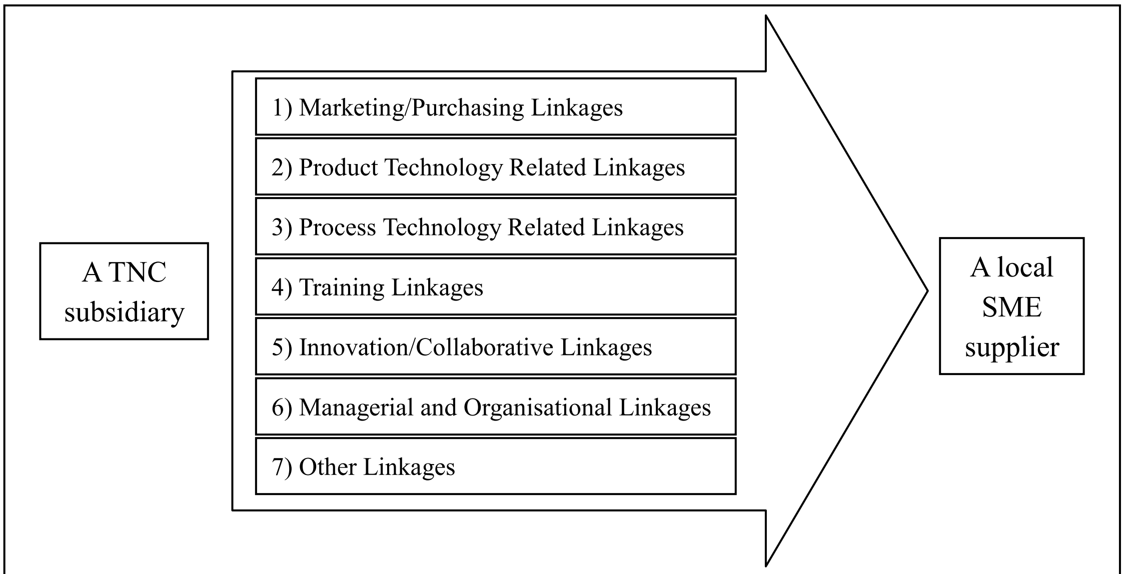
[13] Items contained in the index are training of suppliers' employees by suppliers, training of suppliers' employees by subsidiaries, attendance of suppliers' external training programme

[14] Items contained in the index are collaboration with subsidiaries, collaboration with local universities, assistance or support in product designing know how by subsidiaries

[15] Items contained in the index are assistance in adopting inventory management systems such as JIT, assistance in implementing quality control systems and ISO certification, introduction of new management or organisational practices

[16] Items contained in the index are existence of intermediaries, funding for training of suppliers' employees, suppliers' clubs or meetings with suppliers

Figure 4 Forms of Backward Linkages



Source: Complied and modified from Lall (1980), UNCTAD (2001)

5. Presentation of Hypotheses and Research Methodology

We have presented theoretical reviews of the analysis of technological innovative activities, technological learning, and innovation-related linkages between TNC subsidiaries and local suppliers in developing countries. From these literature reviews we derive our hypotheses. They are divided into null hypotheses on TNC subsidiaries, local suppliers, backward linkages, and environmental factors.

Hypotheses on Local Suppliers Technological Capability

Linkages are a channel by which TNC subsidiaries transfer their technology and knowledge, and create spillovers so that local suppliers can acquire modern technologies as well as new management or organisational practices from subsidiaries. Several studies have done research on backward linkages and resulting spillovers (O'Brien, 1993; Halbach, 1989; Fleury et al., 1994; Supapol, 1995; Rasiah, 1995; Wong, 1991; IDE, 1994; Capannelli, 1997; Ariffin, 2000; Giroud, 2001; UNCTAD, 2001). Spillovers occur when local firms benefit from the TNC subsidiary's superior knowledge of product or process technologies or markets, without incurring a cost that exhausts the whole gain from the improvement (Blomström et all, 2000). Through backward linkages, local firms can gain beneficial spillovers from subsidiaries. The hypothesis therefore becomes:

> Null Hypothesis 1: Local supplier's technologically innovative capability is affected by backward linkages.

In addition to the main issues we also examine internal factors affecting suppliers' technological capabilities:

Null Hypothesis 2: Innovative technological capability is affected by supplier's internal factors

The literature on NIS emphasises the importance of strong linkages among these various institutions in improving national innovative and competitive performance, and this emphasis can apply in particular to the relationships between firms (TNC subsidiaries and local suppliers), universities and government institutes within NIS. The role of governments as a market facilitator and provider of complementary assets is more critical (Narula, 2003). Our hypothesis becomes:

Null Hypothesis 3: Linkages with local universities affect local supplier's technologically innovative capability.

The nature of location advantages determines the ability of the domestic economy to absorb spillovers from TNC subsidiaries. If suppliers in developing countries have absorptive capacity, they can capture knowledge that exists as externalities, such as spillovers from TNC subsidiaries (Lall and Narula, 2004). Thus hypothesis is presented as follows.

Null Hypothesis 4: Local suppliers located in Penang have a different level of innovative technological capability than those located in Selangor.

Null Hypothesis 5: Government programmes have a positive effect on innovative technological capability of local suppliers.

In order to answer these research questions, we will identify the following issues:

1) TNCs' corporate strategies regarding subsidiaries to determine subsidiary typology
2) The technological capability level of local suppliers to determine supplier typology
3) The local institutions that affect industrialisation of local suppliers

Thus we can look at inter-organisational linkages between local suppliers and subsidiaries, and between local suppliers and local institutions, e.g. local universities and government programmes, and examine how these affect backward linkages. In order to answer these questions, we use descriptive statistics and quantitative analysis based on responses obtained from interviews.

Research Methodology

The Malaysian EE industry is the targeted population under the survey. The EE industry consists of two related industries, namely the electronics and electrical industries. The EE industry cluster consists of 1) semiconductors and other components, 2) computers and peripherals, 3) telecommunications equipment, 4) consumer electronics, and 5) Electrical appliances. We picked relevant product groups up from manufacturing categories and found that divisions 25, 27, 28, 29, 30, 31, and 32 are appropriate for the population of EE industry for TNC subsidiaries sample. Key suppliers for these core industries are categorised as 6) tool and die, 7) metal stamping, casting or machining, 8) chemicals, and 9) machinery and equipment.[17] The following table summarises core industries and key suppliers in EE cluster in Malaysian manufacturing.

Table 1 Core Industries and Key Suppliers in the EE industry

Core Industries	1) Semiconductors and Other Components	Microprocessors, Memory devices, Microcontrollers, Programmable memory chips (EPROMs and Flash), Liquid crystal displays (LCDs), Optoelectronics, Printed circuit boards (PCBs), Chip-on-board, Silicon wafers, Lead frames, Cathode ray tubes (CRT)
	2) Computer and Peripherals	Desktop computers, Notebook computers, Monitors, Motherboards, Memory boards, Hard disk drives (HDD), Floppy disk drives (FDD), Removable disk drives, Thin-film media (hard disk), CD-ROMs, UPS, LAN and WAN, Network devices, Printers
	3) Telecommunications Equipment	Switching and transmission equipment, telephones including cordless phones, smart phones, walkie-talkies, Digital telephone and answering machine (TAM), Mobile communication (PCN, GSM), Modems, Fax machines, Cables, Fibre optics
	4) Consumer Electronics	Colour television, Receivers, Flat screen television, Video players, VCRs, DVDs, Video cameras, Audio products, Digital audio-visual, Electronic games
	5) Electrical Appliances	Air conditioners, Washing machines, Refrigerators, Irons, Fans, Cookers, Vacuum cleaners, Ovens, Blenders, Motion detector lighting
	6) Electrical Industrial Apparatus	Switchgears, Electric motors, Transformers, Inductors, Circuit breakers, Power transmission equipment and parts, Voltage regulators, Generators
Key Suppliers	7) Tool and Die	Mould and die design, Precision turned parts for printers, fax, computers, Precision semiconductor tooling, hard disk industrial precision fixtures, Precision cavity mould, precision chip pallet, IC trays,
	8) Metal stamping, casting or machining	Metal stamped parts for disk drives, computers, audio-visual, telecommunication, and consumer electronics products, Die casting and Machined parts
	9) Chemicals	High precision injection for parts and components, Engineering thermoplastic parts and components for consumer electronics and disk drives.
	10) Machinery and Equipment	Fabrication of material handling equipment (e.g. conveyors), Pick and place, Laser marking, trim and form, auto-moulding equipment, PCBA equipment, Back-end chip assembly and test equipment.

Source: Adapted from Department of Statistics (2000) "Malaysia Standard Industrial Classification 2000"

[17] MITI(1996) also includes electrical industrial apparatus as a core industry and packaging and services as key suppliers. (p76-77)

Industrial Clusters and Industry Groups in the EE Industry

In Malaysia, firms are concentrated in a few major locations. Since most foreign subsidiaries are located in Free Trade Zones which are provided by Malaysian government, the regional location of subsidiaries are rather concentrated in Selangor state (33.6%), including Klang Valley, Shah Alam, Bangi and Kuala Lumpur, Johore State (17.9%), and Penang State(16.3%) including Prai, and Kedah area (MIDA 2000). From the regional distribution index given by MITI and numbers of subsidiaries offered by MIDA, the two states of Selangor and Penang were selected as the target locations for samples.

Sample Design

The main target of the empirical part of this research is to collect information from a statistically sufficient number of case studies in order to obtain detailed qualitative and quantitative information so that specific questions can be tested. Questions are centred on the following: whether a local supplier's technological capability level has been developed; whether any of forms of backward linkages show strong effects on the technological development path of suppliers (depth and length of backward linkages); and whether any exogenous factors strongly affect the quality of backward linkages while other things remain equal. These tests would help generalise whether there were differences in the speed of learning, whether there were differences in the depth and length of backward linkages, and what factors contributed to higher levels of technological capabilities and different types of backward linkages.

First of all, firms were identified and selected from the Selangor and the Penang areas since these areas have the highest concentration of employment and are the well-established areas in the EE industry in Malaysia, as explained earlier. The selection of the two most established locations would also allow us to test the importance of location and industrial clustering. Secondly, in terms of the type of product surveyed, since the EE industry in Malaysia consists of electronics and electrical products and components sectors, as well as the equipment, metal and plastic supporting sectors, firms under the research were selected from these sectors. Thirdly, since the nature of inter-organisational linkages is an important part of the research, the sample is comprised of firms from the TNC subsidiaries and local SME suppliers who are sourcing to subsidiaries and local independent suppliers who are already developed and used to be SME suppliers.

Identification of local suppliers through subsidiaries

Local suppliers were identified through introduction by all interviewed TNC subsidiaries. As a result, we had 120 local suppliers in total. The function of some introduced suppliers was not relevant for the research, hence, the final number of the identified local suppliers was 112. Of these suppliers, 24 suppliers were directly interviewed, 18 in Selangor and 6 in Penang.

Methods of Data Collection

This research used direct interviews with managers in the purchasing department, engineers, and company directors in order to a) analyse TNC subsidiaries' production and outsourcing strategies, b) capture the nature of local suppliers' technological learning from TNC subsidiaries, and c) to provide insights into the depth, timing, duration, mechanisms and determinants of backward linkages. The main purpose of the questionnaire for TNC subsidiaries was to generate a qualitative understanding of the extent of strategies among subsidiaries in Malaysia over time.

In order to capture all aspects of linkages in this research, face to face interviews were thought to be the most appropriate. The responses to the questions were qualitative in nature and were restricted to either binary, duration, or five point likert scales (e.g. response values ranged from 1 – high degree of control to 5-no control at all, and so on) depending on the nature of the questions. The questionnaire to TNC subsidiaries was divided into 4 sections: 1) Company's external linkages[18], 2) Issues of Backward linkages[19], 3) Cost and benefits of having linkages with local suppliers[20], and 4) Issues of subsidiary's autonomy[21].

Realising the importance of the role of subsidiaries in backward linkages, the questionnaire instrument was also designed to accommodate responses from suppliers' points of view. In doing so, the interview tried to overcome the biases (that many studies have been subject to) of using the responses of TNC subsidiary alone. The questionnaire to local suppliers was divided into 3 sections which correspond to the questions for TNC subsidiaries: 1) Company's external linkages[22], 2) Issues of backward linkages[23], and 3) Benefit of having linkages with TNC subsidiaries[24].

---

18 This section asked questions relating to strategy of the subsidiary in the group including expected performance within the corporate group, objectives of initial FDI, outsourcing activity, and levels of imports and exports.

19 This section asked questions on the aspects of backward linkages the subsidiary was offering or providing over time. The section was divided into 6 sub-sections namely, product technology-related linkages, process technology-related linkages, training / skill linkages, innovation / collaborative linkages, managerial and organisational linkages, and any other forms of linkages if they provided examples. It also asked questions regarding duration of these linkages.

20 This section questioned the costs and benefits of having linkages with local suppliers in order to measure the subsidiary's perception of performance of local suppliers over time. It also asked if they saw any improvement in suppliers' performances after having linkages with them.

21 This section included the most critical questions in making judgement of competence-creating or competence-exploiting subsidiary. It asked whether the types of decisions made by a subsidiary are freely made or whether they have to ask permission to the parent company in order to see the level of autonomy of a subsidiary.

22 This section asked questions on their customer in Malaysia and outside Malaysia (Export), including the distribution of different nationalities of ownership.

23 This section asked questions on the types of backward linkages which the supplier received from linked subsidiaries over time. The section was divided into 6 sub-sections, namely, product technology-related linkages, process technology-related linkages, training / skill linkages, innovation / collaborative linkages, managerial and organisational linkages, and any other forms of linkages if they received them. It also asked questions regarding the duration of these linkages.

24 This section asked questions relating to perceptions on their own improvements and benefits they received

Summary of Data

The total responses of the interviews with subsidiaries was 46, of which the US accounted for 10, EU for 7, Japanese for 15, other Asian for 10 and Co-ownership for 4 (Table below).

Table 2 Summary of Number of TNC subsidiaries participated in the interviews

Location	US	EU	Japan	Other-Asian	Co-Ownership	Total
Selangor	6	4	13	6	4	33
Penang	4	3	2	4	0	13
Total	10	7	15	10	4	46

The total number of local suppliers interviewed was 24 (Table below). The nationality shown in the table indicates nationality of the company which introduced these local suppliers to us.

Table 3 Summary of Number of local suppliers participated in the interviews

Nationality of ownership who introduced suppliers	US	EU	Japan	Other-Asian	Co-Ownership	Total
Selangor	2	2	9	2	3	18
Penang	4	1	-	1	-	6
Total	6	3	9	3	3	24

6. The Results of Qualitative and Quantitative Analysis on Local Supplier Typology

Qualitative Analysis: Findings of Local Supplier Typology

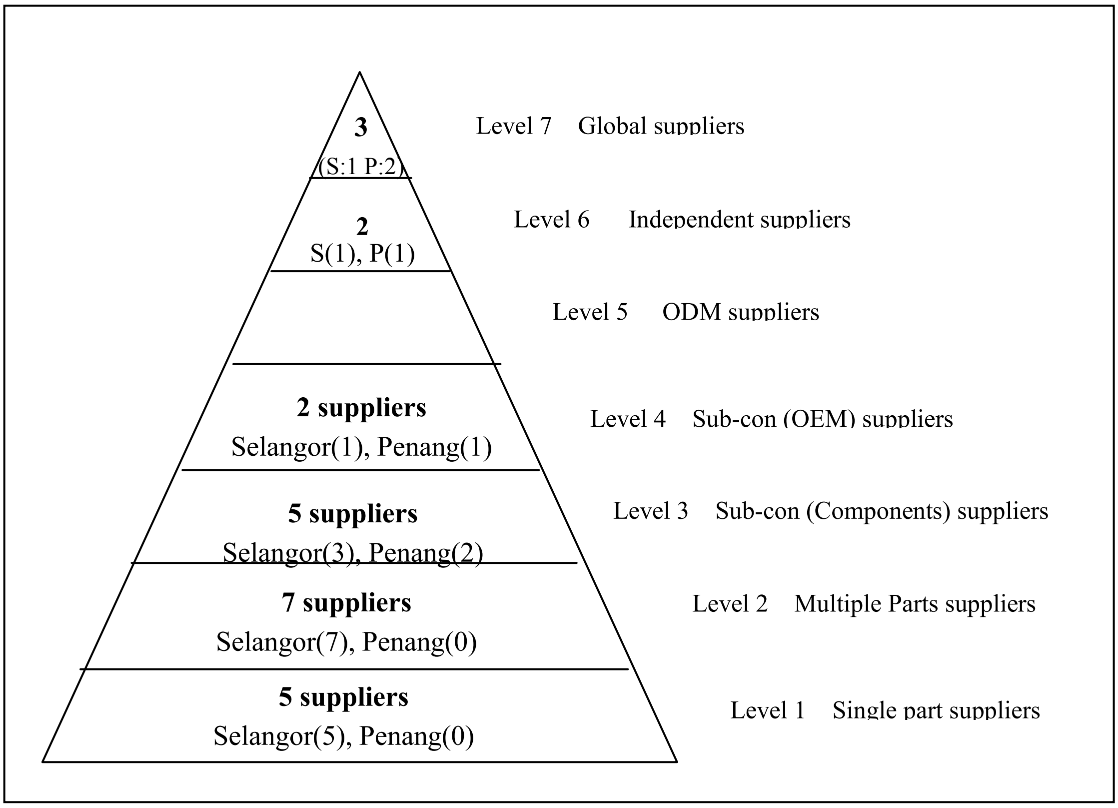
The responses of 24 sampled suppliers were carefully examined, resulting in the following results for local supplier typology. Out of the 24 suppliers, there are 3 global suppliers who are actively exporting with their own export channel and have OBM capability, followed by 2 independent suppliers with R&D capability to develop their own products. There are no ODM suppliers who have not yet achieved at the level corresponding to level 6. There are 2 subcontracting suppliers who are actively manufacturing OEM products for subsidiaries, followed by 5 suppliers of subcontracting suppliers who are manufacturing OEM components. Twelve suppliers are parts suppliers, and 7 out of 12 are multiple parts producers and 5 are single parts producers. This section provides analysis of the technological level, technological learning, and technological upgrading of local suppliers within the framework of the supplier typology. We focus on product sector with which suppliers are involving as well as product sector in which linking subsidiaries are categorised.

---

from subsidiaries. It also asked questions on the most beneficial factors affecting their technological activity and the most significant training which they received from subsidiaries.

Since we assume that influences of a linking subsidiary's strategy affects motivation of providing backward linkages and technological level of local suppliers, we also present a result of subsidiary typology of linking subsidiaries. The subsidiary typology is divided into 4; namely, truncated miniature replica (TMR), rationalised product subsidiaries (RPS), regional product mandates (RPM) and world product mandates (WPM).[25]

Figure 5 The results of technological abilities of local suppliers



Parts suppliers (Level 1 & 2)

Figure 6 presents five level 1 suppliers' period of entering to the EE industry, while table 5-1 describe product sector of suppliers and linking subsidiaries. All 5 suppliers had previous experience and knowledge on the technology which linking subsidiaries required. Since all of the 5 suppliers started their operation, they have been single parts producers although there were some modifications to their production process. From managers' points of view, they have not really found themselves experiencing technological learning from subsidiaries and technological development, although they admit that they are experiencing cost reduction on the same parts. This is because their technology required for supplying subsidiaries is very simple. Since all suppliers have been capable to meet subsidiaries demand from the beginning of

[25] Details of each typology are provided in Cantwell and Iguchi (2005).

establishment (because they were ex-employees), only one has been receiving training from their Japanese subsidiary (RPM) continuously while other 4 suppliers do not usually receive training from subsidiaries. RPS subsidiary which links with S-1 suggests that it does not teach or provide technical assistance to S-1, but let it produce what it can. Subsidiaries of S-1, S-14 and S-4 suggest that they provide weak linkages not only for them but also for other suppliers in general.

Figure 6The period of entering EE industry (Level 1 suppliers)

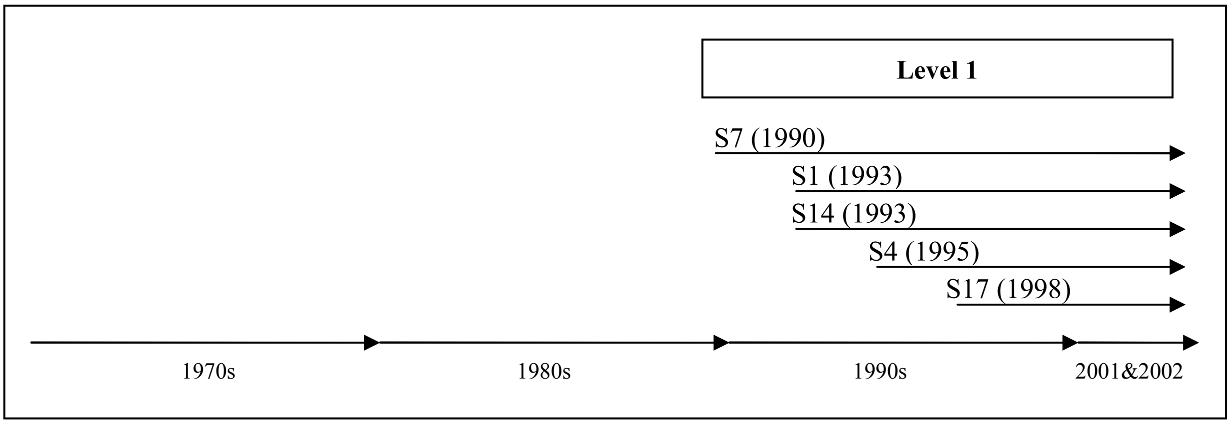


Table 4 Product Sector of Level 1 Suppliers

	Suppliers' Product Sector	Linking Subsidiaries' Product Sector	Linking Subsidiary's Type
S7	9) Chemicals	5) Electrical Appliances	RPM
S1	7) Tool and Die	1) Semiconductors and Other Components	RPS
S14	8) Metal stamping, casting or machining	5) Electrical Appliances	TMR
S4	9) Chemicals	1) Semiconductors and Other Components	RPS
S17	9) Chemicals	4) Consumer Electronics	WPM

The following figure shows the establishment period of suppliers and period of upgrading their technological level from 1 to the current level 2, which was observed from the survey responses.

Figure 7 The period of entering EE industry (Level 2 suppliers)

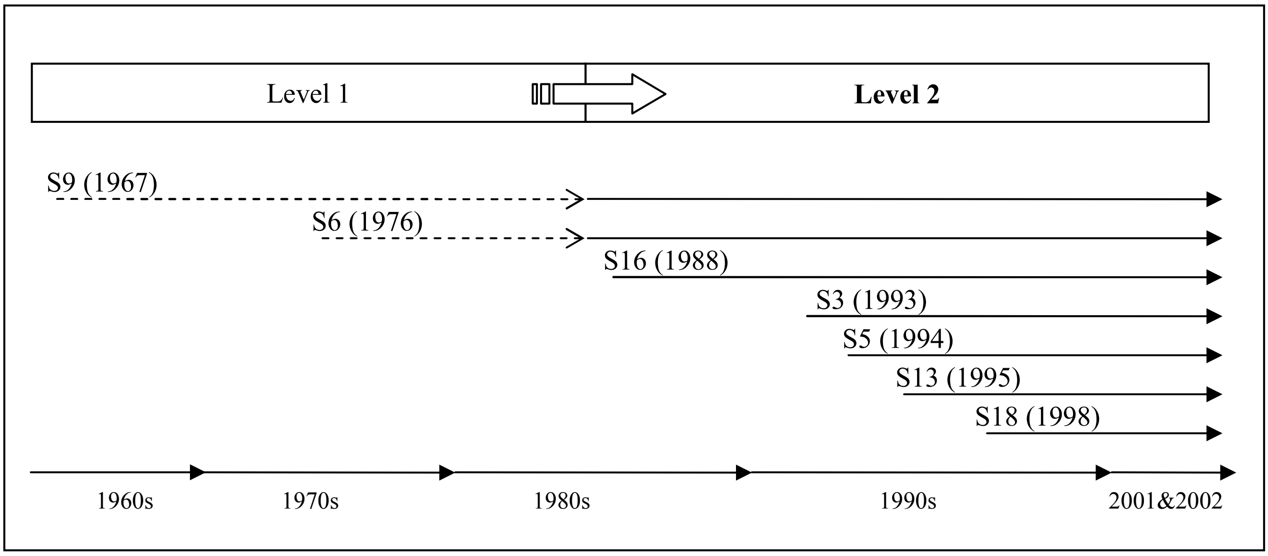


Table 5 Product Sector of Level 2 Suppliers

	Suppliers' Product Sector	**Linking Subsidiaries' Product Sector**	**Linking Subsidiary's Type**
S9	9) Chemicals	5) Electrical Appliances	WPM
S6	7) Tool and Die	1) Semiconductors and Other Components	RPS
S16	8) Metal stamping, casting or machining	4) Consumer Electronics	WPM
S3	7) Tool and Die	4) Consumer Electronics	RPS
S5	9) Chemicals	1) Semiconductors and Other Components	RPS
S13	8) Metal stamping, casting or machining	6) Electrical Industrial Apparatus	RPS
S18	8) Metal stamping, casting or machining	4) Consumer Electronics	WPM

Although all 7 suppliers are producing simple parts and components, all of them have sub-contracting arrangement with subsidiaries. However, we can not call them "sub-con" suppliers due to the nature of their manufacturing products. A supplier has been actively trying product development on parts related products for 8 years. There are 3 suppliers who have collaboration with TNC subsidiaries on parts. However, they were collaborating are plastic or metal parts, since with these suppliers' technological capabilities, suppliers could not manufacture upgraded process-related products at the time of the interview. One of these three suppliers had R&D facilities for 10 years, and the other 2 for 6 years. One of the suppliers with R&D facilities started product design 3 years ago. Four suppliers are exporting their parts directly to subsidiaries with 1% of their production, and 3 suppliers answered 2%, but without involving a new export channel. The parts are ordered from foreign subsidiaries' sister companies outside Malaysia. Their technological capability is limited to manufacturing of parts and components.

Sub-Contracting Components Suppliers and OEM suppliers (Level 3 & 4)

Four suppliers out of 5 have R&D facilities; two suppliers with 3 years experience, and one supplier each with 4 years and 7 years experience. Product development has been implemented by one supplier for 5 years. Three suppliers are actively collaborating with subsidiaries for one year. Product design is not yet tried by any of these suppliers. Four suppliers are directly exporting their components with 5%, 10%, 10% and 25% shares, respectively.

Figure 8The period of entering EE industry (Level 3 suppliers)

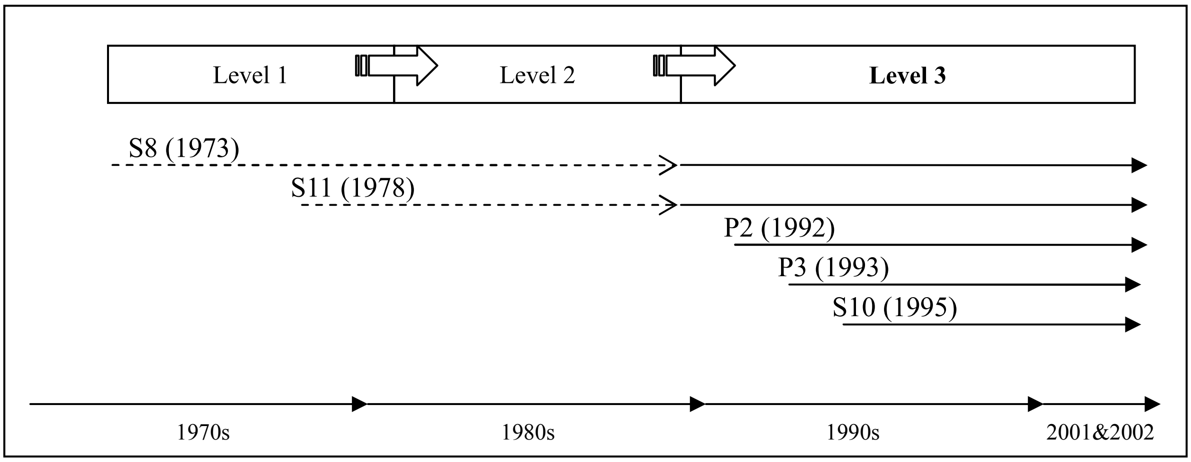


Table 6 Product Sector of Level 3 Suppliers

	Suppliers' Product Sector	Linking Subsidiaries' Product Sector	Linking Subsidiary's Type
S8	7) Tool and Die	5) Electrical Appliances	RPM
S11	7) Tool and Die	5) Electrical Appliances	RPS
P2	7) Tool and Die	3) Telecommunications Equipment	RPM
P3	8) Metal stamping, casting or machining	1) Semiconductors and Other Components	RPS
S10	8) Metal stamping, casting or machining	5) Electrical Appliances	WPM

There are two level-4 suppliers in our sample. At the time of interview, both of them were not components sub-contractors, but acted mainly as OEMs with active collaboration with subsidiaries. One of them has had R&D facilities for 2 years. Neither of them is involved with product design. All designs are done by subsidiaries. These suppliers do not export their products, but supply to subsidiaries in Malaysia.

Figure 9 The period of entering EE industry (Level 4 suppliers)

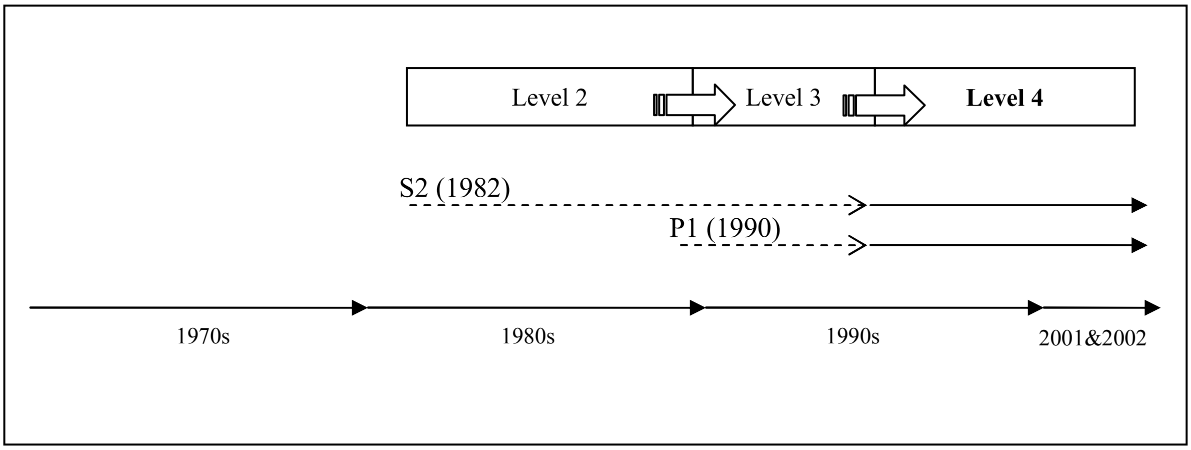


Table 7 Product Sector of Level 4 Suppliers

	Suppliers' Product Sector	Linking Subsidiaries' Product Sector	Linking Subsidiary's Type
S2	8) Metal stamping, casting or machining	5) Electrical Appliances	WPM
P1	8) Metal stamping, casting or machining	2) Computer and Peripherals	RPS

The literature suggests that acting as an OEM requires demanding tasks including the whole process from manufacturing to quality testing on behalf of TNCs brand name. As we can see from the results, 12 suppliers out of 24 have not achieved the level of component sub-contractor, and 17 suppliers out of 24 have not achieved the technological level which is required to be OEM. Achieving level 3, in which suppliers can manage diversified components, is the critical point to becoming an OEM and achieving higher technological capabilities. In addition, OIM (own idea manufacturing) is much more difficult than OEM, but OBM (own brand manufacturing) requires additional knowledge above OEM. Thus, those who are capable to be an OEM can upgrade to becoming an OBM.

There are no suppliers who are categorised as level 5, an ODM of subsidiaries. There are suppliers in the sample who are capable to do ODM activities. However, they are positioned higher than level 5 with some additional technological capabilities accumulated on top.

Independent Local Suppliers (Level 6)

There are 2 suppliers which became independent suppliers with capability of doing active R&D and their own product development in the late 1990s (for S-15) and around 2000 (for P-4). The P-4 supplier is supplying IC related products to subsidiaries (RPM) and it also assembles whole products for subsidiaries in Malaysia. The S-15 supplier produces plastic-related products and assembles whole products of home electronics appliances for subsidiaries (TMR) in Malaysia. The P-4 supplier has its own subsidiaries in Shanghai, Hong Kong and Philippines, which were invested in the late 1990s and 2000. These firms in 3 countries are acting as P-4 supplier's suppliers. The P-4 supplier is an independent supplier which produces mainly OEM type manufacturing, and some of its parts are produced in their own subsidiaries in these 3 countries. These subsidiaries of P-4 supplier in Shanghai, Hong Kong and Philippines are categorised as level 1 and level 2.

P-4 is originally established by former employees of US subsidiary (which is not in the sample of subsidiaries) and still has strong linkages with it. The linking subsidiary of P-4 is RPM which also provide strong linkages. P-4 also mentioned that active involvement with PDC with other TNC subsidiaries help P-4 to learn higher technology than what they have. S-15 supplier receives only quality control training from linking subsidiary. From the subsidiary's point of view, S-15's subsidiary provides weak linkages.

Figure 10 The period of entering EE industry (Level 6 suppliers)

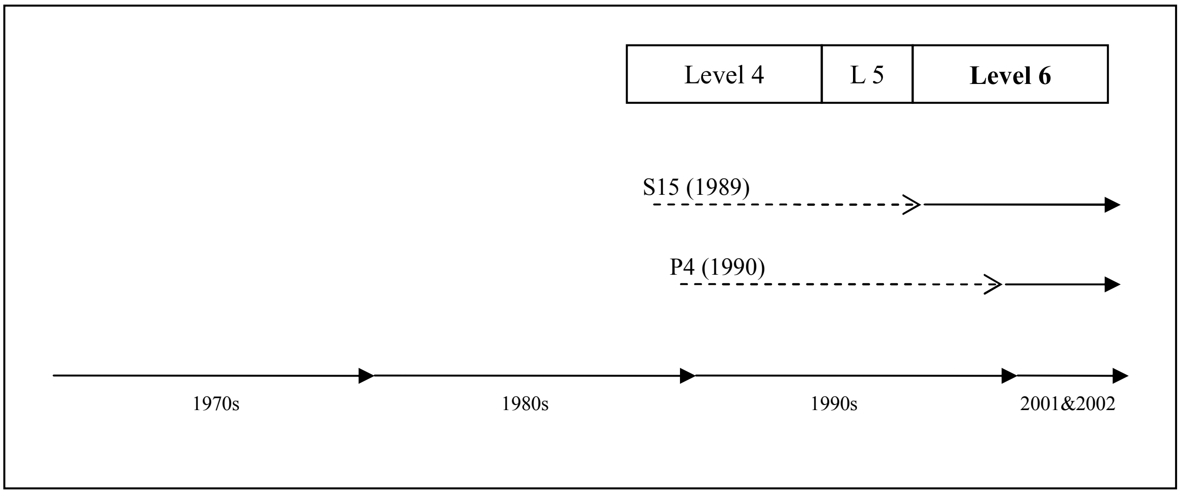


Table 8 Product Sector of Level 6 Suppliers

	Suppliers' Product Sector	Linking Subsidiaries' Product Sector	Linking Subsidiary's Type
S15	9) Chemicals	2) Computer and Peripherals	TMR
P4	7) Tool and Die	1) Semiconductors and Other Components	RPM

Although, one of the suppliers is partially doing components sub-contracting, it is mainly performing as an OEM and ODM for subsidiaries in Malaysia. They have been an ODM for 6 years and 4 years, respestively. They are actively collaborating with subsidiaries for the past 1-2 years at the product designing process. R&D has been established for 12 years and 2 years, respectively, and they have both engaged their own product development for 2 years. Although both suppliers have the capability to be OEM and ODM for subsidiaries, and to do their own product development and product design, they do not have sophisticated knowledge of export channels, so they cannot export their product under their own brand name. One of the suppliers is directly exporting 5% of its products. The supplier mentioned that depending on the products' quality levels, some exported products are re-exported under TNC's brand name. Overall the 2 suppliers' main customers are subsidiaries in Malaysia.

Global Local Suppliers (Level 7)

There are three level-7 suppliers in the sample. The P-5 supplier started its operation as a shop which sold machinery related to the EE industry. It started its operation as a parts supplier using the knowledge it had as a machinery broker in 1970s, and upgraded its technological level continuously. At the time of the interview it produced semi-conductor related equipment, metal-related equipment after receiving knowledge on these technologies by TNC subsidiaries. It has a subsidiary in Thailand as its level 1 and 2 parts supplier and level 3 components supplier. It has an export marketing department in Singapore and in Penang. It is actively exporting 50% of its final products. The P-6 supplier started a family run backyard small factory in 1973, producing small parts. It has 9 companies in 4 countries including Malaysia and manufactures computer hard disk drives and products in the semiconductor industry. Its subsidiaries are located in China, the Philippines, and Thailand, and act as its parts suppliers. Its export ratio is 80%. The S-12 supplier was established in 1992. From the beginning of its operation, it was aiming at R&D-oriented functions due to the director's strategy with employing foreign degree holders. It started its own R&D after a few years of establishment, product development and design, and manufactures transmissions for subsidiaries and supply directly to Malaysian customers. It is exporting 70% of its products.

Figure 11 The period of entering EE industry (Level 7 suppliers)

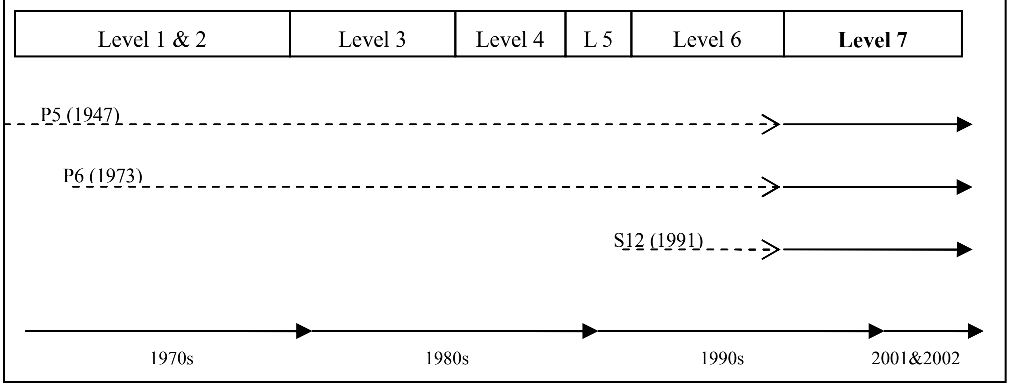


Table 9 Product Sector of Level 7 Suppliers

	Suppliers' Product Sector	Linking Subsidiaries' Product Sector	Linking Subsidiary's Type
P5	7) Tool and Die	1) Semiconductors and Other Components	RPM
P6	8) Metal stamping, casting or machining	3) Telecommunications Equipment	RPM
S12	10) Machinery and Equipment	6) Electrical Industrial Apparatus	TMR

Especially P-5 and P-6 suppliers have moved from acting as parts and components suppliers to acting as OEM sub-contractors and ODMs for past 21 years and 22 years. The S-12 supplier also experienced OEM and ODM for a few years and developed its own brand name. Product development in these firms has been carried out for 7 years, 7 years and 12 years, respectively. They have also collaborated with subsidiaries for 1 year, 10 years and 14 years. The three suppliers have had R&D facilities for 7 years, 14 years and 29 years. All of them have their own export channel and they are exporting directly outside Malaysia. They also explore customers for exporting. Their target is the global market, and they have technological capability to produce global standardised products. Two of them are also actively importing parts from their own companies outside Malaysia and have linkages with these own subsidiaries. Since all of them need to outsource some parts that are not purchased from their own subsidiaries, they have backward linkages with local SMEs.

Especially P-5 and P-6 suppliers have achieved technological upgrading from SME to large manufacturing companies; thus as well advanced suppliers they are no longer so dependent on backward linkages, but have an autonomous innovative drive of their own. The behaviour becomes structurally different from other suppliers from level 1 to 6 who are still heavily dependent on customers (subsidiaries). In addition they provide backward linkages with local suppliers and suppliers outside Malaysia.

Quantitative Analysis: Factors Explaining Different Development Paths

In addition to the qualitative analysis based on the interview data, we also construct a model of the determinants of the technological capability level of local suppliers. The model considers determinants of the technological uses measurements of backward linkages provided by TNC subsidiaries and some other environmental factors affecting local suppliers' technological levels. In the model, the dependent variable, "technological capability level of local suppliers", is analysed by suppliers' perceptions on backward linkages provided by TNC subsidiaries. We use the model to analyse the direct effect of backward linkages on the technological capability level of local suppliers.

Specification of the Model (Non-parametric analysis- Spearman's Correlation Coefficient) on Determinants of Technological Capability of Local Suppliers

The task of the empirical analysis in the model is to determine the characteristics that influence the likelihood of suppliers reaching a certain technological capability level. In a regression model, when the regressors of an equation are categorical they can be dealt with by the introduction of dummy variables. However, when the dependent variable is categorical, the regression model breaks down. Instead, such a model can be analysed by using discrete regression models (Maddala, 1983), such as logit and probit models. However, we apply simple non-parametric analysis rather than logit analysis. These non-parametric tests are more robust as the requirements of a normal distribution and large sample size are not required. These tests were especially suited for smaller samples with nominal or ordinal data, and provided a power efficiency of nearly 95% to their equivalent parametric tests (Siegel, 1956). A range of non-parametric tests[26] were used according to the types of propositions and measurement level of the data:

Dependent variable of the model

The measurement of technological capability level is used as a dependent variable. This is based on the technological capability framework discussed earlier. The ordinal scale is as follows:

Technological Capability levels	Scale
Single parts manufacturing capability	1
Multiple parts manufacturing capability	2
Components production capability	3
OEM capability	4
ODM & product development capability	5
Research based innovative capability	6
Export, OBM capability	7

Although we have treated the three suppliers in the sample with level 7 as local suppliers, the activities of these suppliers, such as manufacturing activities and technologically innovative activities do not have the characteristics of "local SMEs" at all, especially by 2001/2002. These suppliers do not rely on backward linkages provided by TNC subsidiaries[27]. Therefore, at the time of the interview, they had weak backward linkages although they confirmed that they relied on linkages with subsidiaries up to the 1980s, and that they

[26] 1) Cross-tabulations and tests of independence between variables against nominal data: used the Chi-square test of independence. 2) One-sample testing to test the distribution of particular sampled groups: used the Kolmogorov-Smirnov test to test against a normal distribution. 3) Correlation: used the Speaman's rho to test for correlation between two variables with ordinal measurement.

[27] From the survey in 2001 and 2002.

have learned a lot from their customers (e.g., subsidiaries). Therefore, we have decided to look at both 24 observations and 21 observations separately to compare the quantitative analysis in the model. For the entire 24 observation data set, the mean of the dependent variable is 3.125, and the standard deviation is 2.028, while for the 21 observations without level 7 suppliers, the mean of the dependent variable is 2.5714 and standard deviation is 1.46872.

Explanatory Variables of the Model and Hypotheses

The explanatory variables are composed of indexes, binary coding and numbers. The nature and description of the explanatory variables included in the final models is outlined in table 10. Based on the theoretical observations and prior empirical evidence, along with trends from the survey, we formally test some of these explanatory variables as determinants of local suppliers' technological capability levels.

Backward Linkage Factors:

These variables represent the forms of backward linkages. Independent variables in this category are Product index, Process index, Training index, Innovation index, Managerial index, and Other links index. They are all compiled to a single index number based on the responses to all of the items in each category of backward linkages. All the indexes measure the intensity of backward linkages. Responses to each binary item are 1 for yes, 0 for no.

Suppliers' Factors:

These variables represent the suppliers' internal factors. Internal supplier factors are assumed to be important in contributing to their own technological level. In relation to firm size, studies[28] have attempted to test the hypothesis that there is a positive relationship between the technology level and firm size. The positive relationship is based on the argument that the returns from capability acquisition are higher where a firm has a larger volume of sales to spread the fixed costs of capability acquisition and large firms can have more specialised technical manpower (Wignaraja, 2001). Moreover, it is argued that capital market imperfections confer an advantage on large firms in securing finance for risky technological activities and size is correlated with the availability and stability of funds. Thus employment and sales figures are included as control variables. Length of operation is also assumed to be important since the longer the established years, the better suppliers can accumulate technological innovative capability

[28] The pioneering work on this subject is Westphal et al. (1990) on Thailand. Subsequent work includes SRI International (1992) on Indonesia, Gosen (1995) on Mexico Deraniyagala (1995) and Wignaraja (1998) on Sri Lanka, Romijn (1999) on Pakistan, Deraniyagala and Semboja (1999) on Tanzania, Wignaraja and Ikiara (1999) on Kenya, Latsch and Robinson (1999) on Zimbabwe. Works on Malaysia are done by Noor (1999), Arrifin (2000), Giroud (2003).

Environmental Factors:

These variables are factors environmental to the suppliers. The government offers various programmes for suppliers, especially SMEs. We have distinguished between a government programme index which represents the intensity of participation in all programmes, and a BL-related government index which represents the intensity of participating only in BL-related government programmes. These programmes include those of VDP, ILP, PSDC, DDI, ITAF, and BL-related programmes by FMM and other organisations, which are assumed to affect the technological capability of local suppliers as environmental factors. The Location variable is a dummy variable which allows testing on whether significant differences exist between suppliers located in Selangor and in Penang. We also look at whether the existence of university links affects the technological capability of suppliers. These data are presented as binary numbers (e.g., dummy variables).

Table 10 Brief description of explanatory variables in the model

	Variable name/code	Variable type	Description	Mean	Expected sign of coefficient
Backward Linkages factors	Product index	Index Continuous	Product related linkages	0.6408	+
	Process index	Index Continuous	Process related linkages	0.5282	+
	Training index	Index Continuous	Training related linkages	0.7238	+
	Innovation index	Index Continuous	Innovation related linkages	0.4048	+
	Managerial index	Index Continuous	Managerial related linkages	0.2262	+
	Other links index	Index Continuous	Other links linkages	0.4524	+
Suppliers' factors	Employment	Numbers Continuous	Number of employees	369.9048	+
	Length of Operation	Numbers Continuous	Length of operation	13.3810	+
	Sales	Numbers Continuous	Sales figure in RM million in 2001/2002	44.7257	+
Environmental factors	Government programme index	Index Continuous	Participation in all government programmes	0.2440	+
	BL related Government programme index	Index Continuous	Participation in BL related government programmes	0.1837	+
	Location	Binary Discrete	Penang=1/Selangor=0	0.1905	?
	University links	Binary Discrete	Collaboration with local university (Yes=1/No=0)	0.2857	?

Before obtaining the results of the correlation coefficients, we have tested each variable using several methods. First of all, tests of independence between variables against nominal data were carried out with the Chi-Squared test of independence. Next for one-sample testing to test the distribution of particular sampled groups, the Kolmogorov-Smirnov test is used to test against a normal distribution. The Kolmogorov-Smirnov test does not require the assumption that the population is normally distributed. Finally we obtain the Correlation Coefficient, which measures the degree to which two variables are linearly related. Commonly used procedures, based on the Pearson's Product Moment Correlation Coefficient, for making inferences about the population correlation coefficient, make the implicit assumption that the two variables are jointly normally distributed. A non-parametric measure such as Spearman's Correlation Coefficient is more appropriate when this assumption is not justified. Thus we use Spearman's Correlation Coefficient with ordinal measurement (our dependent variable).

Statistical Results and Hypotheses Testing of the Model

From the broad research questions and null hypotheses, five hypotheses (H1, H2, H3, H4, and H5) are tested by using the results of non-parametric tests. The table below reports the Correlation Coefficient of the parameters of the non-parametric model using Spearman's rho.

Table 11 The factors influencing Technological Level of local supplier: Spearman's Correlation Coefficient

		Tech Capability Level N=24	Tech Capability Level 1-6 N=21
Backward Linkages factors	Product linkages index	0.099	0.308
	Process linkages index	0.080	**0.441(**)**
	Training linkages index	0.234	**0.433(**)**
	Innovation linkages index	0.216	0.324
	Managerial linkages index	-0.029	0.223
	Other links index	-0.271	- 0.140
Suppliers' factors	**Number of employees**	**0.572(***)**	**0.662(***)**
	Sales	**0.498(**)**	**0.535(**)**
	Length of operation	**0.476(**)**	0.346
Environment factors	**Location**	**0.569(***)**	**0.517(**)**
	Government programme index	0.290	**0.399(*)**
	BL related Government programme index	**0.448(**)**	**0.499(**)**
	University Links	0.014	-0.09

* Correlation is significant at the 0.10 level (2-tailed).
** Correlation is significant at the 0.05 level (2-tailed).
*** Correlation is significant at the 0.01 level (2-tailed).

H 1: Local suppliers' technological innovative capability is affected by backward linkages.

Backward linkages are important factors affecting the technological capability level of suppliers. The results with the 24 observation dataset do not show that any of the forms of backward linkages are significant. However, the results with the 21 observation set show that out of the 6 forms of linkages, the intensity index of process linkages (0.441) and training linkages (0.433) are positively signed and significant at 1% level. We have also calculated the correlation between a total backward linkages index measure (which is not presented here) and suppliers' technological level. We did not find any significant results for either 24 or 21 observations. Therefore, what we can conclude is that statistically, a higher intensity of backward linkages in process and training is correlated with a higher level of technologically innovative activity. In addition, this result also supports the idea that suppliers of level 7 are not affected by backward linkages anymore, but other suppliers with lower levels rely on backward linkages. Thus, we support our hypothesis and conclude that local suppliers' technologically innovative capability is affected by backward linkages, especially by process and training linkages. Suppliers' technological capability levels are significantly affected by these two forms of backward linkages, and technologically innovative capabilities has been built up through these backward linkages.

H 2: Technologically innovative capability is affected by supplier's internal factors

Previous studies suggested that the size of the firm is a crucial factor for the technological capability level in developing countries. The correlations of technological level with the size of firm variable (number of employees) are significant at 1% and positively signed for both the 24 and 21 observation datasets (0.572 and 0.662 respectively). The correlations with sales figures for both sets of observations are also significant at 5% and positively signed (0.498 and 0.535 respectively). The correlation with length of operations is significant at 5% for 24 observations (0.476) while it is not significant for 21 observations. The possible reason for this result is that level 7 suppliers have a longer length of operation (11, 29 and 55 years), which contributes to a strong correlation between length of operation and technological level of suppliers. Length of operation varies for other levels, and does not affect technological level of suppliers. Therefore, we accept our hypothesis that technologically innovative capability is affected by suppliers' internal factors, particularly by size of the suppliers and total sales.

H 3: Linkages with local universities affect the intensity local suppliers' technologically innovative capabilities

Although linkages with local universities are considered to be one of the important factors for technological development of local suppliers in developing countries, we did not find any significant relationship between linkages with local universities and the technological level of local suppliers. Thus, we reject our hypothesis on linkages with local universities and conclude that linkages with local universities do not affect local suppliers' technologically innovative capability, as of 2001/2002.

H 4: Local suppliers located in Penang have a different level of technologically innovative capability than those located in Selangor.

The locational factor correlation coefficient is positively signed and significant at 1% level (0.569) for the 24 observation set, and at the 5% level (0.517) for the 21 observation set. Therefore, we accept our hypothesis that local suppliers located in Penang have a different level of technologically innovative capability than those located in Selangor. We conclude that suppliers located in Penang have a higher level of technologically innovative capability than those located in Selangor.

H 5: Government programmes have a positive effect on technologically innovative capability of local suppliers.

The results show that the government programme index is significant at the 10% level and positively signed (0.399) for the 21 observation set. It is not significant for the 24 observation set. Participation rates for government programmes do not affect technological capability levels of local suppliers for the full 24 observation set. On the other hand, the backward linkage-related government programme index shows a significant correlation for both the 24 and 21 observation datasets at the 5%, with the expected positive signs. Backward linkage-related government programmes affect technologically innovative capability of local suppliers positively. When we compare backward linkage-related government programme index and the all government programme index for the 21 observation set, the backward linkage-related government programme index (0.499 and significant at the 5% level) affects technological capability level stronger than the all government programme index (0.399 and significant at the 10% level). Therefore, we accept our hypothesis that government programmes have a positive effect on technologically innovative capability of local suppliers. We conclude that backward linkage-related government programmes affects capabilities more than general government programmes for the 21 observation set without level 7 suppliers. With level 7 suppliers (24 observations), the backward linkage-related government programme index has an even greater effect on capabilities. In fact, level 7 suppliers are actively involved with backward linkage-related government programmes (especially in Penang) as a contributor as well as a facilitator of the programmes. This partially contributes to the positive relationship between backward linkage-related government programmes and the technologically innovative capability levels of local suppliers.

Summary of Findings

From the statistical results using non-parametric analysis (Spearman's rho), we support hypotheses H1, H2, H4, H5, and fail to support hypotheses H3. From the results of the 21 observations, the technologically innovative capability of local suppliers is affected by backward linkages, especially by process and training linkages (H1); and by supplier's internal factors, especially size of the suppliers and sales figures (H2). Location in Penang is positively correlated with the level of technologically innovative activities (H4), while linkages with local universities were not correlated with the local supplier's technologically innovative capability (H3) for either dataset. Government programmes also have a positive effect on the technologically innovative capability of local suppliers for both datasets (H5). Overall, although there are slight differences in the results between the 24 and 21 observation datasets, we can still conclude that local suppliers' technologically innovative activities are affected by backward linkages, subsidiaries' nationality of origin, size of the firms, location, and government programmes, based on our statistical results using Spearman's correlation coefficient.

8 Conclusion

Our descriptive statistics and case studies demonstrate that there is a clear development path of suppliers' technological levels over time. We found that suppliers continuously develop new technological capabilities and upgrade their level from lower to higher. Upgrading of capabilities does not occur automatically; rather, suppliers must make effort to acquire higher technological capabilities. We found that these efforts are enabled by backward linkages. This is supported by long relationships with subsidiaries which are continuously shifting their roles in the sophisticated way. As Mortimore and Vergara (2004) mention, the upgrading of subsidiaries respond to improvements in domestic capabilities. From the subsidiary's point of view, we also find support for the idea that suppliers have improved their technological levels over time. On the other hand we unexpectedly find that some suppliers prefer to expand their operation horizontally. Such suppliers are not so interested in upgrading their technological level, but are interested in becoming specialists in simple parts manufacturing able to produce any parts for any required products even in different industries. Thus, suppliers are looking for an expansion of their technological scope within the existing technological level. This phenomenon is especially prevalent in Level 2 suppliers.

We found statistical evidence that a higher intensity of backward linkages in process and training is correlated with a higher level of technological innovative activity. Suppliers' technological capability levels are significantly affected by these two forms of backward linkages, and technological innovative capability has been built up through these backward linkages. This was also supported by descriptive statistics and the qualitative analysis. Descriptive statistics also support that suppliers receive particularly high intensity in product and training backward linkages from subsidiaries. Level 4 and 6 suppliers receive the highest process linkages, followed by level 2 suppliers. From the data we see that suppliers in different technological levels receive linkages of different intensities depend on the roles and strategies of linking subsidiaries; hence, backward linkages are clearly subsidiary driven.

We found that backward linkages are subsidiary-led, and the technological ability of a supplier affects a subsidiary's decisions on whether or not to have linkages. We would like to make final conclusion on backward linkages affecting the upgrading path of technologically innovative activities of local suppliers. The statistical results demonstrate a correlation between backward linkages and suppliers' technological innovative capabilities. We would like to extend our analysis using data in the previous section. In explanation of responses we explained how suppliers have accumulated their technological innovative capabilities. The data as well as evidence from the suppliers' responses suggest that suppliers have learned new technology from subsidiaries. Suppliers are supported by and provided many kinds of backward linkages from subsidiaries over time. They have accumulated their innovative technological capabilities through backward linkages offered by subsidiaries. If their technological innovative capabilities were not accumulated through backward linkages, evidence shows that they learned from former employers of subsidiaries who act as managers, through government programmes (especially for management related capability), or from customers in industrialised countries. To have linkages with customers (usually TNC subsidiaries) in industrialised countries, suppliers are required to have technological capabilities which were accumulated through backward linkages over time. Government programmes affect supplier capabilities as shown in the statistical results, and backward linkages are considered to be the main sources of technology for suppliers. Therefore, we can support our hypothesis that backward linkages affect the upgrading path of innovative technological activities of local suppliers, hence, TNC subsidiaries affect technological innovative activities of local suppliers.

In the context of the NIS of Malaysia, the crucial actors in this study are TNC subsidiaries and local suppliers for technological innovative activity. Subsidiaries and suppliers are effectively interacting through the forms of backward linkages. Of course, in terms of the technological level of suppliers, there is still room for upgrading their technology. However, as a supplier to subsidiaries, they are functioning well and fit with subsidiaries' global production networking. The effectiveness of other actors, specifically the government and Malaysian universities, are statistically analysed. Local universities in Penang and Selangor are not effectively functioning as an actor in NIS, as we found there were no linkages between universities and subsidiaries. As of 2001/2002, local universities were not contributing to the backward linkages, the NIS, or the upgrading of local technological capabilities. The other main actor is the government. Government programmes have a positive effect on the technologically innovative capability of local suppliers. We found that backward linkage-related government programmes affects the technological capabilities of local suppliers more than general government programmes. Descriptive statistics also demonstrated that the establishment of the PDC helped the relationship between subsidiaries and local suppliers. PSDC is functioning well to implement the GSP and SSP and its role is significant. These two organisations are well functioning as coordinators or facilitators between subsidiaries and suppliers. There are programmes offered nationally by the Malaysian government; however, the implementing bodies are not well organised or developed in each region. In the EE industry, upgrading suppliers' technological capabilities and skilled labour in suppliers is best accomplished through implementation of programmes in the regional support institutions.

From these analyses we can emphasise that that backward linkages are a part of the institutional environment in NIS. Thus, intensifying backward linkages is crucial for not only upgrading local suppliers' technological levels, but also for improving national innovative and competitive performance and intensifying NIS in Malaysia.

List of references

Acs, Z. (1999), "The New American Evolution," in Are Small Firm Important? Their Role and Impact, Z. Acs, Ed. Boston: Kluwer Academic Publishers.

Acs, Z. and D. B. Audretsch (1990), Innovation and Small Firms. Cambridge: MIT Press.

Aldrich, J. H. and F. D. Nelson (1984), Linear Probability, Logit, and Probit Models. Newbury Park: Sage Publications.

Archibugi, D. and B.A Lundvall (2001), The Globalising Learning Economy. Oxford: Oxford University Press.

Ariffin, Norlela. (2000), "The Internationalisation of Innovative Capabilities: The Malaysian Electronics Industry," Ph.D thesis, University of Sussex.

Arrow, K. J (1962), "The Economic Implications of Learning by Doing," Review of Economic Studies, 29, 155-73.

Audretsch, D. B. (2000), "Knowledge, Globalization, and Regions: An Economist's Perspective," in Regions, Globalization, and the Knowledge-Based Economy, J.H. Dunning, Ed. Oxford: Oxford University Press.

Bell, M and A. Marin (2004), "Where do foreign direct investment-related technology spillovers come from in emerging economics? An exploration in Argentina in the 1990s," The European Journal of Development Research, 16 (3), 653-84.

Bell, M. and Keith Pavitt (1993), "Technological Accumulation and Industrial Growth: contrast between developed and developing countries," Industrial and Corporate Change, 2 (2), 157-210.

Blomström, M, A. Kokko, and M. Zejan (2000), Foreign Direct Investment Firm and Host Country Strategies. London: MacMillan.

Cantwell, J., A. (1999), "Introduction," in Foreign Direct Investment and Technological Change, J. Cantwell, A., Ed. Vol. I: Theories of Technological Change. Cheltenham: Edward Elgar Publishing.

Cantwell, J., A. and C. Iguchi (2005), "Multinationals and their relationships with local suppliers: Effects on local suppliers' development path in the Malaysian electrical and electronics industry," in Multinational and Asia: Organisational and Institutional Relationships, A. Giroud and A. Mohr and D. Yang, Eds.: Routledge.

Capannelli, G (1997), "Buyer-Supplier Relations and Technology Transfer. Japanese Consumer Electronics," International Review of Economics and Business, 44 (3), 633-62.

Carlsson, B. and R. Stankiewicz (1991), "On the Nature, Function, and Composition of Technological Systems," Journal of Evolutionary Economics, 1 (2), 93-118.

Carlsson, B. and S. Jacobsson (1994), "Technological systems and economic policy: The diffusion of factory automation in Sweden," Research Policy, 23, 235-48.

Dahlman, C. J. and F. V. Fonseca (1987), "From Technological Dependence to Technological Development:

The Case of Usiminas Steelplant in Brazil," in Technology Generation in Latin American Manufacturing Industries, J. Katz, Ed. Basingstoke: Macmillan.

Department of Statistics (2000) "Malaysia Standard Industrial Classification 2000", Kuala Lumpur.

Deraniyagala, S. and H. Semboja (1999), "Trade Liberalisation, Firm Performance and Technology Upgrading in Tanzania," in The Technological Response to Import Liberalisation in Sub Saharan Africa, S. Lall, Ed. London: Macmillan.

Dodgson, M. (1991), The Management of Technological Learning. Berlin: De Gruyter.

Dorfman, N.S. (1987), Innovation and Market Structure: Lessons from the Computer and Semiconductor Industries. Cambridge Mass: Ballinger.

Dosi, G., C. Freeman, R. Nelson, G. Silverberg, and L. Soete (1988), Technical change and Economic Theory. New York: Columbia University Press.

Dosi, G., Keith Pavitt, and L. Soete (1990), The Economics of Technological changes and International Trade. New York: New York University Press.

Driffield, N.L. and A. H. M. Noor (2000), "Foreign direct investment and local input linkages in Malaysia.," Transnational Corporations, 8 (3), 1-25.

Edquist, C (2004), "Systems of Innovation, Perspectives and Challenges," in Oxford Handbook Of Innovation, J. Fagerberg and D. C. Mowery and R. Nelson, Eds. Oxford: Oxford University Press.

Edquist, C. (1992), Systems of Innovation, Technologies, Institutions and Organisations. London: Pinter.

Edquist, C. and B. Johnson (1997), "Institutions and Organisations in Systems of Innovation," in Systems of Innovation: Technologies, Institutions and Organisations, C. Edquist, Ed. London and Washington: Pinter.

Ernst, D., L. Mytelka, and T. Ganiatsos (1998), Technological Capabilities and Export Success in Asia. London: Routledge.

Fagerberg, J. and M. M. Godinho (2004), "Innovation and catching-up," in Oxford Handbook of Innovation, J. Fagerberg and D. C. Mowery and F. D. Nelson, Eds. Oxford: Oxford University Press.

Fleury, M.T., Ruy de Quadros, and A. Fleury (1994), The Role of Japanese Direct Investment in Developing Countries: The Case of Brazil: Institute of Developing Economies.

Freeman, C. (1987), Technology and Policy and Economic Performance: Lessons from Japan. London: Pinter.

Freeman, C. (1991), "Networks of Innovators: a synthesis of research issues.," Research Policy, 20, 499-514.

Freeman, C. (2001), "The learning economy and international inequality," in The Globalising Learning Economy, D. Archibugi and B.A Lundvall, Eds. Oxford: Oxford University Press.

Fukushima, K and C. H. Kwan (1995), "Foreign Direct Investment and Regional Industrial Restructuring in Asia," in The New Wave of Foreign Direct Investment in Asia, ISEAS/Nomura Research Institute, Ed. Singapore.

Gerstenfeld, A. and L.H. Wortzel (1977), "Strategies for Innovation in Developing Countries," Sloan Management Review, Fall, 57-68.

Giroud, A. (2001), "Buyer-Supplier Transfers and Country of Origin: An Empirical Analysis of FDI in Malaysia," in Bradford University School of Management Working Paper 2001/09.

Giroud, A. (2003), Transnational Corporations, Technology and Economic Development: Backward Linkages and Knowledge Transfer in South East Asia: Edward Elgar.

Gorg, H and F Ruane (1998), "Linkages between Multinationals and Indigenous Firms: Evidence for the Electronics Sector in Ireland," in Trinity Economic Papers Series Technical Paper No. 98/13.

Gosen, R. (1995), "Technological Capability in Developing Countries: A Case Study of Biotechnology in Mexico," University of Oxford.

Halbach, A., J. (1989), "Multinational Enterprises and Subcontracting in the Third World: a Study of Inter-Industrial Linkages," in MNEs Programme Working Paper. Geneva: International Labour Office.

Hobday, M. (1995), Innovation in East Asia: The Challenge to Japan. Aldershot, England: Edward Elgar Publishing Ltd.

IDE (1994), The Role of Japanese Direct Investment in Developing Countries: India, Indonesia, Taiwan. Tokyo: Institute of Developing Economies (Asia Keizai Kenkyu-Jo).

ILO/UNCTC (1984), Technology Choice and Employment Generation by Multinational Entreprise in Developing Countries. Geneva: International Labour Office/United Nations Centre for Transnational Corporations.

ILO/UNCTC (1988), Economic and Social Effects of Multinational Enterprise in export Processing Zone. Geneva: International Labour Office/United Nations Centre for Transnational Corporations.

Johnson, A. and S. Jacobsson (2003), "The Emergence of a Growth Industry: A Comparative Analysis of the German, Dutch and SwedishWind Turbine Industries," in Transformation and Development: Schumpeterian Perspectives, S. Metcalfe and U. Cantner, Eds. Heidelberg: Physica/Springer.

Kamien, M.I. and N.L. Schwartz (1982), Market Structure and Innovation. Cambridge: Cambridge University Press.

Katz, J.S. and B.R. Martin (1997), "What is research collaboration?" Research Policy, 26, 1-18.

Kenny, S (1995), "Defining a national system of innovation: implications for Irish industrial development policy," Regional Studies, 29 (692-697).

Kim, L. (1980), "Stages of development of industrial technology in a developing country: a model," Research Policy, 9, 254-77.

Kim, L. (1993), "National System of Industrial Innovation: Dynamics of Capability Building in Korea," in National Innovation Systems: A Comparative Analysis, R. Nelson, Ed. New York: Oxford University Press.

Kim, L. (1997), Imitation to Innovation: The Dynamics of Korea's Technological learning. Boston: Harvard Business School Press.

Kim, L. (2000), "The Dynamics of Technological Learning in Industrialisation," in UNU/INTECH Discussion Paper Series #2000-7.

Kokko, A., M. Zejan and R. Tansini (2001), "Trade Regimes and Spillover Effects of FDI: Evidence from Uruguay," Welwirtschaftliches Archive, 137 (124-149).

Lall, S. (1980), "Vertical inter-firm linkages in LDCs: an empirical study," Oxford Bulletin of Economics and Statistics, 42 (3), 203-26.

Lall, S. (1987), Learning to Industrialise: The Acquisition of Technological Capability by India. Basingstoke: Macmillan.

Lall, S. (1994), "Malaysia's export performance and its sustainability," in Asian Development Bank and Economic Planning Unit, Malaysia.

Lall, S. (2003), "Foreign Direct Investment, Technology Development and Competitiveness: Issues and Evidence," in Competitiveness, FDI and Technological Activity in East Asia, S. Lall and S. Urata, Ed. Cheltenham: Edward Elgar.

Lall, S. and Ganeshan Wignaraja (1998), "Mauritius: Dynamising Export Competitiveness," in Commonwealth Economic Paper No. 33. London.

Lall, S. and R. Narula (2004), "FDI and its role in economic development: Do we need a new agenda?" The European Journal of Development Research, 16 (3), 447-64.

Latsch, W. and P. Robinson (1999), "Technology and the Reponses of Firms to Adjustment in Zimbabwe," in The Technological Response to Import Liberalisation in Sub Saharan Africa, S. Lall, Ed. London: Macmillan.

Lee, J., Z-T. Bae, and D-K. Choi (1988), "Technology Development Processes: A model for a developing country with a global perspective," R&D Management, 18 (3), 235-50.

Lim, L. Y. C and E. F. Pang (1991), Foreign Direct Investment and Industrialisation in Malaysia, Singapore, Taiwan and Thailand: OECD.

Liu.X. and S. White (2001), "Comparing innovation systems: a framework and application to China's transitional context," Research Policy, 30, 1091-114.

Lundvall, B.A (1988), "Innovation as an interactive process: from user-producer interaction to the national system of innovation.," in Technical Change and Economic Theory., G. Dosi, Ed. London: Pinter Publishers.

Lundvall, B.A and B. Johnson (1994), "The learning economy," Journal of Industry Studies, 1 (2), 23-42.

Lundvall, B.A Ed. (1992), National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning. London: Pinter.

Lundvall, B.A, E. S. Johnson, and B Dalum (2002), "National Systems of Production, Innovation and Competence Building," Research Policy, 31, 213-31.

Maddala, G. S. (1983), "Limited-dependent and qualitative variables in econometrics." Cambridge: Cambridge University Press.

Malerba, F. (1992), "Learning by Firm and Incremental Technical Changes," Economic Journal, 102, 845-69.

Menzler-Hokkanen, I (1995), "Multinational enterprises and technological transfer," International journal of Technology Management, 10, 293-310.

MIDA (2000), The Electrical and Electronics Industry Data 2000. Kuala Lumpur: MIDA.

MITI (1996), Second Industrial Master Plan 1996-2005. Kuala Lumpur: Ministry of International Trade and Industry.

Mortimore, M. and S. Vergara (2004), "Targeting Winners: Can Foreign Direct Investment Policy Help Developing Countries Industralise?" The European Journal of Development Research, 16 (3), 499-530.

Mowery, D. C. and B. N. Sampat (2004), "Universities in National Innovation Systems," in Oxford Handbook of Innovation, J. Fagerberg and D. C. Mowery and C Edquist, Eds. Oxford: Oxford University Press.

Myers, S. and D. G. Marquis (1969), "Successful Industrial Innovations: a Study of Factors Underlying Innovation in Selected Firms," National Science Foundation, NSF, 69-117.

Mytelka, L. (2000), "Local Systems of Innovation in a Globalized World Economy," Industry and Innovation, 7 (1), 15-32.

Mytelka, L. K. and L. A. Barclay (2004), "Using Foreign Investment Strategically for Innovation," The European Journal of Development Research, 16 (3), 531-60.

Narula, R. (2003), Globalisation and Technology. Cambridge: Polity Press.

Nelson, R. and N. Rosenberg (1993), "Technical innovation and national systems," in National Systems of Innovation: A Comparative Study, R. Nelson, Ed. Oxford: Oxford University Press.

Nelson, R. Ed. (1993), National Systems of Innovation: A Comparative Study. Oxford: Oxford University Press.

Niosi, J., P. Saviotti, B. Bellon, and Crow M. (1993), "National Systems of innovation: in search of a workable concept," Technology in Society, 15, 207-27.

Noor, H. M. A (1999), "Technological Effort: A Study of its Influencing Factors in MNCs and Local Firms in the Electronics and Electrical Industries in Malaysia," PhD thesis, Cardiff Business School, University of Wales.

North, D. (1990), "Institutions, Institutional Change and Economic Performance," in. Cambridge: Cambridge University Press.

O'Brien, L. (1993), "Malaysian Manufacturing Sector Linkages," in Industrialising Malaysia: Policy, Performance and Prospects, K. S. Jomo, Ed. London: Routledge.

OECD (1991), Strategic Industries in a Global Economy: Policy Issues for the 1990s. Paris: Organisation for Economic Co-operation and Development.

Oyelaran-Oyeyinka, B. (2001), "Networks and Linkages in African Manufacturing: A Nigerian Cluster Study," in UNU/INTECH, Discussion Paper, 2001-5.

Pack, H. and L. E. Westphal (1986), "Industrial Strategy and Technological Changes: Theory versus Reality," Journal of Development Economics, 22, 104.

Patel, P. and Keith Pavitt (1994), "The continuing, widespread (and neglected) importance of improvements in mechanical technologies," Research Policy, 23 (5), 533-45.

Radosevic, S. (1999), International Technology Transfer and Catch-up in Economic Development. Cheltenham: Edward Elgar.

Rasiah, Rajah (1995), Foreign Capital and industrialization in Malaysia. London: Macmillan.

Rasiah, Rajah(1989), "Competition and Restructuring in the Semiconductor Industry: Implication for Technology Transfer and its Absorption in Penang," Sourtheast Asian Journal of Social Sciences, 17 (2).

Rasiah, Rajah. (2004), "Exports and Technological Capabilities: A study of foreign and local firms in the electronics industry in Malaysia, the Philippines and Thailand," The European Journal of Development Research, 16 (3), 587.

Rodriguez-Clare, A. (1996), "Multinationals, Linkages, and Economic Development," American Economic Review, 85, 852-73.

Romijn, H. (1999), Acquisition of Technological Capability in Small Firms in Developing Countries. London: Macmillan Press.

Schmookler, J. (1966), Invention and Economic Growth. Cambridge, MA: Harvard University Press.

Schumpeter, J.A (1926), Theorie der Wirtschaftlichen Entwicklung ("Keizai Hatten no Riron" translated by Shionoya et al): Iwanami Shoten.

Scott-Kennel, J. and P. Enderwick (2001), "Economic Upgrading and Foreign Direct Investment: Exploring the Black Box of the IDP," in Mimeo, University of Waikato, New Zealand.

Siegel, S. (1956), Nonparametric Statistics for the Behavioral Science. New York: McGraw-Hill.

SPRU (1972), Success and Failure in Industrial Innovation: Report on the Project SAPPHO by the Science

Policy Research Unit, University of Sussex. London: The Centre for the Study of Industrial Innovation.

SRI International (1992), Industrial Restructuring in the Electronics Sector. Singapore: SRI International.

Sturgeon, Timothy J. and R. K. Lester (2003), "The New Global Supply-Base: New Challenges for Local Suppliers in East Asia," in MIT Industrial Performance Center Working Paper Series MIT-IPC03-001.

Supapol Atipol, B. (1995), Transnational Corporations and Backward Linkages in Asian Electronics Industries: United Nations.

UNCTAD (1995), World Investment Report 1995: Transnational Corporations and Competitiveness. New York and Geneva: United Nations.

UNCTAD (1999), World Investment Report 1999: FDI and Challenge of Development. New York and Geneva: United Nations.

UNCTAD (2001), World Investment Report 2001: Promoting Linkages. New York and Geneva: United Nations.

United Nations (1997), "Assistance to Small and Medium-Sized Enterprises for Enhancing Their Capacity for Export Marketing," in Economic and Social Commission and For Asia and the Pacific, Studies in Trade and Investment 28. New York and Geneva.

United Nations (2004), "Report of the Task force on Science, Technology and Innovation United Nations Millennium Project."

Utterback, J. M. (1994), Mastering the Dynamics of Innovation: How Companies Can Seize Opportunities in the Face of Technological Change. Boston: Harvard University Business School Press.

Von Hippel, E. (1988), The Sources of Innovation. Cambridge: Cambridge University Press.

Westphal, L. E., K. Kritayakirana, K. Petchsuwan, H. Sutaburtr, and Y Yuthavong (1990), "The Development of Technological Capability in Manufacturing: A Macroscopic Approach to Policy Research," in Science and Technology: Lessons for Development Policy, R. E. Evernson and G. Ranis, Eds. London: Intermediate technology publications.

Wignaraja, Ganeshan (1998), Trade Liberalisation in Sri Lanka: Exports, Technology and Industrial Policy. London: Macmillan.

Wignaraja, Ganeshan (2001), "Firm Size, Technological Capabilities and Market-Oriented Policies in Mauritius," in The United Nations University Institute for New Technologies Discussion Paper Series #2001-1.

Wignaraja, Ganeshan and Ikiara (1999), "Adjustment, Technological Capabilities and Enterprise Dynamics in Kenya," in The Technological Response to Import Liberalisation in Sub Saharan Africa, S. Lall, Ed. London: Macmillan.

Wong, P. K. (1991), "Technological Development through Subcontracting Linkages: A Case Study," in Asian Productivity Organisation, Faculty of Business, Administration, National University of Singapore.